International Journal of Environment and Climate Change

Volume 13, Issue 10, Page 2825-2834, 2023; Article no.IJECC.106365
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Comparative Performance of Planting Materials and Standardization of Nutrient Requirement for High Yield, Quality and Early Spike Development in Tuberose (*Agave amica* Medik.) cv. Arka Prajwal

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2023/v13i102947

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/106365

Original Research Article

Received: 04/07/2023
Accepted: 09/09/2023
Published:09/09/2023

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ABSTRACT

The study was carried out at Vegetable Research Station, TNAU, Palur, Tamil Nadu during 2021to2022. The experiment was laid out in Factorial Randomized Block Design (FRBD) with eight treatments and three replications. Planting materials used for the study were bulbs and bulblets. The eight nutrient combinations were tried with foliar application of micronutrient like zinc sulphate (0.2%), Ferrous sulphate (0.5%), Copper sulphate (0.4%) and Boric acid (0.2%) on 30, 60 and 90 DAP, individually and in combination with 25 t ha^{-1} FYM and recommended dose of fertilizer (200:200:200 kg ha^{-1} NPK). The control was maintained with RDF. Various biometric observations on growth and flowering attributes of tuberose were observed for all the treatments at different stages. The result of the present investigation revealed that among the interaction effects,B_1N_8[RDF + ALL 19 (NPK) + GA_3@ 200 ppm (2 spray at 30 days intervals) + $ZnSO_4$ (0.2%) + $FeSO_4$ (0.5%) + H_3BO_3 (0.2 %) + $CuSO_4$ (0.4 %)] recorded the highest plant height (95.12 cm), leaf length (51.85 cm), leaf width (2.4 cm), number of leaves per plants (42.67), rachis length (34.87cm), number of floret/spikes (46.66), flower duration (18.12 days), floret length (6.92 cm) and floret diameter (4.39cm) followed by the treatment B_2N_8 which recorded the highest height (90.44 cm), leaf length (48.48 cm), leaf width (2.2 cm), number of leaves per plants (39.78), rachis length (30.42 cm), number of floret/spikes (44.95), flower duration (19.93days), floret length (6.45cm) and floret diameter (4.21cm). From the interaction effect, the treatment combinationB_2N_1 [control (RDF) 200:200:200 NPK] recorded the lowest plant height (72.36 cm), leaf length (42.81 cm), leaf width (1.12 cm) and number of leaves per plants (43.00), rachis length (25.11cm), number of floret/spikes (37.00), flower duration (15.23days), floret length (5.04 cm) and floret diameter (3.02 cm).

Keywords: Floral parameters; foliar spray; micronutrient; planting material; tuberose; yield parameters.

1. INTRODUCTION

The word "tuberose" is a Latin word, which means swollen, refers to the root system of the plant. Tuberose - *Agave amica* (Medik.) cv. Prajwal which is formerly known as *Polianthes tuberosa* belongs to the family Amaryllidaceae and native to Mexico, is a popular bulbous ornamental crop in India and worldwide due to its pleasant fragrance, attractive spike and high economic value.

Tuberose is mostly grown as a loose flower crop in Tamil Nadu. According to the Ministry of Agriculture and Farmers Welfare in 2021, the total area under tuberose in Tamil Nadu during 2021-22 is around 7,030 hectares and the production is around 68,000 tonnes. Dindigul, Krishnagiri, Dharmapuri, Salem, Vellore, Madurai, Tiruvannamalai, Tirunelveli, and Erode are the main tuberose growing locations in Tamil Nadu. It is one of the most popular mass-market, bloated and bulb shaped flowers and plays a significant role in both the domestic and international markets. Tuberose can be used as cut flowers and loose flowers for their pleasant fragrance. Farmers appreciate it for its greater financial return, lovely aroma, longer shelf life, adaptability to a wide range of climatic conditions and its capacity to grow in a variety of soil types [1].

Flowering crops are much reactive to micronutrients [2] and use of micronutrients in plant fertilization acquires momentum due to their ability to improve plant growth, flowering and yield. However, the majority of developing nations in the globe struggle with a lack of micronutrients, especially iron and zinc [3]. The optimum quantity, timing and application of the appropriate micronutrients are crucial for the better growth, flowering and quality of tuberose plants. For improved growth and superior flowering in tuberose plants, the right vitamin dosages, timing and application techniques are essential. To correct deficiency symptoms, maintenance of nutritional status enhance growth and produce quality in marginal soils, foliar spray by direct application on aerial plant parts is an efficient way rather than root fertilisation [4]. The nutritional deficiencies are reached quickly by foliar application than root application, foliar application is becoming progressively more in demand [5]. Soil nutrients are not early reachable. This might be due to leaching, soil fixations, blockages and other losses. Foliar fertilization applies the nutrients directly on the leaf, where the plant mostly needs them.

The growing demand for tuberose blooms has resulted in a significant increase in the need for bulbs or other commercial planting materials for cultivation. Bulbs, bulblets and seeds can all be used to multiply tuberose. Although it is commercially propagated through bulbs, the tuberose bulbs are more expensive. It costs roughly Rs. 1,12,000 per acre. As an alternative to the more common technique of propagating tuberose through bulbs (1:1), bulblets have a greater multiplication rate (1:8). Therefore, bulblet propagation will lower the cost of planting material with a greater quantity of propagules. Tuberose propagation by bulblets is preferable to tuberose propagation through bulbs [6].

2. MATERIALS AND METHODS

Field experiments were carried out at Vegetable Research Station (TNAU), Palurduring2021to2022.The experimental site was located at about 11˚ 48' North latitude and 79 ˚ 40' East longitude and an altitude of 13.2 meter at Mean Sea Level. Planting materials of tuberose cv. Prajwal viz., bulbs & bulblets were obtained from the farmer's field at Dharmapuri district, Tamil Nadu. The experiment was carried out in Factorial Randomized Design (FRBD) to study the performance of planting material with eight nutrient combinations replicated three times. Recommended dose of nutrients (NPK@200:200:200 kg ha^{-1}) were applied in the form of Urea, Single Super Phosphate and Muriate of Potash respectively. Full dose of $P_2O_5$and K_2O were applied at the time of planting as basal while N was applied in equal split at the time of planting as basal and 30 and 90 days after planting as top dressing. The nutrients were given with basal application of RDF, foliar spray of micronutrients and GA_3 in different combinations.

Treatment details:
Planting materials:

B_1 - Bulbs
B_2 - Bulblets

Nutrient combination:

N_1 - control (RDF) 200:200:200 NPK
N_2 - RDF + ALL 19 (NPK) + GA_3@ 200 ppm
N_3 - RDF + ALL 19 (NPK) +$FeSO_4$ (0.5%) + $ZnSO_4$ (0.2%)
N_4 - RDF +ALL 19 (NPK) + $ZnSO_4$ (0.2%) + H_3BO_3(0.2 %)
N_5 - RDF + ALL 19 (NPK) + $ZnSO_4$ (0.2%) + $CuSO_4$ (0.2%)
N_6 - RDF + ALL 19 (NPK) +$FeSO_4$ (0.5%) + $ZnSO_4$ (0.2%) + H_3BO_3(0.2 %)
N_7 - RDF + ALL 19 (NPK) + $ZnSO_4$ (0.2%) + H_3BO_3(0.2 %) + $CuSO_4$ (0.2%)
N_8 - RDF + ALL 19 (NPK) + GA_3@200 ppm (2 sprays at 30 days intervals) + $ZnSO_4$ (0.2%) + $FeSO_4$ (0.5%) + H_3BO_3 (0.2 %) + CuSO4 (0.2%)

Planting materials viz., bulbs and bulblets were used for planting. The size of the bulbs used for the experiment were around 4 cm in diameter and the bulblets were 1 to 2 cm in diameter. Bulblets were raised in portray nursery 45 days before planting. To prevent rot infections, the bulbs and bulblets were further treated with 0.1% Bavistin. The bulblets were also treated with Gibberellic acid at 150 ppm to break dormancy before planting for enhanced germination. Different combinations of media, including vermicompost, FYM, red soil and cocopeat were placed in the protrays. The biometric observations like plant height, leaf length, leaf width, number of leaves, days taken for first flowering, number of spikes per plant, spike length, rachis length, number of flowers per spike, flower length, and flower diameter were recorded. The statistical analysis of the data was done by adopting the standard statistical procedure given by Panse and Sukhatme [7] at a critical difference of five percent (P = 0.05) probability.

3. RESULTS AND DISCUSSION

3.1 Effect of Treatment Combinations on Vegetative Characters

The experimental data of various vegetative parameters like plant height, leaf length, leaf width and number of leaves per plant were recorded and statistically analysed which is shown in Table 1.

3.1.1 Planting materials

The effect of planting materials had significantly influenced the vegetative parameters of tuberose cv. Prajwal. Among the planting materials used in the study, bulbs (B_1) had recorded highest mean plant height (85.49 cm), leaf length (47.65 cm), leaf width (2.01 cm), number of leaves per plants (49.33) followed by bulblets (B_2) with plant height (81.06 cm), leaf length (45.82 cm), leaf width (1.85 cm) and number of leaves per plants (48.02). The results illustrate that plant height increased with the increase in bulb size. Similar finding was observed by Mahanta *et al.,* [8] who observed taller plants in tuberose which might be due to the presence of more stored photosynthates in larger bulbs. The initial plant growth and the Vigor are determined by the amount of food supplied to the growing plant by the corm [9].

3.1.2 Nutrient combinations

The effect of nutrient combinations showed significance difference on vegetative parameters. Among the treatments, N_8 [RDF + ALL 19 (NPK) + GA_3@ 200 ppm (2 sprays at 30 days intervals) + $ZnSO_4$ (0.2%) + $FeSO_4$ (0.5%) + H_3BO_3 (0.2 %) + $CuSO_4$ (0.4)] recorded highest mean plant height (92.78 cm), leaf length (50.16 cm), leaf width (2.30 cm) and number of leaves per plants (56.69) while N_1[control (RDF) 200:200:200 NPK] recorded lowest mean plant height (73.18 cm), leaf length (44.32 cm), leaf width (1.16 cm) and number of leaves per plants (40.65).From the findings it is clearly understood that micronutrient treatments(0.5%$FeSO_4$+0.2%$ZnSO_4$+0.1%H_3BO_3) have positively influenced the vegetative characters. This might be due to the effect of Fe^{2+} which regulate the development of chloroplast, formation of chlorophyll, photosynthesis and respiration activities [10] The increase in plant growth by the application of micronutrient treatment (0.5%$FeSO_4$+ 0.2% $ZnSO_4$+0.1%H_3BO_3) might be due to the activity of Zn^{2+} which improves auxin synthesis and chlorophyll content [11].

3.1.3 Interaction effect

The interaction effect between planting materials and nutrient combinations showed highly significant influence on vegetative parameters. The treatment combination of B_1N_8recorded highest plant height (95.12 cm), leaf length (51.85 cm), leaf width (2.4 cm) and number of leaves per plants (42.67) followed by the treatment B_2N_8which recorded the maximum plant height (90.44 cm), leaf length (48.48 cm), leaf width (2.2 cm) and number of leaves per plants (39.78). From the interaction effect, the treatment combination B_2N_1 recorded the lowest plant height (72.36 cm), leaf length (42.81 cm), leaf width (1.12 cm) and number of leaves per plants (43.00).

Micronutrients like zinc and boron which might have benefited in nitrogen assimilation and protein synthesis, as well as working as catalytic agents in enzyme activation. Chaturvedi et al., [12] obtained similar increase in plant growth in gladiolus by spraying Agromin containing micronutrients such as B, Zn, Cu, Mn, Mg, and Mo. The combination of bulb with micronutrient (0.5% Cu + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ + 0.1% Boric acid) obtained the highest number of leaves/plants, leaf length, and leaf width. According to Hatwar et al., [13], the application of micronutrients increased the photosynthetic and other metabolic activities which enhanced the numerous plant metabolites important for cell division and elongation. Banu et al., [14] conducted an experiment with 45 ×20 cm spacing and 0.5% N + 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ + 0.1% Boric acid on tuberose and the results of the experiment showed that plant spacing and foliar nutrition had a substantial impact on the growth leading to yield of tuberose.

3.2 Effect of Treatment Combinations on Flowering Characters

The data on flowering parameters as influenced by different planting material and foliar nutrition in tuberose are presented in Table 2.

3.2.1 Planting materials

The effect of planting materials had significantly influenced the flowering parameters of tuberose cv. Prajwal. Among the planting materials used in the study, the bulbs (B_1) recorded the less number of days for first flowering (98.81 days) whereas the bulblets (B_2) took more of days for first flowering (101.07days). Likewise, bulb recorded the highest mean rachis length (31.93cm), number of floret/spike (44.55), flower duration (17.31 days), floret length (6.12 cm), floret diameter (3.78 cm) whereas bulblets recorded lesser rachis length (26.94 cm), number of floret/spike (40.70), flower duration (16.43 days), floret length (5.72 cm) and floret diameter (4.21 cm).

The correlation between the size of bulb and flowering of tuberose are vital as size of bulb influence the amount of enzymes and nutrient for the flowering of tuberose (Tehranifar and Akbari,2012). Similar finding was observed by Singh [15] who reported that larger corms produced more florets in gladiolus. It was concluded that the large sized bulbs performed better and produced highest number of florets per spike which might be due to availability of more food reserve.

3.2.2 Nutrient combination

The effect of nutrient combination showed significance difference in flowering parameters. Among the treatments, N_8 [RDF + ALL 19 (NPK) + GA_3@ 200 ppm (2 sprays at 30 days intervals) + $ZnSO_4$ (0.2%) + $FeSO_4$ (0.5%) + H_3BO_3 (0.2 %) + $CuSO_4$ (0.4)] took less number of days for first flowering (81.12 days) from the findings of micronutrient treatments (0.5%$FeSO_4$+0.2%$ZnSO_4$+0.1%H_3BO_3) had a positive influence on days taken for first flowering of tuberose and it might be due to Fe^{2+} which has a major role in stimulating the metabolic activity and speed up the reproductive activity. This was in agreement with the findings of Singh [16] in lilium. More days were taken for first flowering (122.96days) in the control [N_1- control (RDF) 200:200:200 NPK].The nutrient combination N_8recorded the highest mean rachis length (34.87cm), number of floret/spike(45.80), flower duration (19.02 days), floret length (6.09cm), floret diameter (4.30cm)Spraying of GA_3 increased the rachis length by elongating the internodal length and this might be due to induction of cell division and cell elongation by the growth hormone. This is in agreement with the findings by Da Silva et al. [17]. N_1-control recorded less compare to other nutrient combination, rachis length (26.21cm), number of floret/spike (38.77), flower duration (15.12days), floret length (5.58cm) and floret diameter (3.11cm).

3.2.3 Interaction effect

The interaction effects between planting materials and nutrient combinations showed highly significant influence on flowering parameters. The treatment combination B_1N_8 recorded less number of days taken for first flowering (79.92 days) followed by B_2N_8 (82.32 days). From the interaction effect, the treatment combination B_2N_1 recorded more number of days for first flowering (124.61 days). The treatment combination B_1N_8 recorded the highest rachis length (34.87cm), number of floret/spike (46.66), flower duration (18.12 days), floret length (6.92 cm) and floret diameter (4.39cm) followed by B_2N_8 with rachis length (30.42 cm), number of floret/spike (44.95), flower duration (19.93days), floret length (6.45cm) and floret diameter (4.21cm). Among the interaction effect, the treatment combination B_2N_1 recorded lowest rachis length (25.11cm), number of floret/spike (37.00), flower duration (15.23days), floret length (5.04cm) and floret diameter (3.02 cm). This might be due to application of micronutrients at their optimum quantities significantly improved flowering characteristics. Similar finding was observed by Ahmad et al., [18] in under foliar treatment mixture with Fe, Zn and B in tuberose flowering characteristics were found to be improved. This might be due to cell elongation, IAA synthesis, cell maturation, sugar translocation and protein synthesis caused by different micronutrients which improved the weight and size of gladiolus [19]. According to the research by Jain et al., [20] combination of (Zn 0.8 % + Fe 0.8 % + B 0.2 %+ Cu 0.4 %) induced the early flowering and increased the floret length of tuberose.

3.3 Effect of Treatment Combinations on Yield Characters

The data on yield parameters influenced by different planting materials and nutrient combinations in tuberose are presented in Table 3.

3.3.1 Planting materials

The effect of planting materials had significantly influenced the yield parameters of tuberose cv. Prajwal. Among the planting materials used in the study, the bulblets (B_2) recorded highest mean flower yield per plot (2.17 kg) whereas the bulbs(B_1) recorded lowest mean yield per plot (1.56 kg). The treatment B_1 recorded the highest mean single floret weight (1.70 g), weight of floret per spike (45.76 g) followed by the treatment B_2 (bulblets) with single floret weight (1.67 g) and weight of floret per spike (44.21 g). Though the flower characters are higher when bulbs were used as planting material, highest yield per plot was obtained when bulblets were used as planting material. This might be due to accommodation of more bulblets in unit space because of its lesser in size compare to the bulb. This is in accordance with the finding of Balan et al., [6].

3.3.2 Nutrient combinations

The effect of nutrient combination showed significance difference in yield parameters. Among the treatments, N_8 [RDF + ALL 19 (NPK) + GA_3 @ 200 ppm (2 sprays at 30 days intervals) + $ZnSO_4$ (0.2%) + $FeSO_4$ (0.5%) + H_3BO_3 (0.2 %) + $CuSO_4$ (0.4)] recorded highest mean single floret yield (1.86 g), weight of floret per plant (47.88 g), flower yield per plot (2.20 kg)This might be due to the fact that, Iron enhanced the

Table1. Effect of planting materials and nutrient combinations on vegetative characters of tuberose *Agave amica* (Medik.)

Vegetative Characters												
	Plant height (cm)			Leaf length (cm)			Leaf width (cm)			No. of leaves per plant		
Planting Material / Nutrient combinations	B_1	B_2	Mean	B_1	B_2	Mean	B_1	B_2	Mean	B_1	B_2	Mean
N_1	74.01	72.36	**73.18**	45.83	42.81	**44.32**	1.21	1.12	**1.16**	42.21	39.09	**40.65**
N_2	76.46	73.28	**74.87**	46.01	43.76	**44.88**	1.92	1.77	**1.80**	43.31	41.46	**42.39**
N_3	84.65	79.77	**82.21**	47.71	44.89	**46.30**	2.00	1.83	**1.90**	46.43	47.23	**46.83**
N_4	89.02	81.31	**85.17**	46.12	45.94	**46.03**	2.11	1.92	**2.01**	49.23	48.75	**48.99**
N_5	79.74	76.93	**78.33**	46.83	45.26	**46.04**	1.96	1.80	**1.80**	45.54	45.76	**45.65**
N_6	93.44	88.65	**91.04**	50.02	48.10	**49.06**	2.30	2	**2.15**	56.38	54.02	**55.20**
N_7	91.47	85.72	**88.59**	46.85	47.36	**47.10**	2.20	2.10	**2.20**	53.49	52.55	**53.02**
N_8	95.12	90.44	**92.78**	51.85	48.48	**50.16**	2.40	2.20	**2.30**	58.04	55.34	**56.69**
Mean	**85.49**	**81.06**	**83.27**	**47.65**	**45.82**	**46.74**	**2.012**	**1.855**	**1.89**	**49.33**	**48.02**	**48.67**
	B	**N**	**B×N**	**B**	**N**	**B×N**	**B**	**N**	**B×N**	**B**	**N**	**B×N**
SE (d)	0.435	0.870	1.231	0.314	0.629	0.890	0.016	0.033	0.047	0.305	0.611	0.864
CD@0.05	0.888	1.777	2.514	0.643	1.286	1.818	0.043	0.068	0.097	0.624	1.248	1.766

Table 2. Effect of planting materials and nutrient combinations on flowering characters of tuberose *Agave amica* (Medik.)

Flowering characters																		
	No of days taken for flowering			**Rachis length (cm)**			**No. of floret/spike**			**Flower duration (days)**			**Floret length (cm)**			**Floret diameter (cm)**		
PM / NC	**B_1**	**B_2**	**Mean**	**B_1**	**B_2**	**Mean**	**B_1**	**B_2**	**Mean**	**B_1**	**B_2**	**Mean**	**B_1**	**B_2**	**Mean**	**B_1**	**B_2**	**Mean**
N_1	121.32	124.61	**122.96**	27.32	25.11	**26.21**	40.54	37.00	**38.77**	15.01	15.23	**15.12**	6.12	5.04	**5.58**	3.21	3.02	**3.11**
N_2	114.54	116.87	**115.54**	28.47	25.32	**28.47**	42.68	38.06	**40.37**	15.23	15.87	**15.55**	6.37	5.10	**5.73**	3.35	3.18	**3.26**
N_3	109.59	112.30	**110.94**	33.21	26.00	**33.21**	44.92	39.71	**42.31**	16.08	16.54	**16.31**	6.40	5.66	**6.03**	3.70	3.67	**3.68**
N_4	90.63	95.87	**93.25**	33.45	26.32	**33.45**	45.00	40.56	**42.78**	16.77	17.99	**17.38**	6.48	6.00	**6.24**	3.82	3.77	**3.80**
N_5	95.42	97.55	**96.48**	29.54	25.89	**29.54**	44.65	38.93	**41.79**	15.86	16.12	**15.99**	6.35	5.18	**5.76**	3.65	3.23	**3.44**
N_6	86.67	89.54	**88.10**	34.98	28.45	**34.63**	46.23	43.42	**44.82**	17.45	18.83	**18.14**	6.66	6.32	**6.05**	4.15	4.02	**4.08**
N_7	92.43	89.54	**90.98**	33.98	28.02	**33.98**	45.72	43.02	**44.37**	16.93	18.03	**17.48**	6.48	6.05	**6.45**	3.95	3.95	**3.95**
N_8	79.92	82.32	**81.12**	34.87	30.42	**34.87**	46.66	44.95	**45.80**	18.12	19.93	**19.02**	6.92	6.45	**6.099**	4.39	4.21	**4.30**
Mean	**98.81**	**101.07**	**99.94**	**31.934**	**26.941**	**29.43**	**44.551**	**40.707**	**42.62**	**16.43**	**17.31**	**16.87**	**6.12**	**5.72**	**6.09**	**3.78**	**3.63**	**3.7**
	B	**N**	**B×N**	**B**	**N**	**B×N**	**B**	**N**	**B×N**	**B**	**N**	**B×N**	**B**	**N**	**B×N**	**B**	**N**	**B×N**
SE (d)	0.583	1.167	1.651	0.259	0.518	0.733	0.243	0.487	0.689	0.094	0.188	0.267	0.053	0.106	0.150	0.024	0.048	0.068
CD@0.05	1.192	2.385	3.373	0.529	1.058	1.497	0.497	0.995	1.407	0.192	0.385	0.545	0.108	0.217	0.307	0.049	0.099	0.140

Table 3. Effect of planting materials and nutrient combinations on yield parameters of tuberose *Agave amica* (Medik.)

	Single floret weight (g)			**Weight of floret per spike (g)**			**Yield per plot(kg)**		
Planting Materials / Nutrient combinations	**B_1**	**B_2**	**Mean**	**B_1**	**B_2**	**Mean**	**B_1**	**B_2**	**Mean**
N_1	1.49	1.41	**1.45**	42.81	40.80	**41.80**	1.28	1.72	**1.50**
N_2	1.57	1.49	**1.53**	44.01	42.32	**43.16**	1.38	1.89	**1.63**
N_3	1.68	1.54	**1.61**	43.57	44.30	**43.93**	1.46	2.04	**1.75**
N_4	1.77	1.64	**1.70**	46.26	45.55	**45.90**	1.62	2.23	**1.93**
N_5	1.76	1.68	**1.72**	44.56	42.66	**43.61**	1.56	2.16	**1.86**
N_6	1.80	1.77	**1.77**	47.34	46.32	**47.14**	1.72	2.42	**2.07**
N_7	1.60	1.75	**1.71**	48.00	45.55	**46.44**	1.57	2.41	**1.99**
N_8	1.92	1.81	**1.86**	49.24	46.24	**47.88**	1.90	2.51	**2.20**
Mean	**1.70**	**1.63**	**1.67**	**45.76**	**44.21**	**44.98**	**1.56**	**2.17**	**1.86**
	B	**N**	**B×N**	**B**	**N**	**B×N**	**B**	**N**	**B×N**
SE(d)	**0.012**	**0.024**	**0.034**	**0.268**	**0.536**	**0.758**	**0.014**	**0.028**	**0.040**
CD@0.05	**0.025**	**0.050**	**0.070**	**0.547**	**1.095**	**1.549**	**0.029**	**0.058**	**0.082**

flowering parameters, relived the plant from chlorosis and produced healthy green leaves which resulted in higher assimilate synthesis and partitioning of flower growth which may in turn have increased the flower production and ultimately yield. Similar results were also reported by Balakrishnan et al., [21] in marigold and Ganga et al., [22] in chrysanthemum and lower value of yield parameter were observed in the N_1[control (RDF) 200:200:200 NPK] single floret yield (1.45 g), weight of floret per plant (41.80 g) and flower yield per plot (1.50 kg) [23].

3.3.3 Interaction effect

The interaction effects between planting materials and nutrient combination showed highly significant influence on yield parameters. The treatment combination of B_2N_8 recorded highest flower yield per plot (2.51 kg) followed by B_1N_8 (1.90 kg). From the interaction effect, the treatment combination B_1N_1 recorded lesser flower yield per plot (1.28 kg). The treatment combination B_1N_8 recorded the highest single floret weight (1.92 g), weight of floret per plant (49.24 g) followed by $B_2N_8$with single floret weight (1.81 g) and weight of floret per plant (46.24 g). Among the interaction effect, the treatment combination B_2N_1 recorded lowest single floret weight (1.41g), weight of floret per plant (40.80 g) [24,25].

Bulblets are small in size with a slow growth process closer planting was done which accommodated more plants per unit area. Closer planting resulted in more plant population in the current study, but there was insufficient space for trapping solar energy for various metabolic activities Banu *et al.,* [14]. While the closer spacing resulted in significantly higher flower yield/plot and yield per hectare. This could be due to a higher number of plants per unit area. This was in accordance with the findings of Singh *et al.,* (2018). The foliar application of zinc sulphate and borax resulted in increased flower weight and yield from the findings of Karuppaiah [26] in tuberose. Cost of bulb is higher compared to the bulblets, where the multiplication rate of bulblets is higher (1:8) compared to the conventional method of propagation through bulbs (1:1) Balan *et al.,* [6].

4. CONCLUSION

From the above results, it is observed that when tuberose cultivation is commercially propagated through bulbs, the cost of bulbs is higher around Rs. 1,12,000 per acre. When tuberose is propagated through bulblets, the multiplication rate of bulblets is higher (1:8) compared to the conventional method of propagation through bulbs (1:1). The results showed that the performance of bulblets which raised in protray nursery for 45 days before transplanting in the main field are almost similar to the normal bulbs in yield and growth parameters with the cost benefit ratio of bulblets which is higher than cultivation by bulbs. Thus, we can reduce the cost of bulbs required for planting by 50 percent and thereby reduce the cost of production and dependence on costly mother bulbs.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/106365