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Studies on the effect of planting date, mulch and fertigation on growth and yield of Tuberose (*Agave amica* L.)

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Abstract

An Experiment entitled “Studies on the effect of planting date, mulch and fertigation on growth and yield of Tuberose (*Agave amica* L.)” was conducted during two consecutive years 2022-23 and 2023-24 at PFDC, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Krishak Nagar Raipur (C.G.). The study was conducted in split-split plot design with three replication having 24 treatment combinations of three planting date (30th may, 30th June and 30th July) as factor A, two levels of mulch (Silver on black plastic mulch with wastage leaves and Silver on black plastic mulch without wastage leaves) as factor B along with 4 level of fertigation (60, 75, 90 and 100% RDF) as factor C.

The results of investigation indicate that the growth and yield characters were significantly influenced by various treatments of planting date, mulch and fertigation level. The 30th June planting, Silver on Black plastic mulch with wastage leaves and 90 % RDF had progressive influence in the Growth and Yield characters such as days taken for sprouting of bulb (days), percentage of sprouting (%), plant height (cm) at 60 and 90 DAP, number of floret per spike, number of spike per plant, flower yield per plot.

Keywords: Tuberose, planting date, mulch, fertigation, growth, yield

Introduction

Floriculture is a rapidly expanding global agribusiness, offering higher economic returns per unit area than field crops. Tuberose (*Agave amica*; Family Asparagaceae), commonly known as Rajnigandha, is an important traditional ornamental crop valued for its fragrant white spikes, long vase life and suitability as both loose and cut flowers. Chadha K. L., 1995 [3]. Native to Mexico, tuberose is a half-hardy, bulbous perennial propagated through bulblets, producing waxy white flowers borne on long spikes. Its flowers are widely used in religious and social ceremonies and are also a source of high-value essential oils utilized in the pharmaceutical and cosmetic industries. Commercial cultivation of tuberose has expanded in India due to increasing demand for ornamental flowers. However, its growth, flowering and yield are highly influenced by climatic conditions and crop management practices. Among these, planting date, mulching and fertigation play a critical role in regulating vegetative growth and yield. Optimum planting time ensures favourable environmental conditions during key developmental stages, while mulching conserves soil moisture, moderates temperature and improves the crop microclimate. Fertigation through drip irrigation enhances nutrient use efficiency, reduces losses and sustains plant vigour. The interaction among planting date, mulching and fertigation is crucial for maximizing productivity and flower quality. Despite their importance, region-specific information on the optimal combination of these practices for tuberose under Chhattisgarh agro-climatic conditions is limited. Therefore, standardization of planting time, mulching and fertigation is essential to improve flower yield in the region.

Materials and Methods

The field experiment was conducted at the PFDC (Precision Farming Development Centre), Raipur, under the College of Agriculture, IGKV, during the years 2023-24 and 2024-25.

The study followed a split-split plot design with three replications, comprising 24 treatment combinations. These included three planting dates (30th May, 30th June, and 30th July), two mulch treatments (silver-on-black plastic mulch with waste leaves and silver-on-black plastic mulch without waste leaves), and four fertigation levels (60%, 75%, 90%, and 100% of the recommended dose of fertilizers). In this design, planting dates were assigned to the main plots, mulch treatments to the sub-plots, and fertigation levels to the sub-sub plots. The experimental site at Raipur falls under a dry sub-humid agro-climatic zone and is geographically located at 21.25° N latitude and 81.03° E longitude, with an elevation of 298 meters above mean sea level.

Results and Discussion

Days taken for sprouting of bulb (days)

Among the different planting dates, minimum days taken for sprouting of bulb was recorded during 2023-24, 2024-25 and on mean basis, respectively on 30th July planting (D₃). However, maximum days taken for to sprouting of bulb were observed on 30th May planting (D₁). As regards the effect of mulching, minimum days taken for sprouting of bulb was recorded the use of Silver on Black plastic mulch with wastage leaves (M₁) whereas, more time for sprouting of bulb was observed in Silver on Black plastic mulch without wastage leaves. As respect to the fertigation treatments, Minimum Days taken for sprouting of bulb was found with the application of 90% RDF *via* Fertigation (F₃) followed by fertigation with 100% RDF (F₄). The maximum days taken for spike emergence were found in fertigation with 60 % RDF (F₁). The interaction effect between planting dates and mulching levels on days taken to sprouting of bulb was found significant during both the years. Tuberose planted on 30th July coupled with Silver on Black plastic mulch with wastage leaves (D₃×M₁) registered significantly minimum followed by (D₂×M₁) 30th June planting and Silver on Black plastic mulch with wastage leaves with the value and the maximum days taken to sprouting of bulb combination between 30th May coupled with Silver on Black plastic mulch with wastage leaves (D₁×M₁) as shown in Table no. 1.

Sprouting in tuberose is strongly influenced by planting time, mulching practices and fertigation levels, as these factors regulate soil temperature, moisture availability and nutrient dynamics during the initial growth phase. In the present study, earlier sprouting observed in 30th July planting can be attributed to favorable monsoon conditions, whereas delayed sprouting in May planting was likely due to higher temperature and moisture stress. These findings are supported by Padaganur *et al.* (2005) [16], Khobragade *et al.* (1997) [11], Ranjan & Misra (2002) [21] and Singh *et al.* (2019) [14], who reported improved sprouting under June-July plantings. Mulching with silver on black plastic along with organic leaves (M₁) further enhanced sprouting by conserving soil moisture, moderating temperature and improving soil microbial activity (Patra *et al.*, 2018; Singh *et al.*, 2020) [18, 28]. Additionally, slightly earlier sprouting under higher fertigation level (F₃) may be due to better availability of essential nutrients, particularly nitrogen and phosphorus, which enhance metabolic activity, enzyme activation and growth regulator synthesis, thereby promoting faster sprout initiation (Taiz and Zeiger, 2010; Salisbury and Ross, 1992; Halevy and Mayak, 1981) [30, 24, 8].

Percentage of sprouting (%)

The planting dates, mulching and fertigation levels did not significantly influence the sprouting percentage of tuberose bulbs, as cent percent sprouting (100%) was recorded across all treatments. This uniform sprouting may be attributed to the physiological maturity and viability of the bulbs, which possessed sufficient stored carbohydrates and moisture to initiate growth under all conditions. Moreover, the prevailing soil temperature (25-35 °C) and adequate soil moisture maintained through fertigation provided a favorable microenvironment for uniform bulb sprouting. Mulching mainly influenced soil hydrothermal properties after emergence hence had negligible effect on initial sprouting response. Similar observations were reported by Singh *et al.* (2019) [14] and Kumar *et al.* (2021) [12] in tuberose under different agro-climatic conditions. The Silver on Black polythene mulch with organic residues in improving sprouting percentage corroborates the findings of Patra *et al.* (2018) [18] in gladiolus and Singh *et al.* (2020) [28] in tuberose. Bulbs with higher internal reserves and better physiological vigour exhibit faster and more uniform sprouting irrespective of nutrient supplementation at planting (Gantait & Paul, 2022) [7].

Plant height (cm) at 60 and 90 DAP

The tallest plant height at 60 DAP was observed during 2023-24, 2024-25 and on mean basis, respectively on 30th June planting (D₂). However, minimum plant height was observed on 30th July planting (D₃). As regard the effect of mulch treatments, the highest plant height at 60 DAP had resulted with the use of Silver on Black plastic mulch with wastage leaves (M₁) than Silver on Black plastic mulch without wastage leaves. In case of fertigation, the maximum plant height at 60 DAP was recorded with the application of 90% RDF *via* Fertigation (F₃) followed by fertigation with 100% RDF (F₄). The lowest plant height at 60 DAP was found in fertigation with 60 % RDF (F₁) during the experiment year 2023-24, 2024-25 and on mean basis, respectively as shown in Table no. 2.

The significantly maximum plant height at 90 DAP was observed during 2023-24, 2024-25 and on mean basis, respectively on 30th June planting (D₂) followed by 30th May planting. However, minimum plant height at 90 DAP was observed on 30th July planting (D₃). As regard the effect of mulch treatments, the highest plant height had resulted with the use of Silver on Black plastic mulch with wastage leaves (M₁) than Silver on Black plastic mulch without wastage leaves. In case of fertigation, the maximum plant height at 90 DAP was recorded with the application of 90% RDF *via* Fertigation (F₃) followed by fertigation with 100% RDF (F₄). The lowest plant height at 90 DAP was found in fertigation with 60 % RDF (F₁) as shown in Table no. 3.

The tuberose bulbs planted on 30 June (D₂) recorded maximum plant height across both years, likely due to favorable climatic conditions such as moderate rainfall, temperature, and humidity that enhanced establishment and nutrient uptake. In contrast, 30 July planting (D₃) showed minimum plant height, possibly due to excessive rainfall, waterlogging, and reduced light intensity. These results align with findings of Reddy *et al.* (2016) [22, 23], Singh *et al.* (2019) [14], and others, emphasizing the importance of optimum planting time. Among mulching treatments, silver on black polythene mulch with waste leaves (M₁) produced

greater plant height than without waste leaves (M_2), likely due to better moisture conservation, temperature regulation, and soil aeration. Similar results were reported by Kumari *et al.* (2019) [14] and Singh *et al.* (2020) [28]. Fertigation at 90% RDF (F_3) resulted in maximum plant height, followed by 100% RDF (F_4), indicating higher nutrient use efficiency at 90% RDF. Lower levels (F_1 and F_2) reduced growth due to insufficient nutrients, as also reported by Chopde *et al.* (2012) [4] and Kadam *et al.* (2018) [9].

Number of floret per spike

The Number of floret per spike affected by planting date treatments, 30th June planting found significantly maximum number of floret per spike whereas, the minimum number of floret per spike in July planting D_3 . Among the mulch treatments, maximum number of floret per spike resulted with the use of Silver on Black plastic mulch with wastage leaves (M_1) as compared to Silver on Black plastic mulch without wastage leaves. Within fertigation treatment, significantly maximum number of floret per spike was recorded with the application of 90% RDF *via*. Fertigation (F_3) followed by fertigation with 100% RDF (F_4). The minimum number of floret per spike was found in fertigation with 60 % RDF (F_1) during the experiment year 2023-24, 2024-25 and on mean basis, respectively. as shown in Table no. 4.

June planting proved superior due to optimum temperature, light intensity and photoperiod, which enhanced photosynthesis, assimilate production and their effective partitioning towards reproductive organs. Adequate assimilate availability during spike development promoted floret differentiation and reduced floret abortion, resulting in a higher number of florets per spike. Similar findings were reported by Khobragade *et al.* (1997) [11] and Verma *et al.* (2021) [21] in tuberose, and Sankari & Kumar (2018) [25] in gladiolus. The better performance under M_1 mulch was attributed to improved soil moisture retention, moderated soil temperature and nutrient enrichment through decomposition of organic matter. These conditions enhanced root activity and nutrient uptake, supporting higher photosynthate production and floret initiation while reducing floret drop. Comparable results were reported by Meena *et al.* (2020) [15] in gladiolus and Panse *et al.* (2019) [17] in tuberose. Moderate fertigation levels enhanced floret number by ensuring balanced nutrient supply, particularly nitrogen and potassium, which improved chlorophyll content, assimilate translocation and floret differentiation. In contrast, lower nutrient levels (60% RDF) limited these processes, resulting in fewer florets. Similar observations were made by Chowdhury *et al.* (2019) [5] in tuberose and Kumar *et al.* (2020) [15] in gladiolus.

Number of spike per plant

The Number of spike per plant affected by planting date treatments, 30th June planting found significantly maximum number of spike per plant followed by treatment D_1 , whereas, the minimum number of spike per plant in July planting D_3 . Among the mulch treatments, maximum Number of spike per plant had resulted with the use of Silver on Black plastic mulch with wastage leaves (M_1) as

compared to Silver on Black plastic mulch without wastage leaves. Within fertigation treatment, significantly maximum number of spike per plant was recorded with the application of 90% RDF *via*. Fertigation (F_3) followed by fertigation with 100% RDF (F_4). The minimum number of spike per plant spike length was found in fertigation with 60 % RDF (F_1) during the experiment year 2023-24, 2024-25 and on mean basis, respectively. as shown in Table no. 5.

June planting favored optimum temperature (25-30 °C) and photoperiod, enhancing growth, assimilate accumulation and spike initiation, resulting in more spikes per plant (Kaur *et al.* 2018) [10]. Silver on black plastic mulch with waste leaves improved soil moisture, aeration and nutrient availability, thereby enhancing root activity and promoting spike initiation (Barman *et al.*, 2017; Singh *et al.*, 2019) [5, 14]. Fertigation at 90% RDF ensured efficient nutrient supply, improved photosynthesis and assimilate translocation, leading to better bud initiation and higher spike production per plant (Rani *et al.* 2019) [20].

Flower Yield per plot

The influence of planting date, mulch, fertigation in tuberose was found significant flower yield 2023-24, 202-25 and on mean basis. 30th June (D_1) recorded maximum flower yield However, minimum flower yield was observed on 30th July planting (D_3). As regard the effect of mulch treatments, the highest Flower Yield had resulted with the use of Silver on Black plastic mulch with wastage leaves (M_1) than Silver on Black plastic mulch without wastage leaves. As appraisal of data indicate that there was a significant influence in the fertigation treatment, the maximum Flower Yield was recorded with the application of 90% RDF *via*. Fertigation (F_3) followed by fertigation with 100% RDF (F_4). The minimum Flower Yield was found in fertigation with 60 % RDF (F_1). as shown in Table no. 6.

The study concluded that planting date, mulching and fertigation significantly influenced flower yield of tuberose. Among planting dates, 30th June (D_2) recorded the highest yield, while 30th July (D_3) resulted in the lowest. The superior performance of June planting was attributed to favorable environmental conditions (optimum temperature, light and humidity), which enhanced photosynthesis, assimilate accumulation and their effective partitioning towards spikes, leading to improved spike number, floret size and overall yield (Singh *et al.*, 2010; Bose *et al.*, 2003) [27, 2]. In contrast, July planting likely experienced reduced radiation and excessive rainfall, resulting in lower yield (Reddy & Janakiram, 2016) [22]. Mulching with silver on black plastic along with waste leaves (M_1) further enhanced yield by improving soil moisture retention, temperature regulation and nutrient availability, which supported better root activity and photosynthesis (Pollet *et al.*, 2009) [19]. Fertigation, particularly at 90% RDF, ensured efficient nutrient supply, improved nutrient use efficiency and enhanced assimilate translocation, leading to better spike development and floret biomass. The slightly superior performance at 90% RDF over 100% RDF may be due to reduced salt accumulation and improved nutrient utilization (Kumar *et al.*, 2012; Abbas *et al.*, 2017; El-Sharkawy *et al.*, 2019) [13, 1, 6].

Table 1: Effect of planting date, mulch and fertigation on days taken to sprouting (days) of Tuberose.

Treatments		2023-24					2024-25					Pooled mean				
		F ₁	F ₂	F ₃	F ₄	Mean	F ₁	F ₂	F ₃	F ₄	Mean	F ₁	F ₂	F ₃	F ₄	Mean
D ₁	M ₁	10.30	10.27	9.10	9.27	9.73	11.70	11.63	11.27	11.63	11.56	11.00	10.95	10.18	10.45	10.65
	M ₂	10.37	10.57	10.03	9.53	10.13	11.90	11.97	11.33	13.50	12.18	11.13	11.27	10.68	11.52	11.15
	Mean	10.33	10.42	9.57	9.40	9.93	11.80	11.80	11.30	12.57	11.87	11.07	11.11	10.43	10.98	10.90
D ₂	M ₁	8.30	8.30	6.97	7.20	7.69	9.87	9.90	9.03	9.27	9.52	9.08	9.10	8.00	8.23	8.60
	M ₂	7.10	6.67	6.23	6.83	7.71	10.27	9.90	9.40	9.20	9.69	8.68	8.28	7.82	8.02	8.20
	Mean	7.70	7.48	6.60	7.02	7.20	10.07	9.90	9.22	9.23	9.60	8.88	8.69	7.91	8.13	8.40
D ₃	M ₁	5.12	4.60	5.60	5.30	5.16	8.30	8.15	7.07	6.67	7.55	6.71	6.38	6.33	5.98	6.35
	M ₂	5.83	5.63	5.14	5.10	5.43	8.07	8.00	7.13	7.10	7.58	6.95	6.82	6.14	6.10	6.50
	Mean	5.48	5.12	5.37	5.20	5.29	8.18	8.08	7.10	6.88	7.56	6.83	6.60	6.24	6.04	6.43
MXF	M ₁	7.91	7.72	7.22	7.26	7.53	9.96	9.89	9.12	9.19	9.54	8.93	8.81	8.17	8.22	8.53
	M ₂	7.77	7.62	7.14	7.16	7.42	10.08	9.96	9.29	9.93	9.81	8.92	8.79	8.21	8.55	8.62
	Mean	7.84	7.67	7.18	7.21	7.47	10.02	9.93	9.21	9.56	9.68	8.93	8.80	8.19	8.38	8.58

Factor	SEm			CD (P = 0.05)		
	2023-24	2024-25	Pooled mean	2023-24	2024-25	Pooled mean
D	0.07	0.15	0.09	0.26	0.59	0.37
M	0.09	0.11	0.07	0.31	0.37	0.23
F	0.15	0.19	0.10	0.42	0.54	0.30
DXM	0.16	0.19	0.12	0.54	0.65	0.41
DXF	0.25	0.32	0.18	NS	NS	NS
MXF	0.21	0.26	0.15	NS	NS	NS
DXMXF	0.36	0.46	0.26	NS	NS	NS

Table 2: Effect of planting date, mulch and fertigation on plant height (cm) at 60 days after planting of Tuberose.

Treatments		2023-24					2024-25					Pooled mean				
		F ₁	F ₂	F ₃	F ₄	Mean	F ₁	F ₂	F ₃	F ₄	Mean	F ₁	F ₂	F ₃	F ₄	Mean
D ₁	M ₁	43.91	45.90	49.77	47.33	46.73	45.13	49.03	52.30	50.84	49.32	44.52	47.47	51.03	49.09	48.03
	M ₂	43.08	44.60	47.68	44.07	44.86	45.21	45.29	48.13	43.94	45.64	44.14	44.95	47.91	44.00	45.25
	Mean	43.49	45.25	48.73	45.70	45.79	45.17	47.16	50.22	47.39	47.84	44.33	46.21	49.47	46.54	46.64
D ₂	M ₁	42.68	49.65	51.28	50.34	48.49	45.01	50.77	52.25	51.24	49.82	43.85	50.21	51.76	50.79	49.15
	M ₂	45.58	47.37	48.60	48.47	47.50	46.96	48.77	50.43	49.80	48.99	46.27	48.07	49.52	49.14	48.25
	Mean	44.13	48.51	49.94	49.41	48.00	45.99	49.77	51.34	50.52	49.40	45.06	49.14	50.64	49.96	48.70
D ₃	M ₁	42.17	43.00	44.57	43.23	43.24	47.77	48.39	49.07	48.75	48.49	44.97	45.69	46.82	45.99	45.87
	M ₂	40.47	42.50	43.93	42.84	42.43	44.07	45.09	49.04	48.27	46.62	42.27	43.79	46.49	45.55	44.53
	Mean	41.32	42.75	44.25	43.04	42.84	45.92	46.74	49.06	48.51	47.56	43.62	44.74	46.65	45.77	45.20
MXF	M ₁	42.92	46.18	48.54	46.97	46.15	45.97	49.40	51.21	50.27	49.21	44.45	47.79	49.87	48.62	47.68
	M ₂	43.04	44.82	46.74	45.13	44.93	45.41	46.38	49.20	47.34	47.08	44.23	45.60	47.97	46.23	46.01
	Mean	42.98	45.50	47.64	46.05	45.54	45.69	47.89	50.20	48.81	48.15	44.34	46.70	48.92	47.43	46.84

Factor	SEm			CD (P = 0.05)		
	2023-24	2024-25	Pooled mean	2023-24	2024-25	Pooled mean
D	0.54	0.60	0.45	2.14	2.36	1.75
M	0.38	0.65	0.45	1.30	2.24	1.54
F	0.66	0.91	0.61	1.88	2.62	1.75
DXM	0.65	1.12	0.77	2.26	3.88	2.67
DXF	1.14	1.58	1.06	NS	NS	NS
MXF	0.93	1.29	0.86	NS	NS	NS
DXMXF	1.61	2.24	1.50	NS	NS	NS

Table 3: Effect of planting date, mulch and fertigation on plant height (cm) at 90 days after planting of Tuberose.

Treatments		2023-24					2024-25					Pooled mean				
		F ₁	F ₂	F ₃	F ₄	Mean	F ₁	F ₂	F ₃	F ₄	Mean	F ₁	F ₂	F ₃	F ₄	Mean
D ₁	M ₁	56.85	58.73	63.39	61.90	60.22	59.65	60.44	64.17	61.77	61.51	58.25	59.59	61.78	61.84	60.36
	M ₂	57.88	58.06	59.33	59.19	58.62	56.68	57.38	57.90	57.19	57.29	57.28	57.72	58.62	58.19	57.95
	Mean	57.36	58.40	61.36	60.55	59.42	58.16	58.91	61.04	59.48	59.40	57.76	58.66	60.20	60.01	59.16
D ₂	M ₁	59.41	59.56	63.41	62.62	61.25	60.08	61.13	64.23	61.75	61.80	59.74	60.35	63.82	58.85	60.69
	M ₂	58.71	59.19	60.70	59.60	59.55	59.40	59.53	60.44	59.63	59.75	59.06	59.36	60.57	59.61	59.65
	Mean	59.06	59.37	62.05	61.11	60.40	59.74	60.33	62.34	60.69	60.78	59.40	59.85	62.20	59.23	60.17
D ₃	M ₁	56.31	58.45	59.77	58.57	58.28	56.77	57.60	58.44	58.05	57.71	56.55	58.03	59.10	58.31	58.00
	M ₂	55.22	56.43	58.72	58.08	57.11	55.13	57.04	59.30	59.23	57.68	55.18	56.74	59.01	58.66	57.39
	Mean	55.77	57.44	59.24	58.32	57.69	55.95	57.32	58.87	58.64	57.70	55.86	57.38	59.06	58.48	57.70
MXF	M ₁	57.52	58.92	62.19	61.03	59.91	58.83	59.73	62.28	60.52	60.34	58.18	59.32	61.57	59.66	59.68
	M ₂	57.27	57.89	59.58	58.96	58.43	57.07	57.99	59.22	58.68	58.24	57.17	57.94	59.40	58.82	58.33
	Mean	57.40	58.40	60.89	59.99	59.17	57.95	58.86	60.75	59.60	59.29	57.67	58.63	60.48	59.24	59.01

Factor	SEm			CD (P = 0.05)		
	2023-24	2024-25	Pooled mean	2023-24	2024-25	Pooled mean
D	0.52	0.49	0.46	2.03	1.93	1.81
M	0.24	0.48	0.32	0.85	1.65	1.12
F	0.66	0.71	0.58	1.90	2.04	1.66
DXM	0.42	0.82	0.56	NS	NS	NS
DXF	1.15	1.23	1.00	NS	NS	NS
MXF	0.94	1.00	0.82	NS	NS	NS
DXMXF	1.62	1.74	1.42	NS	NS	NS

Table 4: Effect of planting date, mulch and fertigation on No. of florets per spike of Tuberose.

Treatments		2023-24					2024-25					Pooled mean				
		F ₁	F ₂	F ₃	F ₄	Mean	F ₁	F ₂	F ₃	F ₄	Mean	F ₁	F ₂	F ₃	F ₄	Mean
D ₁	M ₁	25.97	32.30	37.43	35.43	32.78	31.23	33.07	37.80	36.27	34.59	28.60	32.68	37.62	35.85	33.69
	M ₂	28.20	29.07	34.27	32.43	30.99	30.47	30.90	34.73	32.37	32.12	29.33	29.98	34.50	32.40	31.55
	Mean	27.08	30.68	35.85	33.93	31.89	30.85	31.98	36.27	34.32	33.35	28.97	31.33	36.06	34.13	32.62
D ₂	M ₁	34.83	33.63	42.47	37.37	37.08	35.87	40.20	42.00	37.53	38.90	35.35	36.92	42.23	37.45	37.99
	M ₂	32.40	35.53	38.47	36.57	35.74	32.97	35.87	38.47	36.87	36.04	32.68	35.70	38.47	36.72	35.89
	Mean	33.62	34.58	40.47	36.97	36.41	34.42	38.03	40.23	37.20	37.47	34.02	36.31	40.35	37.08	36.94
D ₃	M ₁	26.47	26.40	33.87	31.43	29.54	26.27	31.00	33.67	31.27	30.55	26.37	28.70	33.77	31.35	30.05
	M ₂	23.43	27.50	30.43	28.47	27.46	23.80	28.47	30.40	28.60	27.82	23.62	27.98	30.42	28.53	27.64
	Mean	24.95	26.95	32.15	29.95	28.50	25.03	29.73	32.03	29.93	29.18	24.99	28.34	32.09	29.94	28.84
MXF	M ₁	29.09	30.78	37.92	34.74	33.13	31.12	34.76	37.82	35.02	34.68	30.11	32.77	37.87	34.88	33.91
	M ₂	28.01	30.70	34.39	32.49	31.40	29.08	31.74	34.53	32.61	31.99	28.54	31.22	34.46	32.55	31.69
	Mean	28.55	30.74	36.16	33.62	32.27	30.10	33.25	36.18	33.82	33.34	29.33	31.99	36.17	33.72	32.80

Factor	SEm			CD (P = 0.05)		
	2023-24	2024-25	Pooled mean	2023-24	2024-25	Pooled mean
D	0.50	0.18	0.21	1.96	0.71	0.83
M	0.28	0.43	0.22	0.96	1.47	0.75
F	0.63	0.59	0.47	1.81	1.68	1.35
DXM	0.48	0.74	0.37	NS	NS	NS
DXF	1.09	1.01	0.82	NS	NS	NS
MXF	0.89	0.83	0.67	NS	NS	NS
DXMXF	1.55	1.43	1.16	NS	NS	NS

Table 5: Effect of planting date, mulch and fertigation on No. of spike per plant of Tuberose.

Treatments		2023-24					2024-25					Pooled mean				
		F ₁	F ₂	F ₃	F ₄	Mean	F ₁	F ₂	F ₃	F ₄	Mean	F ₁	F ₂	F ₃	F ₄	Mean
D ₁	M ₁	2.02	2.51	2.78	2.85	2.54	2.96	3.50	3.77	3.84	3.52	2.49	3.00	3.27	3.35	3.03
	M ₂	1.76	2.22	2.55	2.70	2.31	2.76	3.22	3.55	3.70	3.30	2.26	2.72	3.05	3.20	2.81
	Mean	1.89	2.37	2.67	2.78	2.43	2.86	3.36	3.66	3.77	3.41	2.38	2.86	3.16	3.27	2.92
D ₂	M ₁	2.37	2.80	3.00	2.97	2.79	3.37	3.75	4.00	3.96	3.77	2.87	3.27	3.50	3.46	3.28
	M ₂	2.24	2.52	2.73	2.83	2.58	3.23	3.51	3.72	3.41	3.47	2.73	3.02	3.23	3.12	3.02
	Mean	2.31	2.66	2.87	2.90	2.68	3.30	3.63	3.86	3.68	3.62	2.80	3.15	3.36	3.29	3.15
D ₃	M ₁	1.67	2.08	2.38	2.56	2.18	2.67	3.08	3.37	3.56	3.17	2.17	2.58	2.88	3.06	2.67
	M ₂	1.52	1.85	2.03	2.36	1.94	2.52	2.93	3.01	3.33	2.95	2.02	2.39	2.52	2.85	2.44
	Mean	1.60	1.97	2.20	2.46	2.06	2.59	3.00	3.19	3.44	3.06	2.10	2.48	2.70	2.95	2.56
MXF	M ₁	2.02	2.46	2.72	2.79	2.50	3.00	3.44	3.71	3.79	3.49	2.51	2.95	3.22	3.29	2.99
	M ₂	1.84	2.20	2.44	2.63	2.28	2.83	3.22	3.43	3.48	3.24	2.34	2.71	2.93	3.06	2.76
	Mean	1.93	2.33	2.85	2.71	2.39	2.92	3.33	3.63	3.57	3.36	2.42	2.83	3.17	3.07	2.88

Factor	SEm			CD (P = 0.05)		
	2023-24	2024-25	Pooled mean	2023-24	2024-25	Pooled mean
D	0.09	0.16	0.08	0.35	0.63	0.31
M	0.01	0.07	0.03	0.03	0.23	0.11
F	0.07	0.11	0.08	0.21	0.33	0.23
DXM	0.01	0.12	0.06	NS	NS	NS
DXF	0.13	0.20	0.14	NS	NS	NS
MXF	0.10	0.16	0.11	NS	NS	NS
DXMXF	0.18	0.28	0.20	NS	NS	NS

Table 6: Effect of planting date, mulch and fertigation on flower yield per plot of Tuberose.

Treatments		2023-24					2024-25					Pooled mean				
		F ₁	F ₂	F ₃	F ₄	Mean	F ₁	F ₂	F ₃	F ₄	Mean	F ₁	F ₂	F ₃	F ₄	Mean
D ₁	M ₁	25.33	27.33	30.33	27.17	27.54	33.91	36.58	38.58	33.25	35.58	29.62	31.96	34.46	30.21	31.56
	M ₂	26.00	27.00	30.33	27.67	27.75	34.58	34.58	36.58	35.25	35.25	30.29	30.79	33.46	31.46	31.50
	Mean	25.67	27.17	30.33	27.42	27.65	34.25	35.58	37.58	34.25	35.41	29.96	31.37	33.96	30.83	31.53
D ₂	M ₁	29.33	31.33	34.00	31.93	31.65	38.25	40.25	42.08	40.15	40.18	33.79	35.79	38.04	36.04	35.92
	M ₂	29.67	30.17	32.97	30.53	30.83	37.03	35.25	40.49	37.58	37.59	33.35	32.71	36.73	34.06	34.21
	Mean	29.50	30.75	33.48	31.23	31.24	37.64	37.75	41.29	38.86	38.88	33.57	34.25	37.39	35.05	35.06
D ₃	M ₁	24.00	26.13	28.00	25.90	26.01	31.91	32.57	32.91	32.63	32.51	27.96	29.35	30.46	29.27	29.26
	M ₂	25.33	26.33	28.67	27.03	26.84	31.71	34.41	35.91	34.78	34.20	28.52	30.37	32.29	30.91	30.52
	Mean	24.67	26.23	28.33	26.47	26.43	31.81	33.49	34.41	33.71	33.36	28.24	29.86	31.37	30.09	29.89
MXF	M ₁	26.22	28.27	30.78	28.33	28.40	34.69	36.47	37.86	35.34	36.09	30.46	32.37	34.32	31.84	32.24
	M ₂	27.00	27.83	30.66	28.41	28.48	34.44	34.75	37.66	35.87	35.68	30.72	31.29	34.16	32.14	32.08
	Mean	26.61	28.05	30.72	28.37	28.44	34.57	35.61	37.76	35.61	35.88	30.59	31.83	34.24	31.99	32.16

Factor	SEm			CD (P = 0.05)		
	2023-24	2024-25	Pooled mean	2023-24	2024-25	Pooled mean
D	0.59	1.90	0.96	2.31	7.44	3.75
M	0.59	0.59	0.52	2.04	2.05	1.80
F	0.72	1.31	0.77	2.06	3.74	2.21
DXM	1.02	1.03	0.90	NS	NS	NS
DXF	1.24	2.26	1.33	NS	NS	NS
MXF	1.02	1.85	1.09	NS	NS	NS
DXMXF	1.76	3.20	1.89	NS	NS	NS

Conclusion

The present investigation clearly demonstrated that planting date, mulching, and fertigation levels significantly influenced the growth and yield of tuberose (*Agave amica* L.). Among the different treatments, planting on 30th June, application of silver-on-black plastic mulch with waste leaves, and fertigation at 90% RDF proved to be the most effective combination. This treatment combination resulted in superior performance with respect to key growth and yield parameters such as early and higher sprouting percentage, increased plant height at 60 and 90 days after planting, higher number of florets per spike, more spikes per plant, and ultimately higher flower yield per plot. The enhanced performance under June planting may be attributed to favorable climatic conditions, while mulching with waste leaves improved soil moisture conservation, temperature regulation, and microbial activity. Optimized fertigation at 90% RDF ensured efficient nutrient uptake, thereby improving overall plant growth and productivity. Thus, it can be concluded that the integration of optimum planting time, suitable mulching practice, and balanced fertigation significantly enhances the productivity and quality of tuberose under the agro-climatic conditions of Raipur (C.G.).

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