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Integrated nutrient management using natural farming inputs for improved growth and flowering of tuberose (*Agave amica*)

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Abstract

Tuberose (*Agave amica*) belonging to the family Asparagaceae is indigenous to Mexico and widely cultivated in tropical and subtropical regions for cut and loose flowers as well as for essential oil extraction. Being a heavy nutrition demanding perennial crop, its growth, flowering and bulb development are strongly influenced by soil fertility and nutrient management. Thus, a field trial was performed at Model Floriculture Center, G.B. Pant University of Agriculture and Technology, over a period of two years (2023-2025) to evaluate the effect of various integrated nutrient management treatments including *Beejamrit*, *Ghanjeevamrit*, Herbal *Kunapajala*, *Jeevamrit* and RDF on the vegetative, floral and bulb attributes of tuberose. The experiment comprised seven treatments laid out in a randomized block design (RBD) with three replications. It was reported that, based on the pooled mean data over two years, T₆ (*Beejamrit* + *Ghanjeevamrit* + 50% RDF + 50% herbal *Kunapjal*) was the most effective treatment for most of the vegetative growth attributes and resulted in maximum plant height, increased leaf length, higher number of leaves and wider leaves. On the other hand, the application of 100% RDF (T₁) produced the maximum loose flower yield per plant as well as per hectare, followed by the treatments comprising *Beejamrit* + *Ghanjeevamrit* + 50% RDF + 50% herbal *Kunapjal* (T₆) and *Beejamrit* + *Ghanjeevamrit* + 50% RDF + 50% *Jeevamrit*. Conversely, T₁ (100% RDF) recorded the highest bulb clump weight and the largest bulb diameter. In contrast, treatments relying solely on organic inputs resulted in comparatively reduced vegetative growth and lower loose flower yield and reduced bulb clump weight.

Keywords: *Beejamrit*, *Ghanjeevamrit*, herbal *Kunapajala*, *Jeevamrit*, tuberose, pearl double

Introduction

Tuberose, botanically known as *Agave amica* belongs to family Asparagaceae is among one of the most highly valued ornamental flower crops for its intoxicating intense fragrance and majestic flower spikes. Originating from Mexico, the spikes of tuberose has crossed various continents and has become an integral part of tropical and sub-tropical floricultural industry, particularly for cut flowers, loose flowers and essential oil extraction (Castañeda-Saucedo *et al.*, 2023) ^[1]

In recent decades, Integrated Nutrient Management (INM) is recognized as a key strategy for achieving sustainable crop production by combining chemical fertilizers with organic manures and biological consortia (Rajaselvam *et al.*, 2024) ^[5]. Exclusive dependence on chemical fertilizers often leads to nutrient imbalances, decline in soil organic carbon and deterioration of soil physico-chemical and biological properties. In contrast, integration of organic nutrient sources such as farmyard manure, compost, vermicompost and green manures with mineral fertilizers improves nutrient use efficiency by ensuring synchronized nutrient release in accordance with crop demand (Kamboj *et al.*, 2024) ^[4].

Organic amendments such as farmyard manure, composts and green manures play a critical role in improving soil structure, enhancing microbial activity and sustaining nutrient reserves in the long term (Xu *et al.*, 2025) ^[10]. These inputs not only support plant growth but also rejuvenate soil health by improving water retention, nutrient buffering capacity and resistance to biotic and abiotic stresses (Sudhagar *et al.*, 2020) ^[7]. Thus, INM contributes to stable crop productivity while conserving soil fertility and maintaining ecological harmony.

Tuberose typically has a growth cycle lasting for at least two year or longer. As a result, substantial inputs of both organic and inorganic fertilizers are required to support continuous growth and sustained flowering throughout this extended period (Verma *et al.*, 2025) ^[9]. In view of the significance of integrated nutrient management (INM), the current study was carried out in tuberose with the aim of evaluating different INM combinations that includes the recommended dosage of inorganic fertilizers in conjunction with natural farming inputs such as *Beejamrit*, *Ghanjeevamrit*, *Jeevamrit* and herbal *Kunapjal* for determining the most effective nutrient management techniques for enhancing growth, flowering performance and yield attributes.

Materials and Methods

The present study entitled “Integrated Nutrient Management using Natural Farming Inputs for Enhanced Growth, Flowering and Bulb Yield of Tuberose (*Agave amica*) cv. Pearl Double” was conducted at the Model Floriculture Center, G.B. Pant University of Agriculture and Technology, over a period of two years (2023-2025). The experiment aimed to evaluate the influence of integrated nutrient management (INM) practices involving natural farming inputs in combination with recommended doses of fertilizers (RDF) on the growth, flowering and bulb production of tuberose.

Planting was carried out in the month of April at a spacing of 25 × 25 cm. The experiment comprised seven treatments laid out in a randomized block design (RBD) with three

replications. The treatments included: T₁-100% RDF, T₂-*Beejamrit* + *Ghanjeevamrit*, T₃-*Beejamrit* + *Ghanjeevamrit* + 100% herbal *Kunapjal*, T₄-*Beejamrit* + *Ghanjeevamrit* + 100% *Jeevamrit*, T₅-*Beejamrit* + *Ghanjeevamrit* + 50% RDF, T₆-*Beejamrit* + *Ghanjeevamrit* + 50% RDF + 50% herbal *Kunapjal*, T₇-*Beejamrit* + *Ghanjeevamrit* + 50% RDF + 50% *Jeevamrit*.

Uniform, healthy bulbs with a diameter ranging from 2.5-3.5 cm were selected for planting and treated with *Beejamrit* for two hours under shaded conditions prior to sowing. The recommended dose of fertilizers (150:150:150 kg ha⁻¹ N:P₂O₅:K₂O) was supplied through urea, diammonium phosphate (DAP) and muriate of potash (MOP) as sources of nitrogen, phosphorus, and potassium, respectively. Urea was applied in split doses, with half of the nitrogen applied at the time of planting and the remaining half applied in two equal top dressings at subsequent growth stages. DAP and MOP was applied entirely as basal doses at the time of planting. *Ghan Jeevamruth* was incorporated into the soil as a basal application at the rate of 5 t ha⁻¹. Herbal *Kunapajal* and *Jeevamrit* were applied at 500 L acre⁻¹ at 30 day of intervals through both soil drenching and foliar spray.

The preparation methodologies commonly used for natural farming formulations differ in terms of ingredient composition, water requirement and fermentation period. The quantities of raw materials and the duration required for preparation of *Ghanjeevamrit*, *Beejamrit*, Herbal *Kunapjal* and *Jeevamrit* are summarized in table no. 1.

Table 1: Ingredients and preparation duration of *Ghanjeevamrit*, *Beejamrit*, Herbal *Kunapjal* and *Jeevamrit*

S. No.	Sources	<i>Ghanjeevamrit</i>	<i>Beejamrit</i>	Herbal <i>Kunapjal</i>	<i>Jeevamrit</i>
1.	Water (l)	-	20	200	200
2.	Cow dung (kg)	100	5	15-20	15-20
3.	Cow urine (l)	10-15	5	15-20	15-20
4.	Gram flour (kg)	2	-	-	2
5.	Jaggery (kg)	2	-	2	2
6.	Lime (g)	-	50	-	-
7.	Sprouted black gram (kg)	-	-	2	-
8.	Broad leaf weeds (kg)	-	-	20	-
9.	Milk/Butter milk (l)	-	-	2 l	-
10.	Mustard oil cake (kg)	-	-	2	-
11.	Paddy straw extract after boiling (l)	-	-	5	-
12.	Preparation duration (days)	21-25	1	21-25	3

Results and Discussion

Effect of integrated nutrient management on vegetative characteristics of tuberose

The vegetative attributes of tuberose, as measured by plant height, length of the longest leaf, number of leaves per plant and leaf width, was significantly impacted by different nutrient treatments during both years of trial as well as in pooled analysis and showcased in table no. 2.

Plant height was significantly influenced by different nutrient management treatments during both years as well as in pooled analysis. During the first year, maximum plant height was recorded in T₁ (17.91 cm), which was statistically at par with T₆ (17.32 cm) and T₇ (16.68 cm). The minimum plant height was observed in T₂ (14.22 cm). Whereas, in second year T₆ (19.97 cm) recorded the maximum plant height, followed by T₇ (19.48 cm) and T₁ (19.16 cm). The lowest value again occurred in T₂ (15.43 cm). As per pooled mean, T₆ (*Beejamrit* + *Ghanjeevamrit* + 50% RDF + 50% herbal *Kunapjal*) recorded the highest plant height (18.64 cm), which was statistically at par with

T₁ (18.53 cm) and T₇ (18.08 cm). The lowest pooled plant height was observed in T₂ (14.83 cm).

Similarly, during the first year, T₁ recorded the maximum leaf length (19.32 cm), which was statistically comparable with T₆ (18.53 cm). T₂ recorded the minimum value (15.67 cm). In the second year, T₆ produced the longest leaves (23.87 cm), followed by T₇ (23.21 cm) and T₁ (23.04 cm). The lowest leaf length was again noted in T₂ (20.74 cm). The pooled mean revealed that T₆ registered the highest longest leaf length (21.20 cm), closely followed by T₁ (21.18 cm) and T₇ (20.52 cm). The minimum pooled value was recorded in T₂ (18.21 cm). Improved nutrient availability, particularly nitrogen, which is essential for cell division, elongation, and general vegetative growth, may be the cause of the increase in plant height under RDF and integrated treatments (Tomar *et al.*, 2024) ^[8]. Organic matter releases nutrients slowly and could fail to meet nutrient demands at critical periods. While synthetic fertilizers can supply nutrients immediately, the application of organic substances will release nutrients gradually through

decomposition by microorganisms. This may not happen at the time when the crops need the nutrients most. Moreover, the supply of nutrients from the use of organic substances may not be adequate for the growth of plants without further addition of fertilizers (Gandham *et al.*, 2025) [3].

On the other hand, the number of leaves varied significantly among treatments. In the first year, the maximum number of leaves was recorded in T₆ and T₇ (6.33), while T₂ recorded the minimum (3.67). During the second year, T₆ recorded the highest number of leaves (10.89), followed by T₇ (10.54) and T₁ (10.28). The lowest value was observed in T₂ (7.89). The pooled mean indicated that T₆ recorded the highest number of leaves (8.61), which was statistically at par with T₇ (8.44). The lowest pooled mean was observed in T₂ (5.78).

During the first year, maximum leaf width was recorded in T₆ (1.25 cm), which was statistically superior to all other treatments. T₁, T₃ and T₇ recorded identical values of 1.17 cm, whereas the minimum leaf width was observed in T₂ (1.11 cm). In the second year, the highest leaf width was observed in T₇ (1.18 cm), followed by T₆ (1.14 cm) and T₁ (1.13 cm). The lowest leaf width was recorded in T₄ (1.04 cm). The pooled mean analysis revealed that T₆ recorded the maximum leaf width (1.19 cm), followed by T₇ (1.17 cm) and T₁ (1.15 cm). The minimum pooled leaf width was observed in T₂ and T₄ (1.09 cm).

The increased number of leaves and the wider leaves depicted by treatments involving integrated nutrient management can be related to the cumulative effects of organic and inorganic sources of nutrients. While organic and natural sources of nutrients are known to increase the physical properties of soil, increase microbial activities and hence promote mineralization. Whereas, inorganic sources of nutrition is immediately available to the plant throughout critical growth periods, ensuring availability of nutrition to the plant. Thus, when these sources of plant nutrients work together, there is an appreciable increase in the efficiency of plant nutrient use, ensuring optimal release of plant nutrients during critical periods of plant growth (Rao *et al.*, 2025) [6]. Increased availability of plant nutrients, especially nitrogen, leads to strong plant growth due to increased division and growth of plant cells, eventually ensuring an increase in the number of leaves developed by the plant and wider leaves as well (Zhang *et al.*, 2025) [11].

Effect of integrated nutrient management on loose flower yield and bulb characters of tuberose

The data pertaining to days to 1st floret opening, loose flower yield per plant and loose flower yield per hectare as influenced by integrated nutrient management presented in table no. 3 and the data pertaining to weight of bulb clump, diameter of the largest bulb, length of largest bulb and length of the largest bulblet presented in table no. 4.

According to the reported data, the number of days required for first floret opening in tuberose did not differ significantly among treatments during the first year, whereas significant variation was observed in the second year. In the first year, first floret opening occurred between 24.33 and 27.11 days, while in the second year it ranged from 24.00 to 25.77 days. During the second year, T₄ (*Beejamrit + Ghanjeevamrit + 100% Jeevamrit*) recorded the earliest first floret opening, indicating its positive influence on early

flowering. However, based on pooled mean data, T₁ depicted the minimum number of days for first floret opening.

In case of loose flower yield, the data revealed significant difference among different nutrient management treatments during both years of trial. In the first year, the highest loose flower yield per plant was recorded under T₁ (100% RDF) with 75.10 g, which remained statistically superior among all the treatments. A similar trend was observed during the second year, where T₁ again produced the maximum yield (74.43 g). Consequently, the pooled mean also showed the highest yield under T₁ (74.76 g).

Among integrated nutrient management treatments, T₆ (*Beejamrit + Ghanjeevamrit + 50% RDF + 50% herbal Kunapjal*) recorded comparatively higher loose flower yield per plant (65.10 g), followed closely by T₇ (*Beejamrit + Ghanjeevamrit + 50% RDF + 50% Jeevamrit*) with 64.47 g and T₅ (*Beejamrit + Ghanjeevamrit + 50% RDF*) with 61.99 g. The lowest pooled mean yield per plant was observed under T₂ (*Beejamrit + Ghanjeevamrit*). A similar pattern was seen when the yield was stated per hectare. T₁ produced the highest pooled yield (9.35 lakh flowers ha⁻¹) while T₂ recorded the lowest (4.24 lakh flowers ha⁻¹). A sufficient supply of potassium, phosphorus and nitrogen by RDF increases biomass buildup and metabolic activity, which stimulates flower production. Although natural and organic inputs like *Ghanjeevamrit*, *Jeevamrit*, *beejamrit*, etc. support microbial activity and soil health, however, their nutrient release may not be sufficient, resulting in a lesser yields (Darjee *et al.*, 2024) [12].

In context of bulb data, the overall bulb clump weight varied significantly among treatments, with T₁ recording the maximum pooled weight (339.08 g), followed by T₆ (306.01 g) and T₂ (300.35 g). T₂ showed the lowest bulb clump weight (242.09 g). Similarly, the largest pooled bulb diameter was recorded with T₁ (34.65 mm), whereas T₂ reported the smallest pooled diameter (31.62 mm). Whereas the data pertaining to length of largest bulb and bulblets, no significant differences were observed during the first year of experimentation, while it showed significant variations among second year and pooled mean.

The pooled mean data of the length of the largest bulb demonstrated that the treatment involving *Beejamrit + Ghanjeevamrit + 50% RDF* combined with 50% herbal *Kunapjal* (T₆) resulted in the longest bulb length (6.50 cm) and was statistically superior to most of the other treatments. With respect to the length of the largest bulblet, based on pooled mean analysis, T₃ (*Beejamrit + Ghanjeevamrit + 100% herbal Kunapjal*) recorded the highest bulblet length (5.03 cm), followed by 100% RDF (T₁) and *Beejamrit + Ghanjeevamrit + 100% Jeevamrit* (T₄). In contrast, the minimum pooled mean bulblet length (4.35 cm) was observed under T₆.

These findings suggest that the improved bulblet development observed under integrated and inorganic nutrient management practices is largely due to enhanced and sustained nutrient availability. The adequate supply of essential nutrients supports higher biomass production and facilitates efficient translocation and partitioning of assimilates towards subterranean storage organs, ultimately resulting in better bulblet formation and development (Verma *et al.*, 2025) [9].

Table 2: Effect of integrated nutrient management on vegetative growth parameters of tuberose over two consecutive years

Treatment	Plant height (cm)			Longest leaf (cm)			No. of leaves			Leaf width (cm)		
	1 st Year	2 nd Year	Pooled Mean	1 st Year	2 nd Year	Pooled Mean	1 st Year	2 nd Year	Pooled Mean	1 st Year	2 nd Year	Pooled Mean
T ₁ -100% RDF	17.91	19.16	18.53	19.32	23.04	21.183	5.00	10.28	7.64	1.17	1.13	1.15
T ₂ -Beejamrit + Ghanjeevamrit	14.22	15.43	14.83	15.67	20.74	18.206	3.67	7.89	5.78	1.11	1.12	1.09
T ₃ -Beejamrit + Ghanjeevamrit + 100% herbal Kunapjal	15.51	16.81	16.16	16.53	21.34	18.939	4.33	9.56	6.94	1.17	1.10	1.13
T ₄ -Beejamrit + Ghanjeevamrit + 100% Jeevamrit	15.08	16.48	15.78	16.28	20.91	18.594	4.00	9.33	6.67	1.15	1.04	1.09
T ₅ -Beejamrit + Ghanjeevamrit + 50% RDF	15.97	18.16	17.06	17.11	22.22	19.667	4.67	9.67	7.17	1.12	1.08	1.10
T ₆ -Beejamrit + Ghanjeevamrit + 50% RDF + 50% herbal Kunapjal	17.32	19.97	18.64	18.53	23.87	21.203	6.33	10.89	8.61	1.25	1.14	1.19
T ₇ -Beejamrit + Ghanjeevamrit + 50% RDF + 50% Jeevamrit	16.68	19.48	18.08	17.82	23.21	20.518	6.33	10.54	8.44	1.17	1.18	1.17
C.D. at 5%	0.657	0.765	0.686	0.959	0.928	0.629	0.389	0.623	0.230	0.069	N/A	0.040
SE(m)	0.211	0.246	0.220	0.308	0.298	0.202	0.125	0.200	0.074	0.022	0.032	0.013

Table 3: Effect of integrated nutrient management on floral parameters of tuberose over two consecutive years

Treatment	Days to 1st floret opening (days)			Loose flower yield/plant (g)			Loose flower yield/ha (100 kg)		
	1 st Year	2 nd Year	Pooled Mean	1 st Year	2 nd Year	Pooled Mean	1 st Year	2 nd Year	Pooled Mean
T ₁ -100% RDF	24.33	24.11	24.22	75.10	74.43	74.76	8.67	10.02	9.35
T ₂ -Beejamrit + Ghanjeevamrit	26.00	25.00	25.50	42.11	52.56	47.34	3.80	4.68	4.24
T ₃ -Beejamrit + Ghanjeevamrit + 100% herbal Kunapjal	24.67	24.23	24.44	49.63	53.27	51.45	5.06	6.20	5.63
T ₄ -Beejamrit + Ghanjeevamrit + 100% Jeevamrit	25.67	24.00	24.83	47.60	60.28	53.94	4.56	5.57	5.06
T ₅ -Beejamrit + Ghanjeevamrit + 50% RDF	26.56	24.67	25.61	57.32	66.66	61.99	4.89	7.28	6.09
Beejamrit + Ghanjeevamrit + 50% RDF + 50% herbal Kunapjal	27.11	25.23	26.17	62.41	67.80	65.10	5.91	7.20	6.56
Beejamrit + Ghanjeevamrit + 50% RDF + 50% Jeevamrit	26.78	25.77	26.28	60.75	68.19	64.47	5.96	7.18	6.57
C.D. at 5%	N/A	0.928	1.108	2.194	3.174	2.933	0.258	0.278	0.316
SE(m)	1.006	0.298	0.356	0.704	1.019	0.941	0.083	0.089	0.101

Table 4: Effect of integrated nutrient management on bulb and bulblet parameters of tuberose over two consecutive years

Treatment	Weight of bulb clump (g)			Diameter of largest bulb (mm)			Length of largest bulb (cm)			Length of largest bulblet (cm)		
	1 st Year	2 nd Year	Pooled Mean	1 st Year	2 nd Year	Pooled Mean	1 st Year	2 nd Year	Pooled Mean	1 st Year	2 nd Year	Pooled Mean
T ₁ -100% RDF	295.33	382.83	339.08	35.80	33.50	34.65	5.70	6.03	5.87	4.43	5.53	4.98
T ₂ -Beejamrit + Ghanjeevamrit	228.83	255.34	242.09	30.84	32.39	31.62	6.13	6.47	6.30	4.43	4.53	4.48
T ₃ -Beejamrit + Ghanjeevamrit + 100% herbal Kunapjal	249.40	286.47	267.93	34.26	31.30	32.78	6.03	5.90	5.97	4.93	5.13	5.03
T ₄ -Beejamrit + Ghanjeevamrit + 100% Jeevamrit	243.87	283.64	263.75	31.27	31.71	31.50	5.67	6.13	5.90	4.77	5.07	4.92
T ₅ -Beejamrit + Ghanjeevamrit + 50% RDF	273.87	326.83	300.35	31.14	32.26	31.70	6.17	5.93	6.05	4.33	4.97	4.65
Beejamrit + Ghanjeevamrit + 50% RDF + 50% herbal Kunapjal	283.33	328.69	306.01	31.50	31.83	31.66	6.20	6.80	6.50	3.90	4.80	4.35
Beejamrit + Ghanjeevamrit + 50% RDF + 50% Jeevamrit	278.83	318.90	298.87	32.27	30.27	31.27	6.03	6.23	6.13	4.37	4.83	4.60
C.D. at 5%	10.994	12.673	14.448	N/A	1.279	1.725	N/A	0.243	0.193	N/A	N/A	0.210
SE(m)	3.529	4.068	4.638	2.121	0.411	0.554	0.630	0.078	0.062	0.630	0.469	0.067

Conclusion

The study clearly demonstrated that vegetative growth of tuberose was significantly influenced by different nutrient management practices. For majority of vegetative growth parameters over two years in pooled mean, the integrated application of Beejamrit + Ghanjeevamrit + 50% RDF + 50% herbal Kunapjal proved most effective, resulting in superior plant height, leaf length, number of leaves, and leaf width. In contrast, the sole use of Ghanjeevamrit depicted lower vegetative growth. Whereas, the application of 100% RDF resulted in the highest loose flower yield per plant and per hectare, indicating the effectiveness of readily available nutrients in enhancing flower production followed by T₆ (Beejamrit + Ghanjeevamrit + 50% RDF + 50% herbal Kunapjal) and T₇ (Beejamrit + Ghanjeevamrit + 50% RDF + 50% Jeevamrit). Furthermore, the application of 100% RDF resulted in the highest bulb clump weight and largest

bulb diameter, indicating the role of readily available nutrients in enhancing bulb development. While, the sole application of organic inputs resulted in low yield with respect to loose flower yield and weight of bulb clump.

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