International Journal of Applied Research 2015; 1(5): 207-211

ISSN Print: 2394-7500
ISSN Online: 2394-5869
Impact Factor: 3.4
IJAR 2015; 1(5): 207-211
www.allresearchjournal.com
Received: 12-03-2015
Accepted: 22-04-2015

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Growth and yield of tuberose as influenced by different levels of nutrient sources and mulching materials

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Abstract
The study was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from May 2014 to February, 2015. The experiment consisted with two factors. Factor A- Five levels nutrient sources: F_0 - Control, F_1 - Cowdung 10 t + 250 kg Urea + 190 kg TSP + 190 kg MP/ha, F_2 - Poultry litter 5 t + 250 kg Urea + 190 kg TSP + 190 kg MP/ha, F_3 - Cowdung: 15 t/ha and F_4 - Poultry litter: 10 t/ha; Factor B: Three levels of mulch: M_0 - control, M_1 -Rice straw mulch and M_2 - 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 on most of the parameters. The highest yield of spike (3,69,290 /ha) was found from F_1M_2 and the lowest (2,90,760 /ha) from F_0M_0. The maximum yield of bulb per hectare (31.83 ton) was observed in F_1M_2 and the minimum (12.21 ton) was recorded from F_0M_0. The maximum yield of bulblet per hectare (27.12 ton) was observed from F_1M_2 and the minimum yield (12.85 ton) was observed from F_0M_0. So, application of cowdung 10 t + 250 kg Urea + 190 kg TSP + 190 kg MP per hectare with water hyacinth mulch was found suitable for growth and yield of tuberose.

Keywords: Tuberose, nutrient source, mulching, growth and yield.

1. 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 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) [10]. 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) [12]. The natural flower oil of tuberose remains today as one of the most expensive of the perfumes raw materials.

Tuberose is a native of Mexico from where it spreads to the different parts of the world during 16 century. How and when the tuberose found its entrance to India, Ceylon and elsewhere in the orient is probably an unanswerable question (Yadav *et al*., 1982) [17]. In Bangladesh, for the last few years, tuberose has become a popular cutflower for its attractive fragrance and beautiful display in the vase. Now, it is one of the most important commercial cutflowers. Tuberose has high demand in the market and its production is highly profitable. In Bangladesh, its commercial cultivation was introduced during 1980 by some pioneer and innovative farmers at the Panishara union of Jhikorgacha thana under Jessore district near the Benapol border. Although tuberose is now grown in the country, very little is known about production technology in Bangladesh condition.

Tuberose is a half-hardy bulbus perennial multiplying itself through the bulblets. Roots are mainly adventitious and shallow, the 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.

Plant growth and economic cultivation of tuberose are affected by many factors among them fertilizer is an important one. 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) [14]. Fertilizers have

great influence on growth, flower and bulb production in tuberose (Mitra *et al*, 1979; Yadav *et al*, 1985) [7, 18]. Effect of NPK on tuberose production has been reported by several authors of different geographical region (Cirrito, 1975; Singh *et al.*, 1976; Mitra *et al.*, 1979; Mukhopadhyay and Banker, 1986; Yadav *et al.*, 1985) [2, 14, 7, 8, 18].

Nitrogen has a significant effect on bulb production of tuberose. It also increases plant height, number of leaves, spike per hill, earlier flowering and higher number of flowers per spike (Mukhopahyay and Banker, 1986; Roy, 1992) [8, 13]. Phosphorus has a significant effect on spike production and floret quality (Jana *et al.*, 1974; Banker and Mukhopadhyay, 1985) [6, 1]. Potash appears to help increasing the number of spike, flower per spike and number of flowers per hill (Cirrito, 1975; Singh *et al*., 1976) [2, 14]. Roy (1992) [13] reported the effect of nitrogen and potash on the growth and development of tuberose.

Tuberose is known to be thermo photo sensitive crop and grown in Bangladesh all the year round. The role of mulching is well known on the growth and production of plants. Its vegetative growth, flower and bulb development are greatly influenced by growing environment. Due to long growing period, it requires several irrigations. 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). Mulching is the common and cheapest method for the weed control. 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 the present investigation was undertaken with the following objective to determine the suitable combination of nutrient sources with mulch for better growth, flowering and yield of tuberose.

2. Materials and Methods

The experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The location of the study site is situated in 23°74′N latitude and 90°35′E longitude. The experimental soil belongs to the Madhupur Tract under AEZ No. 28 [16]. The selected experimental plot was medium high land and the soil series was Tejgaon [16]. The climate of experimental site was under the subtropical, characterized by three distinct seasons, 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 [3]. 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, Bangladesh. The experiment consisted with two factors. Factor A- Five levels nutrient sources: F_0 - Control, F_1 - Cowdung 10 t + 250 kg Urea + 190 kg TSP + 190 kg MP/ha, F_2 - Poultry litter 5 t + 250 kg Urea + 190 kg TSP + 190 kg MP/ha, F_3 - Cowdung: 15 t/ha and F_4 - Poultry litter: 10 t/ha; Factor B: Three levels of mulch: M_0 - control, M_1 -Rice straw mulch and M_2 - water hyacinth mulch. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. There were 45 unit plots, the size of each was 2.0 m x 1.0 m. The experimental plot was opened in the first week of May 2014, with a power tiller and left exposed to the sun for a week. The sources of N, P_2O_5, K_2O as urea, TSP and MP were applied, respectively as per treatment (Mollah *et al*., 2002) [9]. 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 cowdung and poultry litter also applied during final land preparation as per treatment. The bulbs were planted on 20 May, 2014 with a distance on 20 cm x 20 cm and the number of bulb/plot was 50.

Data of plant height, number of leaves per plant, days required for emergence of spike, percentage of flowering plant, length of flower stalk at harvest, length of rachis at harvest, number of spikelet per spike, number of spike per hectare, individual bulb thickness, individual bulb weight, individual bulb diameter, number of bulblet per plant, weight of bulblet, diameter of bulblets, bulb yield per plot and hectare, bulblet yield per plot and hectare were recorded from the sample plants during the course of experiment. Ten plants were randomly selected from each unit plot for collection of data.

The experimental data obtained for different parameters were statistically analyzed. The mean values of all the recorded characters were calculated and analysis of variance was performed by 'F' (variance ratio) test. The significance of the difference among the individual and treatment combinations means was estimated by the Duncan's Multiple Range Test (DMRT) at the 5% level of probability [5].

3. Results and Discussion

3.1 Plant height

Significant variation was recorded due to interaction effect of nutrient sources and mulch in terms of plant height of tuberose at 30, 45, 60 and 75 DAP (Table 1). The tallest plant (40.22 cm, 57.61 cm, 66.06 cm and 73.49 cm) was observed from F_1M_2 at 30, 45, 60 and 75 DAP and the shortest plant (28.63 cm, 47.02 cm, 42.11 cm and 60.05 cm) was recorded from F_0M_0 at 30, 45, 60 and 75 DAP.

3.2 Number of leaves per plant

Significant variation was recorded due to the combined effect of nutrient sources and mulch in terms of number of leaves per plant of tuberose at 30, 45, 60 and 75 DAP (Table 1). The highest number of leaves per plant (3.33, 6.56, 10.10 and 12.27) was attained from F_2M_2 at 30, 45, 60 and 75 DAP and the lowest number of leaves per plant (2.13, 4.60, 6.52 and 8.31) was found from F_0M_0 at 30, 45, 60 and 75 DAP.

Table 1: Effect of nutrient sources and mulch on plant height and number of leaves per plant of tuberose

Treatment	Plant height (cm) at				Number of leaves per plant at			
	30 DAP	45 DAP	60 DAP	75 DAP	30 DAP	45 DAP	60 DAP	75 DAP
F_0M_0	28.63h	47.02 f	42.11 d	60.05 e	2.13 f	4.60 e	6.52 f	8.31 h
F_0M_1	30.52 f-h	48.87 ef	52.12 d	61.04 de	2.50 e	5.16 c-e	8.62 cd	9.37 fg
F_0M_2	31.39 e-h	49.95 ef	55.27 cd	60.06 e	2.86 b-d	6.03 ab	9.23 bc	10.61 c-e
F_1M_0	32.39 d-h	52.82 b-e	58.88 bc	66.35 b-d	2.83 b-d	4.96 de	8.03 de	9.71 e-g

F_1M_1	36.34 a-d	56.37 a-c	59.89 bc	67.85 bc	3.09 ab	5.83 b	9.23 bc	11.24 bc
F_1M_2	40.22 a	57.61 a	66.06 a	73.49 a	3.33 a	6.50 a	9.82 ab	12.14 ab
F_2M_0	32.99 d-h	50.89 d-f	57.35 bc	65.83 b-d	2.63 de	4.63 e	7.49 e	9.17 gh
F_2M_1	33.77 c-g	52.04 c-e	58.38 bc	65.16 b-e	2.96 bc	5.83 b	8.96 c	10.97 cd
F_2M_2	38.69 ab	56.46 ab	65.36 a	70.05 ab	3.33 a	6.56 a	10.10 a	12.27 a
F_3M_0	27.20 gh	48.69 ea	51.52 d	59.78 e	2.69 cd	5.50 b-d	8.03 de	9.85 e-g
F_3M_1	37.80 a-c	55.01 a-d	61.76 ab	69.93 ab	2.96 be	5.70 bc	8.93 c	10.90 cd
F_3M_2	34.67 b-f	52.25 b-e	58.36 bc	66.44 b-d	2.90b-d	5.50 b-d	9.10 c	11.21 bc
F_4M_0	33.89 c-f	52.33 b-e	58.09 bc	65.49 b-d	2.83 b-d	5.51 b-d	8.63 cd	10.37 c-f
F_4M_1	32.17 d-h	49.89 ef	55.15cd	62.38 c-e	2.70c-e	55.60 bc	8.93 c	10.14 d-g
F_4M_2	35.81 a-e	55.60 a-c	61.61ab	69.23 ab	3.03 b	5.73 bc	9.03 c	11.01 cd
$LSD_{(0.05)}$	4.086	3.816	4.475	4.890	0.237	0.547	0.673	0.93
CV(%)	7.26	5.39	6.59	7.23	6.07	6.89	5.69	6.37

3.3 Days required to emergence of spike

Combined effect of nutrient sources and mulches showed significant variation due to in terms of days required to emergence of spike of tuberose (Table 2). The minimum days (56.37) required to emergence of spike was found from F_3M_0 and the maximum days (69.70) was recorded from F_0M_0.

3.4 Flowering plant

Combined effect of nutrient sources and mulch showed significant variation in terms of flowering plant of tuberose (Table 2). The maximum flowering plant (97.33 %) was found from F_1M_2 and the minimum flowering plant (70.02 %) was recorded from F_0M_0.

3.5 Length of flower stalk at harvest

Significant variation was recorded due to combined effect on nutrient sources and mulches in terms of length of the flower stalk at harvest of tuberose (Table 2). The maximum length of flower stalk at harvest (67.45 cm) was observed from the treatment combination of F_1M_2 and the minimum length of flower stalk at harvest (51.01 cm) was observed from the treatment combination of F_0M_0.

3.6 Length of rachis at harvest

Length of rachis at harvest of tuberose showed significant variation due to combined effect of nutrient sources and mulch (Table 2). The maximum length of rachis at harvest (40.22 cm) was recorded from the treatment combined of F_1M_2 and the minimum length of rachis at harvest (28.58 cm) was recorded from F_0M_0.

3.7 Number of spikelets per spike

Significant variation was recorded due to combined effect of nutrient sources and mulches in terms of number of spikelets per spike of tuberose (Table 2). The maximum number of spikelets per spike (16.77) was found from F_1M_2 and the minimum number of spikelets per spike (9.30) was recorded from F_0M_0.

3.8 Yield of spike per hectare

Combined effect of nutrient sources and mulches showed significant variation on spike per hectare of tuberose under the present trial (Table 2). The maximum yield of spike per hectare (3,69,290) was found from F_1M_2 and the minimum yield of spike per hectare (2,90,760) was found from F_0M_0.

Table 2: Interaction effect of nutrient sources and mulch on growth parameter of tuberose

Treatment	Days required to emergence of spike	Flowering plant (%)	Length of flower stalk at harvest (cm)	Length of rachis at harvest (cm)	Number of spikelets per spike	Number of spike per hectare (000)
F_0M_0	68.70 a	70.02 g	51.03 f	28.58 g	9.30 h	290.76 g
F_0M_1	60.36 bc	79.02 f	57.41 e	33.60 ef	11.47 e-g	316.41 c-f
F_0M_2	61.36 b	82.02 d-f	59.49 de	31.68 f	12.68 d-f	323.75 c-f
F_1M_0	59.37 cd	84.69 de	60.19 c-e	35.99 c-e	11.81 e-g	333.83 b-e
F_1M_1	58.04 d-f	92.69 ab	64.47 ab	38.18 a-c	15.16 a-c	366.50 a
F_1M_2	58.37 de	97.35 a	67.45 a	40.22 a	16.77 a	369.29 **a**
F_2M_0	58.70 c-e	80.02 ef	57.26 e	33.98 ea	10.29 gh	306.60 c-f
F_2M_1	59.04 c-e	91.02 bc	64.13 a-c	37.33 a-d	15.34 ab	339.90 b-d
F_2M_2	58.38 de	94.02 ab	65.73 a	39.20 ab	16.17 ab	364.12 a
F_3M_0	56.37 f	80.03 ef	56.83 e	34.66 de	10.92 f-h	320.18 d-f
F_3M_1	58.05 d-f	92.85 ab	63.39 a-d	37.70 a-c	15.07 a-c	342.98 bc
F_3M_2	57.38 ef	87.35 cd	64.86 ab	37.99 b-d	14.77 a-c	338.81 b-d
F_4M_0	59.04 c-e	85.92 d	61.03 b-e	37.68 c-e	13.31 c-e	328.86 c-e
F_4M_1	59.71 cd	83.31 d-f	59.76 de	33.99 ef	12.80 d-f	323.97 c-f
F_4M_2	58.37 de	91.58 bc	64.03 a-c	38.13 a-c	12.58 b-d	343.54 ab
$LSD_{(0.05)}$	1.561	4.824	3.803	2.601	1.792	49.931
CV(%)	6.41	7.09	8.61	5.79	7.95	6.64

3.9 Thickness of individual bulb

Statistically significant variation was recorded due to the combined effect of nutrient sources and mulch in terms of thickness of individual bulb of tuberose (Table 3). The maximum thickness of individual bulb (6.47 cm) was observed from F_2M_1 and the minimum thickness of the individual bulb (4.23 cm) was recorded from F_0M_0.

3.10 Weight of individual bulb

Combined effect of nutrient sources and mulches varied significantly in terms of weight of individual bulb of tuberose

(Table 3). The maximum weight of individual bulb (29.42 g) was observed in F_1M_2 and the minimum weight of individual bulb (18.69 g) was observed from F_0M_0.

3.11 Diameter of individual bulb
Significant variation was recorded due to combined effect of nutrient sources and mulch in terms of diameter of individual bulb of tuberose (Table 3). The maximum diameter of individual bulb (2.17 cm) was recorded from the treatment combination of F_1M_2 and the minimum diameter of individual bulb (1.39) was recorded from F_0M_0.

3.12 Number of bulblet per plant
Significant variation was recorded due to combined effect of nutrient sources and mulch in terms of number of bulblet per plant of tuberose (Table 3). The maximum number of bulblet per plant (23.34) was observed from F_1M_2 and the minimum number of bulblet per plant (14.15) was counted from F_0M_0.

3.13 Weight of bulblet per plant
Weight of bulblet per plant of tuberose showed significant variation due to interaction effect of nutrient sources and mulch (Table 3). The maximum weight of bulblet per plant (14.67 g) was observed from F_1M_2 and the minimum weight of bulblet per plant (8.64 g) was recorded from F_0M_0.

3.14 Diameter of bulblet
Significant variation was recorded due to interaction effect of nutrient sources and mulch in terms of diameter of bulblet of tuberose (Table 3). The maximum diameter of bulblet (1.45 cm) was recorded from F_1M_2 and the minimum diameter of bulblet (1.02 cm) was recorded from F_0M_0.

Table 3: Interaction effect of nutrient sources and mulch on bulb and bulblet parameter 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
F_0M_0	4.24 d	18.69 e	1.39 h	14.15 h	7.61 h	1.02 h
F_0M_1	4.98 cd	23.71 cb	1.85 d-f	19.41 de	9.45 g	1.03 gh
F_0M_2	5.27 bc	24.37 c	1.98 b-d	20.26 b-e	10.19 fg	1.13 fg
F_1M_0	5.36 bc	24.18 c	1.72 fg	16.92 fg	11.69 b-d	1.25 c-e
F_1M_1	5.20 bc	26.91 b	2.11 ab	21.77 ab	13.04 a	1.41 ab
F_1M_2	6.21 a	29.42 a	2.17 a	23.34 a	13.64 a	1.45 a
F_2M_0	4.81 cd	22.28 d	1.57 g	16.31 g	10.46 e-g	1.14 e-g
F_2M_1	5.22 bc	26.26 b	2.04 a-c	21.68 ab	12.96 a	1.34 a-d
F_2M_2	6.47 a	27.26 b	2.01 b-d	21.85 ab	13.61 a	1.37 a-d
F_3M_0	4.95 cd	23.56 cd	1.70 fg	17.13 fg	11.01 c-f	1.25 d-f
F_3M_1	5.95 ab	27.35 b	2.02 a-c	21.28 bc	12.71 ab	1.37 a-d
F_3M_2	5.38 bc	23.76 cd	1.84 d-f	20.77 b-d	11.77 bc	1.32 b-d
F_4M_0	5.31 bc	23.81 cd	1.77 ef	18.58 ef	11.51 c-e	1.26 c-e
F_4M_1	5.19 bc	23.71 cd	1.85 d-f	19.24 de	10.56 d-g	1.15 ef
F_4M_2	5.58 a-c	25.84 b	1.90 c-e	19.68 c-e	10.79 ab	1.37 a-c
$LSD_{(0.05)}$	0.683	1.468	0.150	1.596	1.055	0.108
CV(%)	6.55	5.46	6.84	7.85	6.24	5.82

3.15 Yield of bulb per plot
Significant difference was recorded due to interaction effect of nutrient sources and mulch in terms of the yield of bulb per plot of tuberose (Table 4). The maximum yield of bulb per plot (0.64 kg) was found from F_1M_2 and the minimum yield of bulb per plot (0.19 kg) was recorded from F_0M_0.

3.16 Yield of bulblet per plot
Variation was recorded due to combined effect of nutrient sources and mulches in terms of yield of bulblet per plot of tuberose (Table 4). The maximum yield of bulblet per plot (0.57 kg) was observed from the treatment of F_1M_2 and the minimum yield of bulblet per plot (0.19 kg) was observed from F_0M_0.

3.17 Yield of bulb per hectare
Combined effect of nutrient sources and mulches varied significantly on terms of yield of bulb per hectare of tuberose (Table 4). The maximum yield of bulb per hectare (31.83 ton) was observed from F_1M_1 and the minimum yield of bulb per hectare (12.21 ton) was recorded from F_0M_0.

3.18 Yield of bulblet per hectare
Statistically significant variation was recorded due to combined effect of nutrient sources and mulches in terms of yield of bulblet per hectare of tuberose (Table 4). The maximum yield of bulblet per hectare (27.12 ton) was observed from F_1M_2 and the minimum yield of bulblet per hectare (12.85 ton) was observed from F_0M_0.

Table 4: Interaction effect of nutrient sources and mulch on yield of tuberose

Treatment	Yield of bulb (kg/plot)	Yield of bulblet (kg/plot)	Yield of bulb (t/ha)	Yield of bulblet (t/ha)
F_0M_0	0.19 f	0.21 e	12.21 f	12.85 e
F_0M_1	0.41 e	0.37 d	19.52 e	17.24 d
F_0M_2	0.45 cde	0.40 cd	21.36 d	18.71 cd
F_1M_0	0.41 e	0.39 d	19.64 e	17.98 d
F_1M_1	0.55 abc	0.49 bc	26.46 abc	22.94 abc
F_1M_2	0.64 a	0.57 a	30.82 a	27.12 a
F_2M_0	0.38 e	0.37 d	17.81 e	17.16 d
F_2M_1	0.53 bcd	0.49 bc	25.31 bcd	22.80 abc

F_2M_2	0.58 ab	0.52 ab	27.96 ab	24.50 ab
F_3M_0	0.44 de	0.43 cd	21.07 d	20.27 bcd
F_3M_1	0.55 bcd	0.48bc	24.86 bcd	22.70 abc
F_3M_2	0.47cde	0.41 cd	22.32 cde	19.25 cd
F_4M_0	0.46cde	0.41 cd	22.37 cde	20.13 bcd
F_4M_1	0.45 cde	0.39 cd	21.65 cde	19.12 cd
F_4M_2	0.53bcd	0.46 bc	25.61 bcd	22.64 abc
$LSD_{(0.05)}$	0.093	0.072	4.331	4.064
CV(%)	10.42	11.63	10.74	11.65

4. Conclusion

The maximum yield of spike per hectare (3,69,290) was found from F_1M_2 and the minimum (2,90,760) was found from F_0M_0. The maximum diameter of individual bulb (2.17 cm) was recorded from F_1M_2 and the minimum diameter (1.39) was recorded from F_0M_0. The maximum diameter of bulblet (1.45 cm) was recorded from F_1M_2 and the minimum diameter (1.02 cm) was recorded from F_0M_0. The maximum yield of bulb per hectare (31.83 ton) was observed in F_1M_2 and the minimum (12.21 ton) was recorded from F_0M_0. The maximum yield of bulblet per hectare (27.12 ton) was observed from F_1M_2 and the minimum yield (12.85 ton) was observed from F_0M_0. So, application of cowdung 10 t + 250 kg Urea + 190 kg TSP + 190 kg MP per hectare with water hyacinth mulch was found suitable for growth and yield of tuberose.

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