

INFLUENCE OF NUTRIENT SOURCES AND MULCH ON GROWTH AND YIELD OF TUBEROSE

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Abstract

The study was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from May 2010 to February 2011 to estimate the Influence of nutrient sources and mulch on growth and yield of tuberose. The experiment consisted of two factors. Factor A- Five levels of nutrient sources: F₀ - Control, F₁ - Cow dung 5 t + 260 kg Urea + 200 kg TSP + 200 kg MP/ha, F₂ - Poultry litter 3 t + 260 kg Urea + 200 kg TSP + 200 kg MP/ha, F₃ - Cow dung: 10 t/ha, and F₄ - Poultry litter: 6 t/ha; Factor B: Three levels of mulch: M₀ - control, M₁ -Rice straw mulch, and M₂ - water hyacinth mulch. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Application of fertilizer with different mulches showed significant variations in most of the parameters. In case of nutrient sources, the highest yield of spike (3, 53,530/ha) was recorded from F₁ and the lowest (2, 97,300/ha) from F₀. In case of mulching, the highest yield of spike (3, 46,290/ha) was found from M₂ and the lowest (3, 07,140 /ha) from M₀. For combined effect, the highest yield of spike (3, 66,280/ha) was found from F₁M₂ and the lowest (2, 97,300/ha) from F₀M₀. The highest benefit cost ratio (2.36) was found from F₁M₂. So, the application of cow dung 5 t + 260 kg Urea + 200 kg TSP + 200 kg MP per hectare with water hyacinth mulch was found suitable for growth and yield of tuberose.

Key Words: Nutrient sources, Mulch, Plant height, Leaves per plant, Growth parameter, Cost and return, Tuberose, Yield

Introduction

Tuberose (*Polianthes tuberosa* L.) is one of the most popular bulbous ornamental plants of tropical and sub-tropical areas in the family Amaryllidaceae, produces attractive, elegant and fragrant white flowers. The flowers used as cut flowers remain fresh for quite a long time and stand long distance transportation and fill a useful place in the flower market (Patel *et al.*, 2006). It is used as vase decoration, bouquets, making veni, garland, button-holes or crown and frequently used during marriage or religious ceremonies (Randhawa and Mukhopadhyay, 1986). The long flower spikes are excellent for table decoration when arranged in bowls and vases. Emit a delightful fragrance and are the source of tuberose oil. Tuberose is a native of Mexico from where it spreads to the different parts of the world during 16th century. In Bangladesh, its commercial cultivation was introduced during 1980 by some pioneer and innovative farmers at Panishara union of Jhikorgacha Thana under Jessore district near the Benapol border. Tuberose is a half-hardy bulbous perennial multiplying itself through the bulblets. Roots are adventitious, shallow, and the

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leaves are long, narrow, linear grass like, green and arise in rosette. The flowers have a funnel shaped perianth, waxy white in color and borne in a spike. There are three types of tuberose: single with one row of corolla segments, semi- double bearing flowers with two to three rows of corolla segments and double having more than three rows of corolla segments. Tuberose is a gross feeder and requires a large quantity of NPK, both in the form of organic and inorganic fertilizers (Singh *et al.*, 1976). Fertilizers have great influence on growth, flower, and bulb production in tuberose (Mitra *et al.*, 1979; Yadav *et al.*, 1985). Effect of NPK on tuberose production has been reported by several authors of different geographical regions (Cirrito, 1975; Singh *et al.*, 1976; Mitra *et al.*, 1979; Nanjan *et al.*, 1980; Mukhopadhyay and Banker, 1986; Yadav *et al.*, 1985). Nitrogen has significant effect on bulb production of tuberose. It also increases plant height, number of leaves, spikes per hill, earlier flowering, and higher number of flowers per spike (Mukhopadhyay & Banker, 1986; Roy, 1992). Phosphorus has a significant effect on spike production and floret quality (Jana *et al.*, 1974; Banker and Mukhopadhyay, 1985). Potash appears to help increasing the number of spikes, flowers per spike, and number of flowers per hill (Cirrito, 1975; Singh *et al.*, 1976). Roy (1992) reported the effect of nitrogen and potash on growth and development of tuberose. Mulching helps retaining moisture in the soil and sometimes even substitutes soil (Amal *et al.*, 1990). It protects the plants from loss of soil moisture by wind and soil evaporation and reduces the irrigation requirements (Amal *et al.*, 1990; Vanderwerken *et al.*, 1988). Mulches help checking weed growth and improving the soil structure and fertility (Clarkson, 1997). Weeds are major problem in agricultural production throughout the world. In order to maintain good yields of crops, weeds must be controlled. For these reasons, mulching is more common in organic farming and its benefits include weed control, soil moisture conservation, and soil temperature moderation (Larsson *et al.*, 1997).

There is a scope of increasing flower yield, quality of flower and bulb production of tuberose using fertilizer and mulch. Considering the present situations and above facts, this experiment was undertaken with the following objectives:

- i. To determine the effect of nutrient sources on growth and yield of tuberose;
- ii. To determine the effect of mulching on growth, flowering and yield of tuberose;
- iii. To determine the suitable combination of nutrient sources with mulch for better growth and yield of tuberose.

Materials and Methods

Experimental site

The experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the study site is situated in 23°74'N latitude and 90°35'E longitude (Anon., 1989).

Characteristics of soil

The experimental soil belongs to the Modhupur Tract under AEZ No. 28 (UNDP, 1988). The selected experimental plot was medium high land and the soil series was Tejgaon (FAO, 1988). The components of the soil were analyzed in the Soil Testing Laboratory, SRDI, Farmgate, Dhaka.

Weather condition of the experimental site

The climate of the experimental site was under the subtropical characterized by three distinct seasons, namely the monsoon or the winter season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). Meteorological data related to the temperature, relative humidity, rainfalls, and sunshine during the period of the experiment was collected from the Bangladesh Meteorological Department, Sher-e-Bangla Nagar, Dhaka.

Planting materials

Bulbs of tuberose were used as planting materials and they were collected from Horticultural Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka- 1207.

Treatment of the experiment

The experiment had two factors, such as **Factor A**: Nutrient sources: 5 levels, such as i. F_0 = Control: No fertilizer, ii. F_1 = Cow dung 5 t + 260 kg Urea + 200 kg TSP + 200 kg MP/ha, iii. F_2 = Poultry litter 3 t + 260 kg Urea + 200 kg TSP + 200 kg MP/ha, iv. F_3 = Cow dung: 10 t/ha, v. F_4 = Poultry litter: 6 t/ha, and **Factor B**: Mulch: 3 levels, such as i. M_0 = Control: No mulch, ii. M_1 = Rice straw mulch, iii. M_2 = Water hyacinth mulch. There were 15 (5 x 3) treatment combinations, such as F_0M_0 , F_0M_1 , F_0M_2 , F_1M_0 , F_1M_1 , F_1M_2 , F_2M_0 , F_2M_1 , F_2M_2 , F_3M_0 , F_3M_1 , F_3M_2 , F_4M_0 , F_4M_1 , and F_4M_2 .

Experimental design and layout

The experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. An area of 23.5 m x 10.0 m was divided into three equal blocks and each block was divided into 15 plots for distribution 15 treatments randomly. There were 45 unit plots; the size of each was 2.0 m x 1.0 m.

Land preparation

The experimental plot was opened in the first week of May 2010, with a power tiller and left exposed to the sun for a week. Weeds and stubbles were removed and finally obtained desirable filth of soil. Well-decomposed cow dung and poultry manure and NPK fertilizers were mixed with the soil of each unit plot as per treatment.

Table 1. Application of manure and fertilizers

Fertilizers	Dse/ha	Application (%)		
		Basal	30 DAT	55 DAT
Cow dung	As per treatment	100	--	--
Poultry Manure	As per treatment	100	--	--
Nitrogen (as urea)	260 kg	--	33.33	33.33
P ₂ O ₅ (as TSP)	200 kg	100	---	---
K ₂ O(as MP)	200 kg	100	---	---
Fertilizers	Dse/ha	Application (%)		

The sources of N, P₂O₅, K₂O as urea, TSP, and MP were applied as per treatment (Mollah *et al.*, 2002). The entire amounts of TSP and MP were applied during the final land preparation. Urea was applied in three equal installments at 30, 55, and 85 days after planting bulb of tuberose. Well-rotten cow dung and poultry litter were also applied during final land preparation as per treatment.

Planting of bulblet

The bulbs were planted on 20 May, 2010 with a spacing of 20 cm x 20 cm and the number of bulbs per plot was 50.

Intercultural operation

Over-head irrigation was given, well drained water out at the time of heavy rains was ensured. Weeding was done to keep the plots free from weeds, easy aeration of soil, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully. Breaking the crust of the soil was done for two times at 30 DAT and 50 DAT. After basal dose, the remaining doses of urea were top-dressed in three equal installments. The fertilizers were applied on both sides of plant rows and mixed well with the soil by hand. Earthing up was done with the help of nirani immediately after top-dressing of nitrogen fertilizer. After finishing of 1st top dressing, mulching with rice straw and hyacinth was done.

Plant Protection

For controlling leaf caterpillars Nogos @ 1 ml/L water was applied two times at an interval of 10 days starting soon after the appearance of infestation. No remarkable attack of disease was found.

Data collection

Data were recorded on the following parameters from the sample plants during the course of experiment. Ten plants were randomly selected from each unit plot for collection of data.

Plant height

The height of plant was recorded in centimeter (cm) at 30, 45, 60, and 75 days after planting (DAT) in the experimental plots. The height was measured from the ground level up to the tip of the growing point of the plant.

Number of leaves per plant

All the leaves of 10 plants were counted at an interval of 15 days at 30, 45, 60, and 75 days after planting (DAT) in the experimental plots.

Days required for emergence of spike

It was done by recording the days taken for emergence of tuberose spike randomly selected 10 plants from each unit plot.

Percentage of flowering plant

It was calculated by counting the numbers of plants that bearing flowers in each unit plot and divided by the number of plants emerged and converted to percentage.

Length of flower stalk at harvest

Length of flower stalk was measured from the base to the tip of the spike and expressed in centimeter.

Length of rachis at harvest

Length of rachis refers to the length from the axil of first floret up to the tip of the inflorescence and expressed in centimeter.

Number of spikelet per spike

All the spikelets of the spike were counted from 10 randomly selected plants and their mean was calculated.

Number of spikes per hectare

Number of spikes per hectare was computed from number of spikes per plot and converted to hectare.

Individual bulb thickness

Bulbs were separated from the plant and the thickness of bulb was taken by a slide calipers and expressed in centimeter.

Individual bulb weight

It was determined by weighing the bulb from the ten randomly selected plants and mean weight was calculated and expressed in gram.

2.12.11 Individual bulb diameter

A slide calipers was used to measure the diameter of the bulb and expressed in centimeter and mean of 10 bulbs was calculated.

Number of bulblets per plant

It was calculated from the number of bulblets obtained from 10 randomly selected plants and mean was recorded.

Weight of bulblet

Individual weight of bulblet was recorded from the mean weight of ten randomly selected sample bulblets and expressed in gram.

Diameter of bulblet

A slide calipers was used to measure the diameter of the bulblet and expressed in centimeter.

Bulb yield per plot and hectare

Total bulb yield per plot was recorded by adding the total harvested bulb in a plot and expressed in kg and converting the yield of tuberose bulb per plot to per hectare and expressed in ton per hectare.

Bulblet yield per plot and hectare

Total bulblet yield per plot was recorded by adding the total harvested bulb in a plot and expressed in kg and converting the yield of tuberose bulblet per plot to per hectare and expressed in ton per hectare.

Statistical Analysis

The experimental data obtained for different parameters were statistically analyzed. The significance of the difference among the individual and treatment combinations means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

Economic analysis

The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit cost ratio} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

Results and Discussion

The results have been presented and discussed, and possible interpretations are given under the following headings:

Plant height

Plant height of tuberose showed statistically significant differences due to different nutrient sources at 30, 45, 60, and 75 DAT. At different days after planting (DAT), the tallest plant (35.78 cm, 55.58 cm, 61.57 cm and 69.21 cm) was recorded from F₁ at 30, 45, 60, and 75 DAT, respectively, which was statistically similar (35.63 cm, 53.11 cm, 60.31 cm, and 66.99 cm) with F₂ at same DAT, again, at the same DAT, the shortest plant (30.34 cm, 48.61 cm, 53.13 cm, and 60.36 cm) was recorded from F₀, respectively. Plant height of tuberose differed significantly due to the application of different mulches at days after planting of 30, 45, 60, and 75. At 30, 45, 60, and 75 DAT, the taller plants (36.13 cm, 54.35 cm, 61.28 cm, and 67.83 cm) were found from

M₂, which was closely followed (34.09 cm, 52.05 cm, 57.42 cm, and 65.25 cm) by M₁, whereas, the shorter plants (31.41 cm, 50.70 cm, 55.55 cm, and 63.48 cm) were observed from M₀ for the same DAT, respectively (Fig. 3). Due to interaction effect of nutrient sources and mulch, the taller plants (40.18 cm, 57.58 cm, 66.02 cm, and 73.47 cm) were observed from F₁M₂ at 30, 45, 60, and 75 DAT, respectively, whereas the shorter plants (28.67 cm, 47.04 cm, 52.07 cm, and 60.03 cm) were recorded from F₀M₀ at 30, 45, 60, and 75 DAT, respectively (Table 2). F₁M₂ ensure maximum vegetative growth by ensuring nutrients immediate after germination that lead to the higher plant height of tuberose.

Number of leaves per plant

Statistically significant differences were recorded for number of leaves per plant of tuberose with the application of different nutrient sources at 30, 45, 60, and 75 DAT. At 30, 45, 60, and 75 DAT, the higher number of leaves per plant (3.04, 5.73, 9.00, and 10.99) were found from F₁, which was statistically similar (2.94, 5.64, 8.82, and 10.57) with F₂ at same DAT again, at the same DAT, the lower number of leaves per plant (2.47, 5.23, 8.10, and 9.39) were observed from F₀ (Fig. 4). At 30, 45, 60, and 75 DAT, higher number of leaves per plant (3.05, 6.03, 9.43, and 11.41) were recorded from M₂ closely followed by that of M₁ (2.81, 5.59, 8.91, and 10.49) with M₁, respectively, whereas, lower number of leaves per plant (2.59, 5.01, 7.71 and 9.45) were found from M₀ as no mulch i.e., control for the same DAT, respectively (Fig. 5). Due to combined effect of nutrient sources and mulch, higher number of leaves per plant (3.30, 6.53, 10.07, and 12.03) were obtained from F₂M₂ at 30, 45, 60, and 75 DAT, respectively, whereas, lower number of leaves per plant (2.10, 4.57, 6.50, and 8.27) were found from F₀M₀ at 30, 45, 60, and 75 DAT, respectively (Table 2).

Days required to emergence of spike

The minimum days required to emergence of spike (57.22) was found from F₃, which was closely followed (58.56, 58.67, 59.00 days) by F₁, F₂ and F₄, and they were statistically identical, while, the maximum days (63.44) was observed from F₀ (Table 3). The minimum days required to emergence of spike (58.73) was found from M₂, which was statistically similar (59.00 days) to M₁, whereas, the maximum days required to emergence of spike (60.40) was found from M₀ (Table 3). Combined effect of nutrient sources and mulches showed significant variation in terms of days required to emergence of spike of tuberose. The minimum days (56.33) required to emergence of spike was found from F₃M₀, whereas, the maximum days (68.67) was recorded from F₀M₀ (Table 4).

Flowering plant

The highest flowering plant (92.56%) was observed in F₁, which was closely followed (89.33%, 87.92% and 87.72%) by that of F₂, F₄ (poultry litter: 6 t/ha) and F₃ while, the lowest flowering plant (78.00%) was obtained from that of F₀ (Table 3). It was revealed that F₁ produced maximum flowering plant compared to other nutrient sources. Nutrient sources have great influence on flower production in tuberose (Mitra *et al.*, 1979; Yadav *et al.* 1985). The highest flowering plant (91.44%) was found from M₂ (water hyacinth mulch) whereas, the lowest flowering plant (81.11%) was recorded from M₀ i. e., control condition (Table 3). The

maximum flowering plant (98.33%) was found from F_1M_2 , whereas, the minimum flowering plant (71.00%) was recorded from F_0M_0 (Table 4).

Length of flower stalk at harvest

The highest length of flower stalk at harvest (66.01 cm) was observed from F_1 , which was statistically identical (64.35 cm) to that in F_2 and closely followed (63.67 cm and 63.58 cm) by that in F_3 and F_4 , while the lowest length of flower stalk at harvest (57.96 cm) was found from F_0 (Table 3). The highest length of flower stalk at harvest (66.29 cm) was found from M_2 , which was followed (63.81 cm) by that of M_1 , whereas; the lowest length of flower stalk at harvest (59.81 cm) was obtained from M_0 (Table 3). Chaudhry *et al.* (2004) reported similar findings. The maximum length of flower stalk at harvest (69.43 cm) was observed from F, M_2 whereas the minimum length of flower stalk at harvest (53.01 cm) was observed from the treatment combination of F_0M_0 (Table 4).

Length of rachis at harvest

The highest length of rachis at harvest (35.11 cm) was recorded from F_1 , which was statistically identical (33.82 cm) to that of F_2 , while the lowest length of rachis at harvest (28.27 cm) was recorded from that in F_0 (no fertilizer) (Table 3). Yadav (2007) reported that length of rachis was remarkably increased with N and P application, alone and in combination. The highest length of rachis for different mulch materials at harvest (34.23 cm) was found from M_2 , which was statistically identical (33.14 cm) to M_1 , whereas, the lowest length of rachis at harvest (30.76 cm) was found from M_0 (Table 3). The maximum length of rachis at harvest (37.20 cm) was recorded from the treatment combination of F_1M_2 whereas, the minimum length of rachis at harvest (25.56 cm) was recorded from F_0M_0 (Table 4).

Number of spikelets per spike

The highest number of spikelets per spike (13.61) was obtained from F_1 , which was statistically identical (12.96, 12.61, and 12.60) to that in F_2, F_3 and F_4 , while the lowest number of spikelets per spike (10.18) was found from F_0 (Table 3). Yadav (2007) reported that number of spikes per plot was remarkably increased with N and P application, alone and in combination. Different mulch materials differed significantly on number of spikelets per spike. The highest number of spikelets per spike (14.02) was found from M_2 and the lowest number of spikelets per spike (10.16) was recorded from M_0 as (Table 3). The maximum number of spikelets per spike due to nutrient sources and mulches (15.80) was found from F_1M_2 , whereas, the minimum number of spikelets per spike (8.33) was recorded from F_0M_0 (Table 4).

Yield of spikes per hectare

Yield of spikes per hectare of tuberose differed significantly due to application of different mulches. The highest yield of spike per hectare (3, 46,290) was observed in M_2 , whereas, the lowest yield of spike per hectare (3, 07,140) was observed from M_0 (Table 3). Combined effect of nutrient sources and mulches showed significant variation on spike per hectare. The maximum yield of spike per hectare (3, 66,280) was found from F_1M_2 , whereas, the minimum yield of spike per hectare (2, 57,750) was found from F_0M_0 (Table 4).

Table 2. Effect of nutrients and mulches on plant height and number of leaves/plant of tuberose

Treatment	Plant height (cm)					No. of leaves/plant						
	30 DAT	45 DAT	60 DAT	75 DAT	30 DAT	45 DAT	60 DAT	75 DAT	30 DAT	45 DAT	60 DAT	75 DAT
F ₀ M ₀	28.67h	47.04 f	42.07 d	60.03 e	2.10 f	4.57 e	6.50 f	8.27 h				
F ₀ M ₁	30.49 fgh	48.85 ef	52.08 d	61.02 de	2.47 e	5.13 cde	8.60 cd	9.33 fg				
F ₀ M ₂	31.36 efgh	49.93 ef	55.23 cd	60.04 e	2.83 bcd	6.00 ab	9.20 bc	10.57 cde				
F ₁ M ₀	32.36 defgh	52.80 bcde	58.84 bc	66.32 bcd	2.80 bcd	4.93 de	8.00 de	9.67 efg				
F ₁ M ₁	36.31 abcd	56.35 abc	59.85 bc	67.83 bc	3.07 ab	5.80 b	9.20 bc	11.20 bc				
F ₁ M ₂	40.18 a	57.58 a	66.02 a	73.47 a	3.27 a	6.47 a	9.8 ab	12.10 ab				
F ₂ M ₀	32.96 defgh	50.87 def	57.31 bc	65.81 bcd	2.60 de	4.60 e	7.47 e	9.13 gh				
F ₂ M ₁	33.74 cdefg	52.02 cde	58.35 bc	65.14 bcde	2.93 bc	5.80 b	8.93 c	10.93cd				
F ₂ M ₂	38.67 ab	56.44 ab	65.28 a	70.03 ab	3.30a	6.53 a	10.07a	12.23 a				
F ₃ M ₀	27.17 gh	48.66 ea	51.48 d	59.76 e	2.67 cd	5.47 bcd	8.00 de	9.83 efg				
F ₃ M ₁	37.77 abc	54.99 abcd	61.74 ab	69.91 ab	2.93 bc	5.67 bc	8.90 c	10.87 cd				
F ₃ M ₂	34.64 bcdef	52.23 bcde	58.32 bc	66.42 bcd	2.87bcd	5.47 bcd	9.07 c	11.17 bc				
F ₄ M ₀	33.86 cdef	52.31 bcde	58.05 bc	65.48 bcd	2.80 bcd	5.47 bcd	8.60 cd	10.33 cdef				
F ₄ M ₁	32.14 defgh	49.85 ef	55.10cd	62.35 cde	2.67cde	55.57 bc	8.90 c	10.10 defg				
F ₄ M ₂	35.78 abcde	55.58 abc	61.57 ab	69.21ab	3.00 b	5.70 bc	9.00c	10.97 cd				
LSD(0.05)	4.086	3.816	4.475	4.890	0.237	0.547	0.673	0.93				
Level of significance	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.05				
CV(%)	7.18	4.36	6.61	7.45	5.06	5.89	4.63	5.32				

In a column means having similar letter(s) are statistically identical and those having letter(s) differ significantly as per 0.05 level of probability

Table 3. Effect of nutrients and mulches on growth parameter of tuberose

Treatment	Days to emergence of spike	Flowering plant (%)	Length of flower stalk at harvest (cm)	Length of rachis at harvest (cm)	No. of spikelets/spike	No. of spikes/ ha (000)
Nutrient sources						
F ₀	63.44a	78.00c	57.96c	28.27c	10.18b	297.30 c
F ₁	58.56 b	92.56 a	66.01 a	35.11 a	13.61 a	353.53 a
F ₂	58.67 b	89.33 b	64.35 ab	33.82ab	12.96 a	333.86 b
F ₃	57.22 c	87.72 b	63.67 b	33.43 b	12.61 a	330.98 b
F ₄	59.00 b	87.92 b	63.58 b	32.91 b	12.60 a	331.44 b
LSD _(0.05)	0.9.3	2.783	2.196	1.502	1.036	23.06
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
Mulch						
M ₀	60.40 a	81.11 c	59.24 c	30.76 b	10.16 c	307.14 c
M ₁	59.0 b	88.76 b	63.81 b	33.14 a	13.00 b	334.94 b
M ₂	58.73 b	91.44 a	66.29 a	34.23 a	14.02 a	346.29 a
LSD _(0.05)	0.700	22.156	1.701	1.164	0.803	17.86
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
CV (%)	6.58	7.31	9.60	4.76	8.66	6.33

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

Table 4. Interaction effect of nutrients and mulches on growth parameter of tuberose

Treatment	Days required for emergence of spike	Flowering plant (%)	Length of flower stalk at harvest (cm)	Length of rachis at harvest (cm)	No. of spikelets/spike	No. of spikes/ ha (000)
F ₀ M ₀	68.67a	71.00g	53.01f	25.56g	8.33h	257.75 g
F ₀ M ₁	60.33bc	80.00f	59.39e	30.58ef	10.50 efg	313.40 ea
F ₀ M ₂	61.33b	83.00def	61.47de	28.66f	11.71 def	320.74 cdef
F ₁ M ₀	59.33cd	85.67de	62.17cde	32.97cde	10.84 efg	330.82 bcde
F ₁ M ₁	58.00def	93.67ab	66.45ab	35.16 abc	14.19 abc	363.49 a
F ₁ M ₂	58.33de	98.33a	69.43a	37.20 a	15.80 a	366.28 a
F ₂ M ₀	58.67cde	81.00ef	59.24e	30.96 ea	9.32 gh	303.59 a
F ₂ M ₁	59.00cde	92.00bc	66.10abc	34.31 abcd	14.37 ab	336.89 bcd
F ₂ M ₂	58.33de	95.00ab	67.70a	36.18 ab	15.20 ab	361.11 a
F ₃ M ₀	56.33f	81.00ef	58.80e	31.64 de	9.95 fgh	317.17 def
F ₃ M ₁	58.00def	93.83ab	65.37abcd	34.68 abc	14.10 abc	339.97 bc
F ₃ M ₂	57.33 ef	88.33 cd	66.84 ab	33.97 bcd	13.80 abc	335.80 bcd
F ₄ M ₀	59.00 cde	86.90 d	63.00 bcde	33.66 cde	12.34 cde	325.85 cde
F ₄ M ₁	59.67 cd	84.29 def	61.73 de	30.97 ef	11.83 def	320.96 cdef
F ₄ M ₂	58.33 de	92.56 bc	66.01 abc	35.11 abc	13.61bcd	347.53 ab
LSD _(0.05)	1.564	4.820	3.804	2.602	1.794	49.93
Level of significance	0.01	0.01	0.05	0.05	0.01	0.01
CV (%)	6.58	7.31	9.60	4.76	8.66	6.33

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

Table 5. Effect of nutrients and mulches on the growth and yield of tuberose

Treatment	Weight of individual Bulb (g)	Diameter of individual bulb (cm)	Number of bulblet/plant	Weight of bulblet/plant (g)	Diameter of bulblet	Yield of bulb (kg/plot)	Yield of bulblet (kg/plot)	Yield of bulb (t/ha)	Yield of bulblet (ton/ha.)
Nutrient Sources									
F ₀	24.34 c	1.81 c	20.00c	10.11 d	1.09 c	0.35b	0.31 b	17.33c	15.62b
F ₂	27.36b	1.94 b	22.01 ab	13.37 ab	1.31 b	.047 a	0.43 a	23.66 ab	21.45 a
F ₃	26.98b	1.92 b	21.79 ab	12.86 bc	1.34 ab	0.45 a	0.41 a	22.72 b	20.71 a
F ₄	26.54b	1.91 b	21.22 b	12.65 c	1.29 b	0.46a	0.41 a	23.11 ab	20.59a
LSD _(0.05)	10.846	0.086	0.919	0.608	0.091	0.053	0.043	2.503	2.348
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Mulch									
M ₀	24.59b	1.70 b	18.68b	11.48c	1.21c	0.37 b	0.35 b	18.38 c	17.28b
M ₁	27.68 a	2.04a	22.74 a	12.78b	1.29b	0.47 a	0.42 a	25.53b	20.92 a
M ₂	28.22 a	2.05 a	23.24 a	13.43 a	1.36 a	0.51 a	0.45 a	25.57 a	22.38 a
LSD _(0.05)	0.655	0.067	0.712	0.471	0.047	0.041	0.033	1.939	1.819
Level of CV (%)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	5.26	6.50	7.42	5.01	5.06	11.52	12.04	11.25	12.04

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

Table 6. Interaction effect of nutrients and mulches on growth and yield of tuberose

Treatment	Thickness of individual bulb(cm)	Weight of individual Bulb (g)	Diameter of individual bulb (cm)	Number of bulb/plant (g)	Weight of bulblet/plant (g)	Diameter of bulblet	Yield of bulb (kg/plot)	Yield of bulb (t/ha)	Yield of bulblet (kg/plot)
F ₀ M ₀	5.25d	20.78e	1.46 h	16.21 h	8.64 h	1.05 h	0.22 f	11.17f	11.00e
F ₀ M ₁	5.99cd	25.80 cb	1.92 def	21.47de	10.48 g	1.06 gh	0.39 e	19.50e	17.20d
F ₀ M ₂	6.28 bc	26.46c	2.05 bcd	22.32 bcde	11.22 fg	1.16fg	0.43 cde	21.33d	18.67cd
F ₁ M ₀	6.37 bc	26.27 c	1.79 fg	18.98 fg	12.72 bcd	1.28 cde	0.39 e	19.61e	17.95 d
F ₁ M ₁	6.22 bc	29.00b	2.18 ab	23.83 ab	14.07 a	1.43ab	0.53 abc	26.43abc	22.90abc
F ₁ M ₂	7.17 a	31.51 a	2.24 a	25.40 a	14.67a	1.48a	0.61 a	30.72 a	26.95a
F ₂ M ₀	5.80cd	24.37 d	1.64 g	18.37 g	11.49 efg	1.17 efg	0.36 e	17.78 e	17.12d
F ₂ M ₁	6.21bc	28.35 b	2.11 abc	23.74 ab	13.99a	1.37 abcd	0.51 bcd	25.28bcd	22.76abc
F ₂ M ₂	7.23a	29.35 b	2.07bcd	23.91 ab	14.63a	1.40 abcd	0.56 ab	27.93 ab	24.46ab
F ₃ M ₀	5.97cd	25.65 cd	1.77fg	19.19 fg	12.03cdef	1.28 def	0.42 de	21.04 d	20.24bcd
F ₃ M ₁	6.96ab	29.44b	2.09 abc	23.34 bc	13.74 ab	1.40 abcd	0.50 bcd	24.84bcd	22.67 abc
F ₃ M ₂	6.39bc	25.85 cd	1.91 def	22.83 bcd	12.80 bc	1.35 bcd	0.45cde	22.28cde	19.22cd
F ₄ M ₀	6.32bc	25.90cd	1.84 ef	20.64 ef	12.54 cde	1.29 cde	0.45cde	22.33cde	20.09bcd
F ₄ M ₁	6.20bc	25.80 cd	1.92 def	21.30 de	11.59defg	1.18 ef	0.43 cde	21.62cde	19.08cd
F ₄ M ₂	6.59abc	27.93 b	1.97 cde	21.74 cde	11.82 ab	1.40 abc	0.51bcd	25.59bcd	22.60abc
LSD _(0.05)	0.681	1.465	0.150	1.592	1.052	0.106	0.092	4.336	4.067
Level of significance	0.05	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CV (%)	6.43	5.26	6.50	7.42	5.01	5.06	11.52	12.04	11.52

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

Table 7. Cost and return of tuberose cultivation as influenced by nutrients and mulches

Treatment	Cost of production (Tk./ha)	Yield of bulb(t/ha)	Price of bulb(Tk.)	Yield of Bulblet(t/ha)	Price of bulblet	Tuberose (1000)	Price of cut flower	Gross return (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio
F ₀ M ₁	300128	19.50	156000	17.20	137600	313.40	313398	606998	306870	2.02
F ₀ M ₂	300128	21.33	170640	18.67	149360	320.74	320744	640744	340616	2.13
F ₁ M ₀	340733	19.61	156880	17.95	143600	330.82	330818	631298	290565	1.85
F ₁ M ₁	350949	26.43	211440	22.90	183200	363.49	363492	758132	407183	2.16
F ₁ M ₂	350949	30.72	245760	26.95	215600	366.28	366284	827644	476695	2.36
F ₂ M ₀	343287	17.78	142240	17.12	136960	303.59	303586	582786	239499	1.70
F ₂ M ₁	353502	25.28	202240	22.76	182080	336.89	336890	721210	367708	2.04
F ₂ M ₂	353502	27.93	223440	24.46	195680	361.11	361114	780234	426732	2.21
F ₃ M ₀	315451	21.04	168320	20.24	161920	317.17	317170	647410	331959	2.05
F ₃ M ₁	325666	24.84	198720	22.67	181360	339.97	339972	720052	394386	2.21
F ₃ M ₂	321835	22.28	178240	19.22	153760	335.80	335800	667800	345965	2.07
F ₄ M ₀	320558	22.33	178640	20.09	160720	325.85	325850	665210	344652	2.08
F ₄ M ₁	330774	21.62	172960	19.08	152640	320.96	320956	646556	315782	1.95
F ₄ M ₂	320558	25.59	204720	22.60	180800	347.53	347530	733050	412492	2.29

Thickness of individual bulb

The highest thickness of individual bulb (6.59 cm) was observed in F₁, which was statistically identical (6.44 cm, 6.41 cm, and 6.37) with F₃, F₂, and F₄, while the lowest thickness (5.84 cm) was found from F₀. The highest thickness of individual bulb (6.73 cm) was found from M₂ (water hyacinth mulch), which was closely followed (6.32 cm) by that in M₁ (rice straw mulch), whereas, the lowest thickness of individual bulb (5.94 cm) was observed in M₀ as no mulch i.e., control. The maximum thickness of individual bulb (7.23 cm) was observed in F₂M₁, whereas, the minimum thickness of individual bulb (5.25 cm) was recorded from F₀M₀ (Table 6).

Weight of individual bulb

The highest weight of individual bulb (28.93 g) was observed in F₁, which was closely followed (27.36 g, 26.98 g, and 26.54 g) by that of F₂, F₃ and F₄, while the lowest weight of individual bulb (24.34 g) was found from F₀ (Table 5). The highest weight of individual bulb (28.22 g) was observed in M₂, which was statistically similar (27.68 g) to M₁, whereas, the lowest weight of individual bulb (24.59 g) was found from M₀ as no mulch i.e., control (Table 5). The maximum weight of individual bulb (31.51 g) was observed in F₁M₂, whereas the minimum weight of individual bulb (20.78 g) was observed from F₀M₀ (Table 6).

Diameter of individual bulb

The highest diameter of individual bulb (2.07 cm) was found from F₁, which was closely followed (1.94 cm, 1.92, and 1.91 cm) by F₂, F₃, and F₄, while the lowest diameter of individual bulb (1.81 cm) was observed from F₀ (Table 5). The highest diameter of individual bulb (2.05 cm) was found from M₁, which was statistically similar (2.04 cm) to that of M₂, whereas, the lowest diameter of individual bulb (1.70 cm) was observed from M₀ as no mulch i.e., control (Table 5). The maximum diameter of individual bulb (2.24 cm) was recorded from the treatment combination of F₁M₂, whereas, the minimum diameter of individual bulb (1.46) was recorded from F₀M₀ (Table 6).

Number of bulblets per plant

The highest number of bulblets per plant (22.74) was found from F₁, which was statistically identical (22.01 and 21.79) to that in F₂ and in F₃ and closely followed (21.22) by that in F₄, while the lowest number of bulblets per plant (20.00) was recorded from F₀ (Table 5). Patil *et al.* (1999) reported that application of 250:200:200 kg NPK/ha on three tuberose tubers per hill resulted in the highest flower and spike yields (7.86 t/ha, 3.33 spikes/ha, respectively). The highest number of bulblets per plant (23.24) was found from M₂, which was statistically similar (22.74) to M₁ whereas, the lowest number of bulblets per plant (18.68) was obtained from M₀ (Table 5). The highest number of bulblets per plant (25.40) was observed from F₁M₂, whereas, the minimum number of bulblets per plant (16.21) was obtained from F₀M₀ (Table 6).

Weight of bulblets per plant

Significant variation was observed for weight of bulblets per plant for the application of different nutrients. The highest weight of bulblets per plant (13.82 g) was recorded from F₁, which was statistically similar (13.37 g) to that in F₂ and closely followed (12.86 g) by that of F₃ while the lowest weight of bulblets per plant (10.11 g) was recorded from F₀ (no fertilizer) (Table 5). Different mulches differed significantly for weight of bulblet per plant of tuberose. The highest weight of bulblets per plant (13.43 g) was recorded from M₂ (water hyacinth mulch), which was statistically similar (12.78 g) that of M₁ (rice straw mulch), whereas, the lowest weight of bulblets per plant (11.48 g) was observed from M₀ as no mulch i.e., control (Table 5). Due to interaction effect of nutrients and mulches, the maximum weight of bulblet per plant (14.67 g) was observed from F₁M₂, whereas, the minimum weight of bulblets per plant (8.64 g) was recorded from F₀M₀ (Table 6).

Diameter of bulblet

Diameter of bulblet varied significantly due to the application of different nutrient sources. The highest diameter of bulblet (1.40 cm) was found from F₁, which was statistically similar (1.34 cm) to that in F₃ and closely followed (1.31 and 1.29) by that in F₂ and F₄, while the lowest diameter of bulblets (1.09 cm) was found from F₀ (Table 5). Different mulches differed significantly for diameter of bulblet of tuberose. The highest diameter of bulblet (1.36 cm) was found from M₂, whereas, the lowest diameter of bulblets (1.21 cm) was found from M₀ (Table 5). Due to interaction effect of nutrients and mulches, the maximum diameter of bulblet (1.48 cm) was recorded from F₁M₂, whereas, the minimum diameter of bulblet (1.05 cm) was recorded from F₀ M₀ (Table 6).

Yield of bulb per plot

Yield of bulbs per plot varied significantly for the application of different nutrient sources. The highest yield of bulbs per plot (0.51 kg) was observed in F₁, which was statistically similar (0.47 kg, 0.46 kg and 0.45 kg) to that of F₂, F₄ and F₃, while the lowest yield of bulbs per plot (0.35 kg) was found from F₀ (Table 5). Singh *et al.*, 2001 reported that N, P and K contents in leaves were higher than those in bulbs (rhizomes). Bulb N increased with increasing rates of all nutrient sources. Bulb P content was affected by N and P nutrient sources, but not by K nutrient sources. Bulb K content also increased with increasing rates of all nutrient sources. Mulches differed significantly on yield of bulbs per plot of tuberose (Appendix V). The highest yield of bulbs per plot (0.51 kg) was recorded from M₂, which was statistically similar (0.47 kg) to that in M₁, whereas, the lowest yield of bulb per plot (0.37 kg) was observed from M₀ (Table 5). Due to interaction effect of nutrient sources and mulch the maximum yield of bulb per plot (0.61 kg) was found from F₁M₂, whereas, the minimum yield of bulb per plot (0.22 kg) was recorded from F₀M₀ (Table 6).

Yield of bulblets per plot

Application of different nutrient sources varied significantly on yield of bulblet per plot for the. The highest yield of bulblets per plot (0.45 kg) was obtained from F_1 , while the lowest yield of bulblets per plot (0.31 kg) was recorded from F_0 (Table 5). Due to use of different mulches, the highest yield of bulblets per plot (0.45 kg) was found from M_2 , which was statistically similar (0.42 kg) to that in M_1 , whereas, the lowest yield of bulblets per plot (0.35 kg) was found from M_0 (Table 5). Variation was recorded due to combined effect of nutrient sources and mulches in terms of yield of bulblets per plot of tuberose. The maximum yield of bulblets per plot (0.54 kg) was observed from the treatment of F_1M_2 whereas the minimum yield of bulblets per plot (0.22 kg) was observed from F_0M_0 (Table 6).

Yield of bulbs per hectare

Yield of bulbs per hectare showed statistically significant difference for the application of different nutrient sources. The highest yield of bulb per hectare (25.59 ton) was recorded from F_1 , which was statistically similar (23.66 tons and 23.18 tons) to that of F_2 and F_4 and closely followed (22.72 tons) by that of F_3 , while the lowest yield of bulbs per hectare (17.33 tons) was recorded from F_0 (Table 5). Due to the use of different mulches, the highest yield of bulbs per hectare (25.57 tons) was observed from M_2 , whereas, the lowest yield of bulbs per hectare (18.38 ton) was obtained from M_0 (Table 5). Due to combined effect of nutrient sources and mulches, the maximum yield of bulbs per hectare (30.72 tons) was observed from F_1M_1 , whereas the minimum yield of bulbs per hectare (11.17 tons) was recorded from F_0M_0 (Table 6).

Yield of bulblets per hectare

Significant difference was recorded on yield of bulblets per hectare due to the application of different nutrient sources. The highest yield of bulblets per hectare (22.60 tons) was found from F_1 , which was statistically similar (21.45 tons, 20.71 tons, and 20.59 tons) to that of F_2, F_3 and F_4 , while the lowest yield of bulblets per hectare (15.62 tons) was recorded from M_0 (Table 5). It was revealed that F_1 promote maximum vegetative growth compared to F_2 and F_3 . The highest yield of bulblets per hectare (22.38 tons) was found from M_2 , which was statistically similar (20.92 tons) to that of M_1 , whereas, the lowest yield of bulblets per hectare (17.28 tons) was found from M_0 (Table 5). Due to combined effect of nutrient sources and mulches the highest yield of bulblets per hectare (26.95 tons) was observed from F_1M_2 , whereas, the minimum yield of bulblets per hectare (11.00 tons) was observed from F_0M_0 (Table 6).

Economic analysis

Input costs for land preparation, seed cost, nutrient sources, irrigation and manpower required for all the operations from planting to harvesting of tuberose flower, bulb, and bulblet were recorded for unit plot and converted into cost per hectare. Price of tuberose flower, bulb, and bulblet was considered as per market rate. The economic analysis presented under the following headings.

Gross return

The combination of nutrient sources and mulch showed different gross returns. The highest gross return (Tk.8,27,644) was obtained from F₁M₂ and the second highest gross return (Tk. 7,80,234) was found in F₂M₂ The lowest gross return (Tk. 4,35,112) was obtained from F₀M₀ (Table 7).

Net return

In case of net return, different treatment combinations showed different concentrations of net returns. The highest net return (Tk. 4,76,695) was found from F₁M₂ and the second highest net return (Tk. 4,26,732) was obtained from F₂M₂ The lowest (Tk. 1,45,199) net return was obtained F₀M₀ (Table 7).

Benefit cost ratio

In the combination of nutrient sources and mulch highest benefit cost ratio (2.36) was noted from F₁M₂ and the second highest benefit cost ratio (2.29) was estimated from F₄M₂ The lowest benefit cost ratio (1.50) was obtained from F₀M₀ (Table 7). From economic point of view, it was apparent from the above results that the combination of F₁M₂ was more profitable than rest of the combination.

Conclusion

From economic point of view, it was apparent from the above results that the combination of F₁M₂ was more profitable than rest of the combination. Further studies at different agro ecological zone of Bangladesh are needed for final conclusion.

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