

Influence of Organic Amendments and Bio-Control Agent on Yield and Quality of Tuberose

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Abstract

An experiment was conducted to determine the appropriate dose and combination of organic and chemical fertilizers and to assess the effect of bio-control agent (*Trichoderma*) on qualitative and quantitative characteristics of tuberose (*Polianthes tuberosa* L. cv. Single), including stem length, rachis length, spike length, floret number, flower yield, flower durability, number of bulb etc. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications having eight treatments as follows: T₁= Farmyard manure (5 t/ha) + ¼ RDF, T₂= Poultry refuse (5 t/ha) + ¼ RDF, T₃= Bokashi (3 t/ha) + ¼ RDF, T₄= Mustard oil cake (500 kg/ha) + ¼ RDF, T₅= Vermicompost (5 t/ha) + ¼ RDF, T₆= Tricho-compost (3 t/ha) + ¼ RDF, T₇= Tricho-leachate (3000 L/ha) + ¼ RDF and T₈= Control (Recommended doses of fertilizer) (N₁₅₀ P₄₅ K₈₈ S₁₀ B₁ Zn₁ kg/ha). Maximum growth, yield and yield contributing characters were recorded in T₆= Tricho-compost (3 t/ha) + ¼ RDF which were statistically superior to other treatments. Maximum plants emergence (93.3%) recorded in T₆ (Tricho-compost + ¼ RDF). In case of plant height, number of leaves per plant, plant spread, days to flowering, number of florets, flower yield, bulb production, T₆= Tricho-compost (3 t/ha) + ¼ RDF gave superior results over control (Recommended doses of fertilizer). The data obtained from the experiment showed that Tricho-compost with fertilizer enhanced qualitative and quantitative characters of tuberose flowers.

Keywords: *Polianthes tuberosa* L.; Organic amendments; Tricho-compost; Flower quality; Bulb production

Introduction

Tuberose (*Polianthes tuberosa* L.), a member of Amaryllidaceae family was originated in Mexico and grown on large scale in Asia. It is an important cut flower crop from aesthetic as well as commercial point of view. 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 [1]. Tuberose occupies a very selective and special position to flower loving people. It has a great economic potential for cut flower trade and essential oil industry. Apart from ornamental value, tuberose is extensively utilized in medicines for headache, diarrhea, rheumatism and allied pains (Mukhopadhyay, 1998). In Bangladesh, for the last few years, tuberose has become a popular cut flower for its attractive fragrance and beautiful display in the vase. Now it has high demand in the market and its production is highly profitable [2].

In recent years, there have been serious concerns about long-term adverse effect of continuous and indiscriminate use of inorganic fertilizers on deterioration of soil structure, soil health and environmental pollution [3]. In contrast, to inorganic fertilizer, the use of bio-control agent, green manures, and other organic matter can improve soil structure, maintain soil health, increase nutrient uptake, suppress soil borne fungal pathogens and that is why interests have been raising in organic farming and uses of *Trichoderma* spp. in

flowers for bio-control and improve flower quality [4-6]. Tuberose is a gross feeder and requires a large quantity of NPK, both in the form of organic and inorganic fertilizers [7]. Fertilizers have great influence on growth, building and flower production in tuberose. Effect of chemical and manures on tuberose production has been reported by several authors for different geographical region [3,8].

Nitrogen, phosphorus and potassium have a significant effect on spike production and floret quality. Duration of flower in the field was improved through using organic fertilizer. Poultry manure is an excellent organic fertilizer, as it contains high nitrogen, phosphorus, potassium and other essential nutrients [9]. Vermicompost has been shown to have high levels of total and available nitrogen, phosphorus, potassium, micronutrients, microbial and enzyme activities and growth regulators [10]. Mustard oil cake is an excellent source of organic amendment can replace not only the use of chemical fertilizers but also replace the use of pesticides by suppressing pathogens and insects [11]. Research works have shown that compost and other organic manures like bokashi, farmyard manure, cocodust, water hyacinth, mustard oil cake, vermicompost etc. can serve as soil amendments to improve soil nutrient status and water holding capacity particularly in sandy soils [12]. They also stabilize soil pH, increase soil organic matter and ultimately improve plant growth, yields and quality.

Trichoderma harzianum is a saprophytic fungus which is generally used as a biological control agent against a wide range of economically important aerial and soil borne plant pathogens and has been extensively studied as potential bio-control agents [13,14]. However, some studies have also shown that it can stimulate the growth of a

number of flower and ornamental crops [15,16]. Mazhabi, et al. [5] investigated the effect of *Trichoderma* spp. on growth of tuberose and its ability to control stem rot disease caused by *Rhizoctonia solani*. They observed that *Trichoderma* suppressed soil borne fungal pathogens as well as enhanced quantitative and qualitative traits of tuberose. They also found that tuberose bulbs planting in Tricho-compost treated plot reduced emergence time compared to controls. From their results and those of Mishra et al. [17] it was concluded that some *Trichoderma* strains have the potential to consistently increase plant growth, spike length, rachis length, floret number as well as flower yield by suppressing soil borne fungal pathogens, root knot nematode and bacterial wilt. Moreover, Tricho-compost is highly rich in various elements that may enrich soil fertility and provide nutrition to the crops. Considering the importance and constraints to cultivate tuberose in Bangladesh an investigation will be carried out with the following objectives: to determine the appropriate dose and combination of organic and chemical fertilizers and to assess the effect of bio-control agent (*Trichoderma*) on qualitative and quantitative characteristics of tuberose.

Materials and Methods

An experiment was conducted at the Floriculture Research Field, Horticulture Research Centre of Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh during February 2013 to December 2013.

Planting material

Medium sized (2.0-2.5 cm diameter) bulb of tuberose single cultivar was selected as planting materials. The single ever blooming Mexican Tuberose is one of the most fragrant of cultivated tuberose. This wonderful cut flower bears clusters of waxy, white tube-shaped flowers from early to late summer. The flowers are beautiful but it is their sweet, rich fragrance that steals the show.

Treatments

The experiment consisted of 8 treatments comprising of different level of organic amendments and bio-control agent.

T₁=Farmyard manure (5 t/ha) + ¼ RDF

T₂= Poultry refuse (5 t/ha) + ¼ RDF

T₃= Bokashi (3 t/ha) + ¼ RDF

T₄= Mustard oil cake (500 kg/ha) + ¼ RDF

T₅= Vermicompost (5 t/ha) + ¼ RDF

T₆= Tricho-compost (3 t/ha) + ¼ RDF

T₇= Tricho-leachate (3000 L/ha) + ¼ RDF and

T₈ = Control (Recommended doses of fertilizer i.e. N₁₅₀ P₄₅ K₈₈ S₁₀ B₁ Zn₁kg/ha) [18].

Soil and climatic condition of the experimental site

The experimental site was situated in the subtropical climatic zone and characterized by heavy rainfall during the month of May to September while scanty rainfall during the rest of the year. During study period the average maximum and minimum temperature was 30°C and 25°C respectively, average RH was 80% and the average rainfall was 205 mm. The soil of the experimental field was silty clay

loam in texture and acidic in nature. It belongs to the "Shallow red-brown Terrace" soil of Madhupur Tract [19].

Farmyard manure

Farmyard Manure is prepared using cow dung, cow urine, waste straw and other dairy wastes. Cow dung which get in abundance (10 cows...) was collected after cleaning cowshed in a pit close by and was allowed to decompose over a period of time. Every month this manure (compost) was applied to the plants or the field to enrich the soil.

Poultry refuse

Poultry refuse is a waste material, which is organic in nature and comprises of urine and feces of animals, which are related to poultry e.g. chicken. Poultry manure is a mixture of certain types of bedding material such as sawdust or wood shavings. The manure is acquired by cleaning of the poultry houses on regular basis where thin bedding layers are removed along with such manure. So the manure which is basically the waste from chicken dropping and other mixtures, when used as fertilizer is called Chicken fertilizer.

Tricho-compost

Tricho-compost, a *Trichoderma* based compost fertilizer, was developed by mixing a definite concentration of spore suspension of a *Trichoderma harzianum* strain with measured amounts of processed raw materials, such as cowdung, poultry refuse, water hyacinth, vegetable wastes, sawdust, maize bran, and molasses. Tricho-leachate, a liquid by-product of the Tricho-compost, was obtained during decomposition of Tricho-compost materials.

Bokashi

Bokashi was made comprising fish meal, oil cake, bone meal, rice bran, poultry refuse @ 20 kg, 40 kg, 20 kg, 100 kg and 100 kg, respectively. After adding 50% water, the components were mixed together and 5 kg half fermented cowdung were added which contained effective micro-organism. Then the mixtures were piled for fermentation for several weeks. During fermentation temperature was raised up to 70°C. While the temperature exceeded 55°C the piled was broken for removing heat. Temperature did not exceed 40°C indicated that the mixture was fermented.

Vermi-compost

The cowdung collected from local cowshed was decomposed for 10 days before putting into vermicompost process. These were kept in a chari. Twenty kg of decomposed cowdung substrate was taken in a chari for vermicomposting. Two hundred gram of *Eisenia fetida* earthworms were introduced on the top of the substrate in the chari. The chari was covered on the top by jute cloth cover to prevent and protect the earthworms from predators. After 60-70 days, when the substrate looks tea like structure, the vermicompost was ready for use.

Mustard oil cake

Mustard oil cakes are the by-products of mustard oil seed crop. Oil cakes are the important and quick acting organic nitrogenous manure. It also contain small amount of phosphorous and potassium.

Cultivation procedures

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The unit plot size was 1.5 m × 1.2 m accommodating 30 plants per plot. Two adjacent unit plots were separated by 60 cm space and there was 80 cm space between the blocks. The entire amount of organic amendments, tricho-compost, tricho-leachate, P, K, S, B and Zn were applied during final plot preparation. N was applied in three installments at 35, 55 and 75 days after planting of bulbs. Bulbs were thoroughly treated with fungicide Provax for 5 minutes and planted at a depth of 6 cm in each plot on February 15, 2013. Spacing was maintained at 30 cm from row to row and 20 cm from plant to plant. Weeding was done periodically whenever necessary. The experimental plot was irrigated as and when necessary during the whole period of plant growth following flood method. The soil was mulched frequently after irrigation by breaking the crust for easy aeration and conservation of soil moisture. Earthing up was done at 40, 60 and 80 days after planting to make a continuous ridge for facilitating easy drainage of excess water.

Data collection

Data were recorded on various growth characteristics such as emergence percentage, plant height (cm), plant spread and number of leaves per plant, flowering characteristics such as days required for flowering, number of spikes per plant, spike length (cm), spike weight (g), rachis length (cm), flower durability (days), flower yield and bulb characteristics such as number of bulbs per plant, size (diameter) and weight of bulb, number and weight of bulblets.

Emergence percentage was observed by counting the sprouted bulbs after 60 days of sowing and then converted it in percentage (%). Plant height was measured in cm with the help of measuring tape when plants were fully matured. Total number of leaves of each plant was counted after the completion of vegetative growth of the plant. Days required for flowering in 25 percent plants were counted from sowing of the bulbs up to when 25 percent of sown bulbs produced flowers. Number of spikes plant⁻¹ was counted when plants completed their blooming. The length of spike was measured in cm from the end where from it was cut off at the base to the tip of the spike by measuring scale. The length of rachis was measured in cm by placing lower end of the measuring rod touching the base of lowest floret up to top of the upper floret of the spike. Weight of spike was measured by an electrical balance expressed in grams. Number of florets spike⁻¹ was counted when all the florets of the spike were fully opened. Flower durability was recorded from the time of first floret opening to the maximum freshness on each sample plant and expressed in days.

Flower yield per hectare was computed from counting the number of spikes per plot and converted to hectare. Numbers of bulbs were counted when all the florets of the spike were dropped. Size (diameter) of bulb was measured with the help of vernier caliper from each sample and finally the bulbs were weighed on an electric balance to observe weight of bulbs in grams. Collected data were analyzed statistically by performing analysis of variance technique and treatments were compared according to Duncan's Multiple Range test at 5% level of probability [20].

Results

Vegetative growth characteristics

Emergence Percentage(%): Emergence percentage varied significantly with different treatments. Maximum emergence percentage was observed in T₆ (93.3%) followed by T₁, T₂, T₃, T₄ and T₅. The lowest emergence percentage was noted in T₈ (80%) (Figure 1). These results indicate that application of organic fertilizers with chemical fertilizer had tremendous effects on plant growth and development in tuberose. But the effect was more pronounced in Tricho-compost.

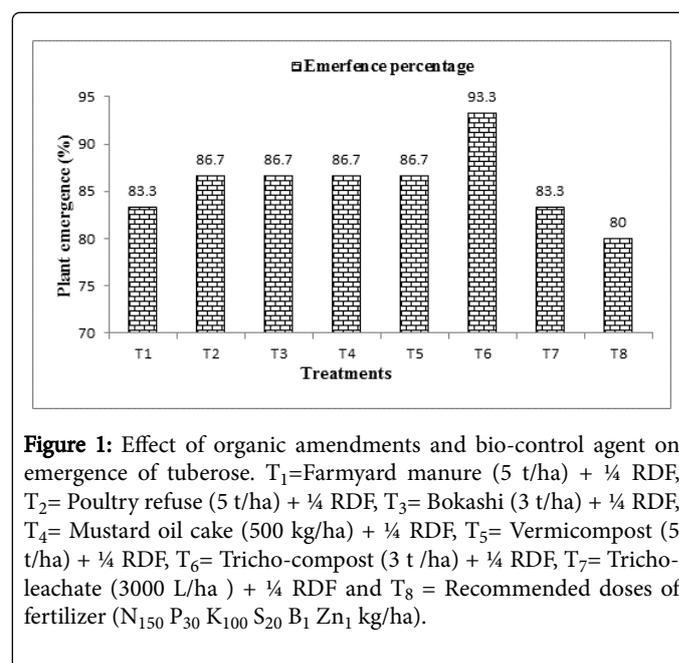


Figure 1: Effect of organic amendments and bio-control agent on emergence of tuberose. T₁=Farmyard manure (5 t/ha) + ¼ RDF, T₂= Poultry refuse (5 t/ha) + ¼ RDF, T₃= Bokashi (3 t/ha) + ¼ RDF, T₄= Mustard oil cake (500 kg/ha) + ¼ RDF, T₅= Vermicompost (5 t/ha) + ¼ RDF, T₆= Tricho-compost (3 t/ha) + ¼ RDF, T₇= Tricho-leachate (3000 L/ha) + ¼ RDF and T₈ = Recommended doses of fertilizer (N₁₅₀ P₃₀ K₁₀₀ S₂₀ B₁ Zn₁ kg/ha).

Days to sprouting: The variation among the treatments in respect of days to sprouting of bulb per plant was found significant. The bulbs under T₆ (6 days) took minimum time for sprouting, while the bulbs of T₈ (11 days) required maximum time (Table 1).

Treatments	Days sprouting to	Plant height (cm)	Leaves/plant	Plant spread (cm)
T ₁	8.0ab	56.6ab	32.0ab	18.9ab
T ₂	8.0ab	59.5a	34.0a	19.8ab
T ₃	8.0ab	59.0a	33.0a	19.5ab
T ₄	8.0ab	57.0ab	33.0a	19.4ab
T ₅	8.0ab	55.0b	32.0ab	19.2ab
T ₆	6.0b	60.0a	35.0a	20.8a
T ₇	9.0ab	49.6c	30.0b	18.0ab
T ₈	11.0 a	53.4 bc	25.0 c	16.0 b
CV%	8.7	10.2	11.1	10.9

Table 1: Effect of organic amendments and bio-control agent on vegetative growth of tuberose. T₁=Farmyard manure (5 t/ha) + ¼ RDF, T₂= Poultry refuse (5 t/ha) + ¼ RDF, T₃= Bokashi (3 t/ha) + ¼ RDF,

T₄= Mustard oil cake (500 kg/ha) + ¼ RDF, T₅= Vermicompost (5 t/ha) + ¼ RDF, T₆= Tricho-compost (3 t /ha) + ¼ RDF, T₇= Tricho-leachate (3000 L/ha) + ¼ RDF and T₈ = Recommended doses of fertilizer (N₁₅₀ P₃₀ K₁₀₀ S₂₀ B₁ Zn₁ kg/ha).

Plant height: Significant variations among the treatments were observed in respect of plant height. Tricho-compost, poultry manure and bokashi treatments were statistically identical but superior to other treatments. Maximum plant height was recorded in T₆ (60.0 cm) followed by T₂ (59.5 cm) and T₃ (59.0 cm). Shortest plants were recorded in T₇ (49.6 cm) (Table 1).

Leaf number: The result revealed that there was a variation in number of leaves per plant among the treatments studied (Table 1). The maximum number of leaves were found in T₆ (35.0) which statistically similar to T₂ (34.0), T₃ (33.0) and T₄ (33.0). The lowest number of leaves/plant was found in control (25.0).

Plant spread (cm): The plant spread of tuberose plant is an important morphological character that influences the yield, because it is correlated with photosynthesis by the higher leaf area. There were significant differences among the treatment in respect of plant spread (Table 1). Maximum plant spread was recorded in T₆ (20.8 cm) which was statistically different from other treatments. The minimum plant spread (16.0 cm) was observed in control.

Floral characteristics

Days to flowering: Days required to flowering showed variation for different treatment (Figure 2). The minimum days required for bulb planting to flowering was recorded in T₆ (75 days) followed by T₂ (78 days), T₃ (81days) and T₄ (82 days). Time required to flowering (90 days) was found to be delayed in control treatment (Figure 2).

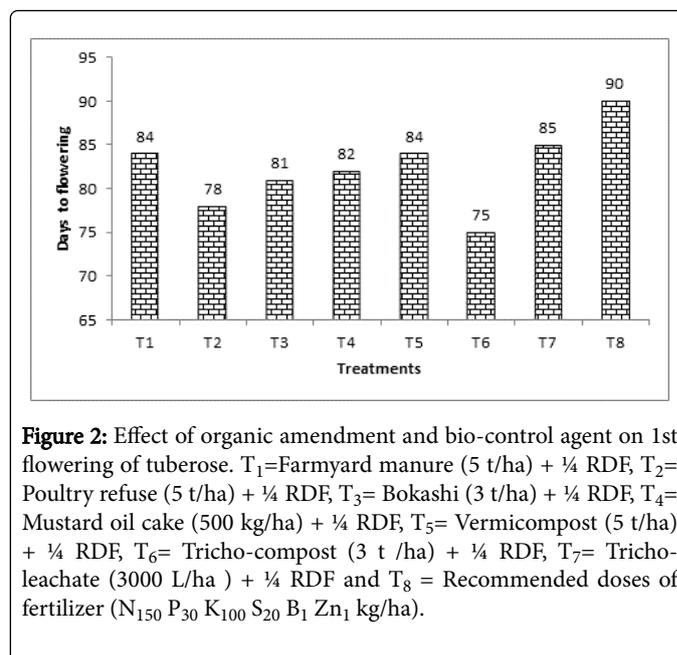


Figure 2: Effect of organic amendment and bio-control agent on 1st flowering of tuberose. T₁=Farmyard manure (5 t/ha) + ¼ RDF, T₂= Poultry refuse (5 t/ha) + ¼ RDF, T₃= Bokashi (3 t/ha) + ¼ RDF, T₄= Mustard oil cake (500 kg/ha) + ¼ RDF, T₅= Vermicompost (5 t/ha) + ¼ RDF, T₆= Tricho-compost (3 t /ha) + ¼ RDF, T₇= Tricho-leachate (3000 L/ha) + ¼ RDF and T₈ = Recommended doses of fertilizer (N₁₅₀ P₃₀ K₁₀₀ S₂₀ B₁ Zn₁ kg/ha).

Spike length: Length of flower spike for different treatments showed a statistically significant variation in tuberose (Table 2). The maximum spike length was recorded in T₆ (80.0 cm) followed by T₂ (77.5 cm), T₃ (77.3 cm) and T₄ (77.1 cm). The shortest spike length was found in control (70.0 cm). The increased spike length was probably due to the better vegetative and reproductive growth of tuberose in T₆.

Treatments	Spike length (cm)	Rachis length (cm)	Spike weight (g)	Yield /plot (no.)	Yield/ha (no.)
T1	76.0b	26.5b	53.9bc	90	500000
T2	77.5ab	31.0a	55.6b	108	600000
T3	77.3ab	30.4ab	55.4b	99	550000
T4	77.1ab	30.2ab	54.8bc	93	515000
T5	74.0bc	25.7bc	50.4c	84	460000
T6	80.0a	32.0a	60.0a	120	660000
T7	72.0bc	21.8c	47.0cd	72	400000
T8	70.0c	14.5d	45.6d	66	360000
CV%	10.7	6.5	11.8	-	14.1

Table 2: Effect of organic amendment and bio-control agent on flowering of tuberose. T₁=Farmyard manure (5 t/ha) + ¼ RDF, T₂= Poultry refuse (5 t/ha) + ¼ RDF, T₃= Bokashi (3 t/ha) + ¼ RDF, T₄= Mustard oil cake (500 kg/ha) + ¼ RDF, T₅= Vermicompost (5 t/ha) + ¼ RDF, T₆= Tricho-compost (3 t /ha) + ¼ RDF, T₇= Tricho-leachate (3000 L/ha) + ¼ RDF and T₈ = Recommended doses of fertilizer (N₁₅₀ P₃₀ K₁₀₀ S₂₀ B₁ Zn₁ kg/ha).

Rachis length: Different treatments of organic amendment and bio-control agent had significant effect on the length of rachis in tuberose (Table 2). The rachis length ranged from 14.5 to 32.0 cm. The maximum length of rachis was obtained in T₆ (32.0 cm), while the minimum length was found in T₈ (14.5 cm), which differed significantly from all other treatments.

Spike weight: It was revealed from Table 2 that different treatments of organic amendment and bio- control agent had significant effect of spike weight (Table 2). The maximum weight of spike was obtained in T₆ (60.0 g) followed by T₂ (55.6 g) and T₃ (55.4 g) and the minimum in T₈ (45.6 g) and was statistically comparable to the remaining treatments. These results indicated that, spike weight was increased

with the increases of nutritional element from tricho-compost. Maximum number of leaves was produced by the application of Tricho-compost which enhanced to constitute chlorophyll that leads better quality of spike in tuberose.

Floret number per spike: The floret number is an important parameter of tuberose. Variation was recorded for number of floret/spike for different treatments under the investigation (Figure 3). The maximum number of florets were found in T₆ (45) followed by T₂ (42), T₃ (41) and T₄ (40). The lowest numbers of floret/plant were found in control (29).

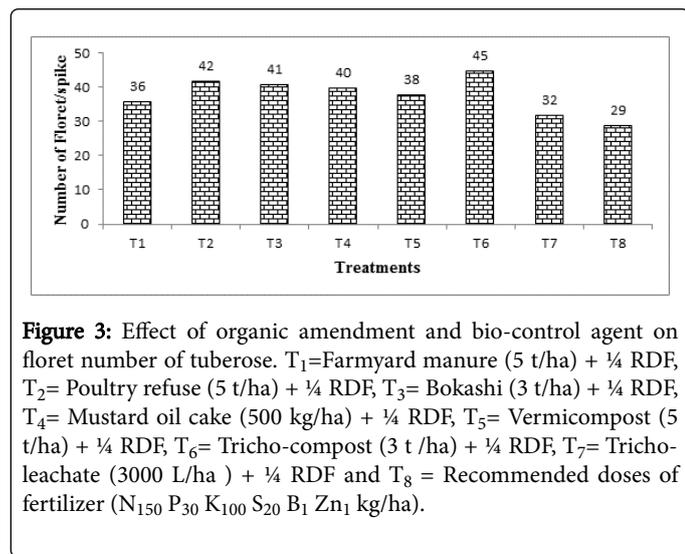


Figure 3: Effect of organic amendment and bio-control agent on floret number of tuberose. T₁=Farmyard manure (5 t/ha) + ¼ RDF, T₂= Poultry refuse (5 t/ha) + ¼ RDF, T₃= Bokashi (3 t/ha) + ¼ RDF, T₄= Mustard oil cake (500 kg/ha) + ¼ RDF, T₅= Vermicompost (5 t/ha) + ¼ RDF, T₆= Tricho-compost (3 t/ha) + ¼ RDF, T₇= Tricho-leachate (3000 L/ha) + ¼ RDF and T₈ = Recommended doses of fertilizer (N₁₅₀ P₃₀ K₁₀₀ S₂₀ B₁ Zn₁ kg/ha).

Flower durability: Maximum duration of flowering was observed in T₆ (12 days) followed by T₂, T₃ and T₄ (11 days). The minimum flowering duration was in T₈ (7 days) (Figure 4).

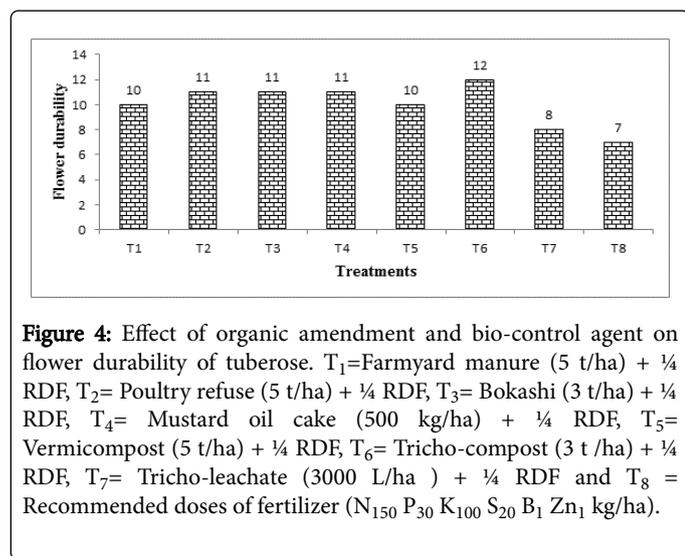


Figure 4: Effect of organic amendment and bio-control agent on flower durability of tuberose. T₁=Farmyard manure (5 t/ha) + ¼ RDF, T₂= Poultry refuse (5 t/ha) + ¼ RDF, T₃= Bokashi (3 t/ha) + ¼ RDF, T₄= Mustard oil cake (500 kg/ha) + ¼ RDF, T₅= Vermicompost (5 t/ha) + ¼ RDF, T₆= Tricho-compost (3 t/ha) + ¼ RDF, T₇= Tricho-leachate (3000 L/ha) + ¼ RDF and T₈ = Recommended doses of fertilizer (N₁₅₀ P₃₀ K₁₀₀ S₂₀ B₁ Zn₁ kg/ha).

Yield/ha: Maximum yield per plot was found in T₆ (120 sticks) and the minimum was observed in T₈ (66 sticks). When the unit plot yield of the treatments was converted into per ha yield regarding numbers, T₆ (6, 60,000) produced the maximum number of flowering spike which was statistically superior to other treatments. The second highest number of flowering spikes per ha was recorded in T₂ (6, 00,000) (Figure 5).

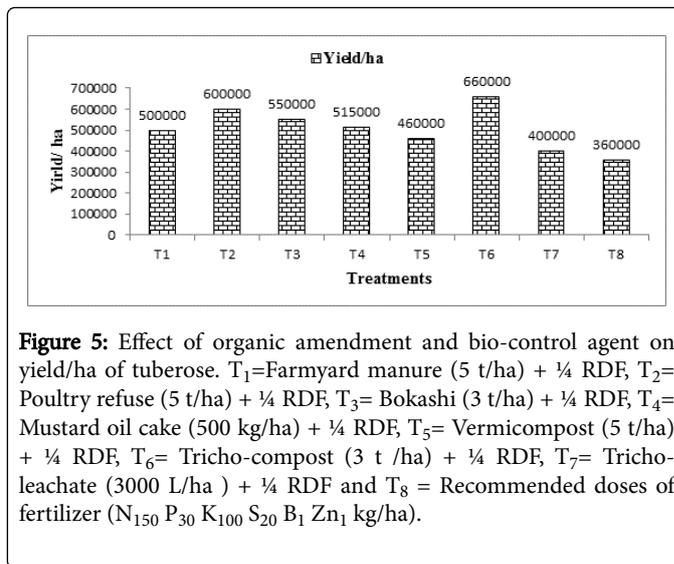


Figure 5: Effect of organic amendment and bio-control agent on yield/ha of tuberose. T₁=Farmyard manure (5 t/ha) + ¼ RDF, T₂= Poultry refuse (5 t/ha) + ¼ RDF, T₃= Bokashi (3 t/ha) + ¼ RDF, T₄= Mustard oil cake (500 kg/ha) + ¼ RDF, T₅= Vermicompost (5 t/ha) + ¼ RDF, T₆= Tricho-compost (3 t/ha) + ¼ RDF, T₇= Tricho-leachate (3000 L/ha) + ¼ RDF and T₈ = Recommended doses of fertilizer (N₁₅₀ P₃₀ K₁₀₀ S₂₀ B₁ Zn₁ kg/ha).

Bulb characteristics

Number of bulb/hill: Number of bulb per hill showed significant difference among the treatments (Table 3). The maximum number of bulb/hill was found in T₆ (6.0) which was significantly higher than all other treatments. The lowest number of bulb per hill was observed in T₈ (2.0).

Treatments	Number of bulb/hill	Number of Bulblet/hill	Bulb diameter (cm)	Bulb weight (g)
T1	3.0 ab	11.0 b	2.9 ab	36.8 ab
T2	4.0 ab	13.0 ab	2.8 ab	38.0 ab
T3	4.0 ab	13.0 ab	2.6 ab	37.0 ab
T4	4.0 ab	13.0 ab	2.5 ab	30.3 c
T5	3.0ab	11.0 b	2.5 ab	35.0 b
T6	6.0 a	15.0 a	4.0 a	40.0 a
T7	3.0 ab	8.0bc	2.3 ab	28.5 cd
T8	2.0 b	6.0 c	1.5 b	24.0 d
CV%	6.8	9.7	7.2	10.1

Table 3: Effect of organic amendment and bio-control agent on bulb and bulblet production of tuberose. T₁=Farmyard manure (5 t/ha) + ¼ RDF, T₂= Poultry refuse (5 t/ha) + ¼ RDF, T₃= Bokashi (3 t/ha) + ¼ RDF, T₄= Mustard oil cake (500 kg/ha) + ¼ RDF, T₅= Vermicompost (5 t/ha) + ¼ RDF, T₆= Tricho-compost (3 t/ha) + ¼ RDF, T₇= Tricho-leachate (3000 L/ha) + ¼ RDF and T₈ = Recommended doses of fertilizer (N₁₅₀ P₃₀ K₁₀₀ S₂₀ B₁ Zn₁ kg/ha).

Number of bulblet/hill: Number of bulblet/hill showed a statistically significant variation for different treatments under present study (Table 3). The maximum number of bulblet/hill was recorded in T₆ (15.0) followed by T₂ (13.0), T₃ (13.0) and T₄ (13.0) and T₈ (6.0) produced minimum number of bulblets (Table 3).

Bulb diameter: Data on the effect of different level of organic amendment and bio-control agent on tuberose bulb diameter are presented in Table 3. The largest bulb was produced in T₆ (4.0 cm) which were statistically different from other treatments. The smallest bulb obtained from control (1.5 cm).

Bulb weight: Weight of individual bulb showed statistically significant variation for different treatments under the present investigation (Table 3). The maximum weight of individual bulb was recorded in T₆ (40.0 g) which was statistically different from other treatments and the minimum weight of individual bulb was recorded in T₈ (24.0 g).

Insect and disease infestation: Tuberose is susceptible to several insect and disease which adversely affect the quality and quantity of the crop. The crop is mostly infested by mealybug and aphids [11]. The major diseases like leaf spot disease and botrytis blight occurred in tuberose [21]. Misra and Singh [22] reported very few diseases and pest occur in tuberose. Leaf spot disease, mealybug and aphid infestation were not found in case of T₂, T₃, T₄ and T₆. The highest disease incidence and insect infestation was observed in T₈ (control) (Table 4). The results are in partial agreement with Mishra et al. [23] in gladiolus.

Treatments	Disease incidence		Insect infestation	
	Leaf spot	Botrytis blight	Aphid	Mealy bugs
T1	+	-	1	1
T2	-	-	0	0
T3	-	-	0	0
T4	-	-	0	0
T5	+	-	1	1
T6	-	-	0	0
T7	+	-	1	1
T8	++	-	2	2

Table 4: Disease incidence and insect infestation in tuberose. 0 = No population; 1 = a small colony of 10-20 aphid or mealy bug /plant; 2 = a colony with > 20 aphid or mealy bug/plant; 3 = > one colony and - = Nil; + = Less; ++ = Medium; +++ = High.

Discussion

Results of present study indicated that organic amendment and bio-control agent with chemical fertilizers had a positive effect on vegetative growth and flowering of tuberose. Application of Tricho-compost with chemical fertilizer significantly improved the most parameters of growth and flowering compared to control treatment. In case of vegetative growth, all parameters showed better result in Tricho-compost treatment. Tricho-compost gave the best performance might be due to the synergistic effect of compost and trichoderma in increasing the root surface area per unit of soil volume, water use efficiency and photosynthetic activity of seedlings in addition of higher nutrient contents in tricho-compost which had been reflected in sample analysis.

In case of vegetative characteristics, Emergence percentage increased significantly among all treatments compared with control. The increment was significant at 93.3% in tricho-compost and 86.7% in Poultry refuse, Bokashi, Mustard oil cake and Vermicompost. Application of tricho-compost with chemical fertilizers resulted in more emergence which might be due to presence and release of more food and nutrients in tricho-compost. Mishra et al. [23] reported that corm planting in Tricho-compost treated plot showed 100% plant emergence in gladiolus crops which support more or less the present findings. The results indicated that essentiality of nitrogenous element in organic form enhanced more leaves over control treatment. Haque et al. [24] in Mustard and Tomato. The plant spread was found maximum in Tricho-compost treatment might be due to getting optimum nutrients resulting higher vegetative growth compared to other treatments. Mashaldi [25] and Rabby [26] have also reported similar results in case of marigold and broccoli respectively.

In case of floral characteristics, application of Tricho-compost along with chemical fertilizer enhanced early flowering in tuberose. The application of *Trichoderma* would have helped in uptake of micronutrients and have provided essential plant growth promoting substances which results in early flowering. The results are in accordance with the results of et al. [27] in gladiolus. in accordance with earlier reports of Mazhabi et al. [5] and Kabir et al. [28] they found that spike length and rachis length were increased with the application of trichoderma and organic amendment. The balanced supply of nitrogen from chemical and organic sources promotes the translocation of phytohormones to the shoots [29]. Tricho-compost might have role in supply of macro and micronutrients, enzymes and growth hormones, solubilization of insoluble minor nutrients in soil and provides micronutrients in an optimum level which help in proper flower development [30]. Maximum spike weight was produced by plants which received ¼ RDF along with Tricho-compost. These healthy spikes produced maximum number of florets with increased length and diameter. This might be due to the fact that these plants had put forth good vegetative growth which enabled the plants to produce more photosynthates and supply to spikes for their development. The improvement in quality of spikes was mainly due to castings of *Trichoderma* which consists of plant growth hormones, various enzymes along with macro and micronutrients. Similar results were reported by Rao [31] in case of spike length in gladiolus and Patil [32] in case of floret number per spike in tuberose. Information pertaining to flower durability revealed that Tricho-compost perform best than any other treatments.

Maximum flower yield was also observed in plants which received ¼ RDF along with Tricho-compost. Increase in spike yield per plot and per hectare might be due to increased number of spikes per plant. This increase in number of spikes per plant, florets per spike and fresh weight of florets could be attributed to increase in vegetative growth in terms of plant height, number of leaves, number of shoots and leaf area. The significant differences in flower production when Tricho-compost applied along with fertilizers might be due to the fact that it presents the nutrients in most available form, which made it possible for the plants to grow and put forth luxuriant growth which in turn helped the plants to produce more photosynthates that promoted number of spike per hill to produce higher flower yields. Similar trend has also been reported by Lin [33]. Beneficial effect of *Trichoderma* application improving plant vegetative growth and yield has been reported in tulip [34].

Increase in bulb yield due to the application of Tricho-compost might be due to enhanced N availability to the plants which might increase average number of bulb and bulblets, average diameter and weight of bulbs. *Trichoderma* has plant growth promoting activity along with it helps in uptake of certain minerals, such as P and N and other micro nutrients. This might have helped in production of more bulb and growth of bulblets and increasing the bulb weight. These results were in line as reported by Mazhabi et al. [5] in tuberose that the bulb diameter was enhanced when Tricho-compost was applied in tuberose cultivation. Tricho-compost is a rich source of micro and macro nutrients, which changes in the microfloral composition on roots, enhanced nutrient uptake (not limited to nitrogen), solubilization of soil nutrients, enhanced root development which might increase plant growth [34].

Conclusion

In the present study, it was clearly observed that the *Trichoderma* had a positive impact on growth and yield of tuberose. 3 t/ha + $\frac{1}{4}$ increased uptake and translocation of less-available minerals. Undoubtedly, there is a prospective and potential of *Trichoderma* contained biofertilizer in crop cultivation to achieve attractive yield quality flower in tuberose.

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