# Influence of Vermicompost and bio-fertilizers on growth and flowering of tuberose (Polianthes tuberosa L.) cv. Prajwal

**Abstract:** The experiment was planned to sustainably improve the growth and yield of tuberose using bio-fertilizers and organic manures. performed in pots in completely randomized design (CRD) with 11 treatments having four replications to study the response of organic manures, chemical fertilizers and bio fertilizers on growth and flower yield of tuberose (Polianthes tuberosa L.) cv. Prajwal. The treatment containing sand + vermicompost (4:1) + Bio-fertilizers (*Azotobacter* & *Pseudomonas* sp.) was significantly superior in terms of plant height (70.50cm), length of leaf (36.98cm), Number of leaf (25.67), spike length (66.58cm), rachis length (27.23cm), diameter of stem (1.096cm), florets number per spike (35), number of opened florets per spike (33.67), spikes number per clump, spike weight (75.33g), bulb number per clump (21), bulb diameter (1.20cm), bulb weight (3.98g). While lowest values of these parameters were observed in the control (sand). Minimum days taken to bulb sprouting (21.75days), days taken to complete bulb sprouting (24.50days), days taken to spike emergence (93days) and days taken to opening of first floret (106.75days) were observed in sand + inorganic manures. Treatment having Sand + vermicompost (4:1) + Bio-fertilizers (*Azotobacter* & *Pseudomonas* sp. was observed best to promote growth and flowering of tuberose.

**Key words**: *Azotobacter*, FYM, *Pseudomonas*, Vermicompost.

## Introduction

Tuberose has a great economic potential for cut flowers as well as loose flowers. Tuberose is grown for various purposes such as making gajras, veni, artistic garlands, bouquets, and religious offerings. Tuberose flowers are also used in cosmetic products, the raw material of perfumes, and in aromatherapy due to their ability to calm nerves. Tuberose is a semi-hard perennial bulbous plant and is suitable for growing in tropical and subtropical climates. Plant nutrition is an important factor for growth and development, quality of spikes and flowers. Generally, farmers apply inorganic fertilizers in improper doses which adversely affects the soil productivity and fertility status. The main aim of researchers nowadays is to sustainably increase yield without deteriorating the environment. The usage of organic fertilizers and biofertilizers may thus open new horizons to preserve or recover soil health without reducing crop yield. Organic manures and biofertilizers supply the nutrients to the plants from sources, to which the plant cannot tap themselves (Srivastava *et al*., 2014).

Organic manures are eco-friendly which improves soil health in terms of physical, chemical, and biological properties. FYM is rich in nutrients and most commonly used manure. Vermicompost is produced through earthworms by feeding on plant residue and biological waste matter. Vermicompost has an adequate quantity of N, P, K along with different micronutrients vital for plant growth and development. Biofertilizers contain active microorganisms, which hydrolyze the insoluble phosphate into soluble one and these are safe for humans, animal and the environment. These are low-cost and eco-friendly inputs and have tremendous potential for supplying nutrients, especially N and P which ultimately reduce the chemical fertilizer dose by 25-50% (Vyas *et al*., 2018). *Azotobacter* is free-living, nitrogen-fixing, mesophilic, heterotrophic bacteria and aerobic in nature. It has the ability to synthesize growth-promoting substances such as auxins, gibberellins, and to some extent vitamins along with the ability to fix atmospheric nitrogen in soils. *Azotobacter* utilizes atmospheric nitrogen for its cell protein synthesis. After the death of *Azotobacter*, the cell protein is mineralized into the soil and it contributes towards the nitrogen availability of plants. *Pseudomonas* is phosphorus solubilizing bacteria having the ability to solubilize precipitated forms of P or mineralize organic phosphorus. *Pseudomonas* is the producer of plant hormones, having the ability to colonize the rhizosphere and act as an effective biocontrol agent. The experimental location exhibits a sandy loam texture. The vermicompost, bio-fertilizers, and sand were used in the treatment combination to be concurrent with the site characteristics.

Keeping in view the above facts, the present investigation was planned to analyze the effect of vermicompost and bio-fertilizers for growth and flower yield in tuberose (*Polianthes tuberosa* L.).

## Materials and methods

The study was conducted during 2017-18 at the Botanical Garden of CCSHAU, Hisar, Haryana, India. The bulbs were planted in the first week of April. The pot mixtures were prepared according to the treatment and the bulbs were planted in the pots the same day.

**Design and treatments:** The experiment was laid out in a Completely Randomized Design (CRD) with 11 treatments and four replications. Treatments include-, $T_1$ : Sand (control), $T_2$ : Sand + Inorganic manure, $T_3$ : Sand + Bio-fertilizers (*Azotobacter* & *Pseudomonas* sp.), $T_4$ : Sand + FYM (1:1), $T_5$ : Sand + FYM (1:1) + Bio-fertilizers (*Azotobacter* & *Pseudomonas* sp.), $T_6$ : Sand + FYM (2:1), $T_7$ : Sand + FYM (2:1) + Bio-fertilizers (*Azotobacter* & *Pseudomonas* sp.), $T_8$ : Sand + vermicompost (3:1), $T_9$ : Sand + vermicompost (3:1) + Biofertilizers (*Azotobacter* & *Pseudomonas* sp.), $T_{10}$ : Sand + vermicompost (4:1), $T_{11}$ : (Sand + vermicompost (4:1) + Bio-fertilizers (*Azotobacter* & *Pseudomonas* sp.)

**Experimental material:** In this experiment uniform-sized bulbs of tuberose cv. Prajwal were treated with *Azotobacter* (200 ml) and *Pseudomonas* sp. (200 ml) for one hour. *Azotobacter* is a free-living $N_2$ fixer and *Pseudomonas* helps solubilize the phosphorus to make it available to plants. Organic fertilizers are light in weight in comparison to sand and have sufficient nutrient contents, due to which, different treatment combinations were tested on a volume basis instead of a weight basis giving the basic texture similar to the experimental site to know the best exact proportion to be used for bed preparation. Vermicompost used was prepared from the rice straw residue at the IFS unit of Agronomy Farm (CCSHAU, Hisar). The method given by Ismail (2005) was followed to prepare the bed for vermicomposting. Vermicompost can easily be stored for one year in a dark and cool place with at least 40% moisture content in it. Vermicompost contains 9.5-17.98% organic carbon, 0.5-1.5% nitrogen, 0.1-0.30% phosphorus, and 0.15-0.56% potassium. Also, it is rich in micro-nutrients such as Cu, Fe, Zn, and S. Inorganic nutrients viz. half dose of nitrogen (20g N /$m^2$), full dose of $P_2O_5$ (10g / $m^2$) and $K_2O$ (10g /$m^2$) was applied at the time of planting and remaining half dose of nitrogen was applied through top-dressing method at the time of spike emergence. The data of plant and flower characters recorded were: days taken to sprouting, days taken to complete sprouting, plant height (cm), length of leaf (cm), No. of leaf, days taken to spike emergence, days taken to opening of the first floret, spike length (cm), rachis length (cm), diameter of stem (cm), florets number per spike, number of opened florets per spike, spikes number per clump and weight of spike (g). The data for bulb characters (bulb number per clump, bulb weight and bulb diameter) were recorded at the full bloom stage.

**Statistical Analysis:** Data recorded was subjected to statistical analysis (Panse and Sukhatme, 1987) and tested for the critical difference at a 5% level of significance for plant growth, flower parameters, and bulb characters. Analysis was done using OPSTAT software.

## Result and discussion

**Vegetative growth characters:** The data in Table1 clearly shows minimum days taken to bulb sprouting (21.75) and complete bulb sprouting (24.50) were recorded in treatment $T_2$ (Sand + Inorganic manure), and were found at par with treatment $T_5$, and $T_9$. The maximum days taken to bulb sprouting (27.75) and complete bulb sprouting (30.25) were recorded in treatment $T_1$ (Sand) which were recorded at par with $T_{10}$ and $T_6$. Earliness in bulb sprouting and complete bulb sprouting were recorded in $T_2$ (sand + inorganic manures) the probable reason for earliness in bulb sprouting might be due to early absorption of essential nutrients through the surface of bulbs or through primary roots, which might have stimulated early sprouting. Similar results were reported by Kumar *et al*. (2015a) and Singh *et al*. (2014) in tuberose.

**Table 1: Influence of organic manures and bio-fertilizers on plant growth characters of tuberose**

| Treatments | Days taken to sprouting | Days taken to complete sprouting | Plant height (cm) | Length of leaves (cm) | No. of leaves per clump |
|---|---|---|---|---|---|
| $T_1$: Sand (control) | 27.75 | 30.25 | 59.65 | 30.31 | 15.00 |
| $T_2$; Sand + Inorganic manure, | 21.75 | 24.50 | 62.42 | 33.04 | 19.33 |
| $T_3$: Sand + Bio-fertilizers | 25.00 | 27.75 | 60.67 | 32.02 | 15.75 |
| $T_{4:}$ Sand + FYM (1:1) | 23.00 | 28.75 | 65.24 | 34.18 | 19.25 |
| $T_{5:}$ Sand + FYM (1:1) + Bio-fertilizers | 22.75 | 25.00 | 68.60 | 36.72 | 24.50 |
| $T_{6:}$ Sand + FYM (2:1) | 27.00 | 30.00 | 61.36 | 31.10 | 15.50 |
| $T_{7:}$ Sand + FYM (2:1) + Bio-fertilizers | 25.75 | 28.00 | 68.43 | 32.31 | 20.67 |
| $T_{8:}$ Sand + vermicompost (3:1) | 25.50 | 28.25 | 63.78 | 33.26 | 15.67 |
| $T_9$: Sand + vermicompost (3:1) + Bio-fertilizers | 22.75 | 24.75 | 68.15 | 33.66 | 19.25 |
| $T_{10:}$ Sand + vermicompost (4:1) | 26.25 | 29.00 | 67.48 | 35.63 | 17.33 |
| $T_{11}$: (Sand + vermicompost (4:1) + Bio-fertilizers | 25.50 | 28.25 | 70.50 | 36.98 | 25.67 |
| **C.D. at 5%** | **1.99** | **1.37** | **1.29** | **1.71** | **1.44** |

**Plant height (cm), length of leaf (cm), and number of leaves per clump:** It is evident from the data given in Table 1 that plant height, length of leaf, and number of leaves differed significantly with various treatments. The maximum plant height (70.50 cm), length of leaf (36.98 cm), and number of leaf (25.67) were recorded with treatment $T_{11}$ (Sand + Vermicompost (4:1) + Bio-fertilizers (*Azotobacter* & *Pseudomonas* sp.), which was significantly higher over the remaining treatments, however minimum plant height (59.65cm), length of leaf (30.31 cm) and a number of leaves (15) were recorded in treatment T1 (Sand). The rise in height of the plant, leaf length, and leaf number might be due to nutrients available to the plants in accessible form from the organic manures and bio-fertilizers. They are ample in micro-nutrients in addition to plant growth-encouraging substances viz., enzymes, hormones, and humus-forming beneficial microbes. Organic matters, on usage to the soil, enhance the physical properties of soil such as aeration, permeability, aggregation, and water holding capacity which build up the growth, and development of plants. A similar trend was reported in Sudhagar *et al*. (2020), Singh *et al*. (2015), Preetham *et al*. (2017), and Kumar (2015a) in tuberose.

**Days taken to spike emergence and opening of first florets:** The perusal of data on days taken to spike emergence and opening to first floret is depicted in Table 2 and different treatments differed significantly among each other. The minimum days taken to spike emergence (93.00) and opening of first floret (106.75) were observed with treatment $T_2$ (Sand + Inorganic manure), which was statistically at par with $T_{11}$ and $T_9$. The maximum days taken to spike emergence (103.63) and opening of first floret (119.3) were observed in $T_4$ (Sand + FYM (1:1), closely followed by $T_6$ which was significantly higher over the other treatment. Earliness in spike emergence and opening of the first floret with $T_2$ (sand + inorganic manures) reverts in early completion of the growth phase and has greater stimulation in bulb metabolism which leads to the earliness spike emergence. Similar results were obtained by Kumar *et al*. (2015b), Shirsat *et al*. (2015) in tuberose, and Sudhagar *et al*. (2020) in tuberose).

**Table 2: Influence of organic manures and bio-fertilizers on flowering characters of tuberose**

| Treatments | Days taken to spike emergence | Days taken to opening of first floret | Stem diameter (cm) | No. of spikes per clump | No. of florets per spike | No. of opened florets per spike | No. of unopened florets per spike |
|---|---|---|---|---|---|---|---|
| $T_1$-Sand (control) | 101.00 | 117.33 | 0.88 | 1.25 | 23.50 | 17.50 | 6.00 |
| $T_2$-Sand + Inorganic manure | 93.00 | 106.75 | 0.92 | 1.00 | 31.00 | 28.50 | 2.50 |
| $T_3$-Sand + Bio-fertilizers | 100.95 | 112.50 | 0.89 | 1.75 | 29.33 | 27.66 | 1.67 |
| $T_{4:}$ Sand + FYM (1:1) | 103.63 | 119.31 | 0.90 | 1.25 | 25.00 | 21.00 | 4.00 |
| $T_{5:}$ Sand + FYM (1:1) + Biofertilizers | 96.75 | 112.25 | 0.97 | 1.75 | 28.71 | 27.04 | 1.67 |
| $T_{6:}$ Sand + FYM (2:1) | 103.00 | 119.00 | 0.90 | 1.00 | 30.11 | 25.11 | 5.00 |
| $T_{7:}$ Sand + FYM (2:1) + Biofertilizers | 100.75 | 117.50 | 0.94 | 2.00 | 32.17 | 29.17 | 3.00 |
| $T_{8:}$ Sand + vermicompost (3:1) | 96.13 | 109.40 | 0.90 | 2.25 | 26.53 | 21.03 | 5.50 |
| $T_9$-Sand + vermicompost (3:1) + Bio-fertilizers | 94.03 | 109.20 | 0.96 | 1.75 | 27.44 | 23.94 | 3.5 |
| $T_{10:}$ Sand + vermicompost (4:1) | 95.50 | 111.15 | 0.96 | 1.75 | 29.83 | 28.05 | 1.78 |
| $T_{11:}$ Sand + vermicompost (4:1) + Bio-fertilizers | 93.50 | 107.00 | 1.10 | 1.00 | 35.00 | 33.67 | 1.33 |
| **C.D. at 5%** | **1.59** | **1.56** | **0.04** | **NS** | **1.21** | **1.55** | **1.06** |

**Stem diameter (cm):** The stem diameter varied significantly with the application of organic manures and bio-fertilizers is presented in Table 2. The maximum diameter of the stem (1.096 cm) was recorded with treatment $T_{11}$ (Sand + Vermicompost (4:1) + Bio-fertilizers (*Azotobacter* & *Pseudomonas* sp.), which was statistically significant over the remaining treatments. The minimum stem diameter (0.882 cm) was found in $T_1$ (Sand), which is at par with $T_2$ (0.916 cm), $T_3$ (0.889 cm), $T_4$ (0.896 cm), $T_6$ (0.897 cm), and $T_8$ (0.896 cm). Treatments $T_2$, $T_5$, $T_7$, $T_{9,}$ and $T_{10}$ were found at par with each other. The maximum increase in stem diameter (1.10 cm) was with $T_{11}$ may be due to protoplasm formation, division, and elongation of meristem cells, enhancing the biosynthesis of proteins and carbohydrates which lead to enhancing the growth. Preetham *et al*. (2017) reported that plant vegetative growth attained maxima with the use of vermicompost (2 kg) followed by poultry manure (0.5 kg) in the Shringar variety of tuberose. Similar results were also reported in tuberose by Shirsat *et al*. (2015).

**Number of florets per spike and number of opened florets per spike:** The data given in Table 2 presents that florets number per spike and number of opened florets per spike increased with the application of organic manures and bio-fertilizers over $T_1$ (sand). The maximum florets number per spike (35.00) and number of opened florets per spike (33.67) were recorded with treatment $T_{11}$ (Sand + Vermicompost (4:1) + Bio-fertilizers (*Azotobacter* & *Pseudomonas* sp.) which was statistically higher over the remaining treatments. The minimum florets number per spike (23.50) and number of opened florets per spike (17.50) were counted with treatment $T_1$ (Sand). Treatments $T_2$, $T_{6,}$ and $T_7$ were at par with each other; similarly, $T_3$, $T_{5,}$ and $T_{10}$ were at par with each other. The increase in florets number per spike and number of opened florets per spike might be because the organic matter and bio-fertilizers use nutrients to the plants in the transferable form and they are also ample in micro-nutrients along with having plant growth encouraging substances viz., enzymes, hormones, and humus creating beneficial microbes, which increases rachis length as clear from the present investigation, which ultimately produces a greater number of florets per spike. Similarly, Kumar *et al*. (2012) in their study on tuberose reported the number of florets per spike (32.60). Munikrishnappa *et al*. (2004), Bhalla *et al*. (2007), and Shirsat *et al*. (2015) reported that t  number of florets per spike significantly increase with organic manures and bio-fertilizers in tuberose.

Number of florets unopened per spike: The unopened florets per spike decreased significantly with the application of organic manures and bio-fertilizers over $T_1$ (sand) except $T_6$ and $T_8$ represented in Table 2. The minimum number of florets unopened per spike (1.33) was with treatment $T_{11}$ (Sand + Vermicompost (4:1) + Bio-fertilizers (*Azotobacter* & *Pseudomonas* sp.) which was found at par with $T_2$ (2.50), $T_3$ (1.67), $T_5$ (1.67) and T10 (1.78). The maximum number of florets unopened per spike (6.00) was noticed with treatment $T_1$ (Sand). Treatments $T_4$, $T_{7,}$ and $T_9$ were found at par with each other. The decrease in the number of florets unopened per spike, is because the organic matter and bio-fertilizers use nutrients to the plants in the accessible form and they are also ample in micro-nutrients along with having plant growth-encouraging substances viz., enzymes, hormones, and humus forming favorable microbes, which improves the flower quality, which ultimately produces a smaller number of florets unopened per spike. Similar findings were reported by Koley and Pal (2011), and Kumar (2015a) in tuberose.

**Number of spikes per clump:** The perusal of data presented in Table 2 shows that the effect of organic manures and bio-fertilizers upon the number of spikes per clump was non-significant. However, an increase in the number of spikes per clump (2.25) was observed in $T_8$ and lowest (1.00) in $T_2$, $T_6$ and $T_{11}$.

**Length of spike (cm) and Length of the rachis (cm):** The mean values presented in Table 3 revealed that spike length, and rachis length increased with the application the organic manures and biofertilizers over $T_1$ (sand). The maximum length of the spike (66.58 cm) and length of rachis (27.23 cm) was recorded with treatment $T_{11}$ (Sand + Vermicompost (4:1) + Bio-fertilizers (*Azotobacter* & *Pseudomonas* sp.), which was significant over other treatments. The minimum length of the spike (52.13 cm) and length of rachis (17.90 cm) was recorded with $T_1$ (Sand) which was at par with $T_6$ and $T_{10}$. Treatments $T_2$, $T_{9,}$ and $T_7$ were at par with each other and $T_3$, $T_4$, $T_7$ and $T_8$ were at par with each other. As the supply of nutrients through the organic manures and bio-fertilizers are rich in micro-nutrients besides having plant growth promoting substances viz., hormones, enzymes, and humus forming beneficial microbes, which leads to an increase in length of spike and rachis length. Organic sources, on application to the soil, improve the physical properties of soil such as aggregation, aeration, permeability, and water-holding capacity which promote the growth, and development of plants. Similarly, length of the spike (70.50 cm) and length of the rachis (27.50 cm) were reported by Kumar (2015a) in his study on tuberose. Singh *et al*. (2015), Preetham *et al*. (2017) and Suchismita *et al*. (2018) also reported a similar trend in tuberose.

**Table 3: Influence of organic manures and biofertilizers on flowering characters**

| Treatments | Spike weight (g) | Length of spike (cm) | Length of rachis (cm) | No. of bulb per clump | Diameter of bulb (cm) | Weight of bulb (g) |
|---|---|---|---|---|---|---|
| $T_1$-Sand (control) | 54.22 | 52.13 | 17.90 | 13.00 | 1.04 | 2.12 |
| $T_2$-Sand + Inorganic manure | 71.96 | 60.68 | 22.50 | 15.50 | 1.10 | 2.77 |
| $T_3$-Sand + Bio-fertilizers | 55.67 | 58.25 | 19.43 | 14.75 | 1.05 | 2.74 |
| $T_{4:}$ Sand + FYM (1:1) | 63.00 | 59.41 | 20.77 | 18.50 | 1.13 | 2.44 |
| $T_{5:}$ Sand + FYM (1:1) + Bio-fertilizers | 66.67 | 64.36 | 21.68 | 19.00 | 1.18 | 2.77 |
| $T_{6:}$ Sand + FYM (2:1) | 60.00 | 52.20 | 18.83 | 16.50 | 1.07 | 2.14 |
| $T_{7:}$ Sand + FYM (2:1) + Bio-fertilizers | 64.67 | 59.10 | 21.03 | 19.50 | 1.09 | 2.43 |
| $T_{8:}$ Sand + vermicompost (3:1) | 60.71 | 58.72 | 20.75 | 18.00 | 1.18 | 2.71 |
| $T_9$-Sand + vermicompost (3:1) + Bio-fertilizers | 62.50 | 60.33 | 23.43 | 19.50 | 1.18 | 2.83 |
| $T_{10:}$ Sand + vermicompost (4:1) | 68.26 | 52.75 | 22.54 | 16.25 | 1.06 | 2.60 |
| $T_{11:}$ (Sand + vermicompost (4:1) + Biofertilizers | 75.33 | 66.58 | 27.23 | 21.00 | 1.20 | 3.98 |
| **C.D. at 5%** | **2.45** | **1.64** | **1.50** | **1.29** | **0.06** | **0.51** |

**Spike weight (g):** The spike weight increased significantly with the application of organic manures and bio-fertilizers over $T_1$ (sand) except $T_3$ represented in Table 3. The maximum spike weight (75.33 g) was found with treatment T11 (Sand + Vermicompost (4:1) + Bio-fertilizers (*Azotobacter* & *Pseudomonas* sp.) which was statistically higher over the other treatments. The minimum spike weight (54.22 g) was found with treatment $T_1$ (Sand) which was found at par with $T_3$ (55.67). The second most effective treatment in increasing the spike weight (71.96 g) was $T_2$ which was again superior to $T_3$ to $T_8$. The increase in the spike weight might be due to an abundant supply of nutrients, which prolonged the vegetative growth and ultimately uses a supply of nutrients towards spike development hence increasing the weight of spike. Pradhan *et al*. (2015), Kumar (2015b), and Bohra and Nautiyal (2019) recorded a similar trend in tuberose.

**Number of bulbs per clump:** It is obvious from the data presented in Table 3 that number of bulbs per clump rises significantly with the implementation of organic manures and bio-fertilizers on top of $T_1$. The maximum bulbs number per clump (21) was found with treatment $T_{11}$ (Sand + Vermicompost (4:1) + Bio-fertilizers (*Azotobacter* & *Pseudomonas* sp.), which was statistically superior over the other treatment in increasing the number of bulbs per clump. The minimum number of bulbs per clump (13) was found with treatment $T_1$ (Sand). The second most effective treatment in increasing the number of bulbs per clump (19.50) was noticed $T_7$ and $T_9$ which were at par with $T_4$ and $T_5$. The increase in the number of bulbs might be due to the fact that nutrients and various growth hormones helped in increasing the amount of assimilates that are needed for enhancing the number of bulbs. Similar results were reported by Prity *et al*. (2011) in their study that the number of bulbs per clump (39.40) was found in organic fertilizer and rich compost @10t/ha in tuberose.

**Diameter of bulb (cm):** Data presented in Table 3 revealed that the diameter of the bulb varied much with the application of various treatments. The greatest diameter of the bulb (1.20 cm) was found with treatment $T_{11}$ (Sand + Vermicompost (4:1) + Bio-fertilizers (*Azotobacter* & *Pseudomonas* sp.) which was found at par with $T_5$ (1.18 cm), $T_8$ (1.18 cm) and $T_9$ (1.18 cm). The smallest diameter of the bulb (1.04 cm) was found with $T_1$ (Sand) which was at par with $T_2$ (1.10 cm), $T_3$ (1.05 cm), $T_6$ (1.07 cm), $T_7$ (1.09 cm), and $T_{10}$ (1.06 cm). Organic manures and bio-fertilizers led to improving the vegetative growth of plants so the plants could produce good quality bulbs. Furthermore, nutrients had a positive effect on photosynthesis and respiration rates and leaf carbohydrate and the nutrients uptake and transport, consequently producing good plants which can store a large amount of food in the bulb, thus bulb diameter could be increased. Similar results were reported in tuberose by Yadav *et al*. (2005) and Kumar (2015b).

**Weight of bulb (g):** It is apparent from the data shown in table 3 that the weight of the bulb increased significantly with the application of organic manures and bio-fertilizers over T1 (sand) except $T_4$, $T_6$, and $T_7$. The maximum weight of bulb (3.98 g) was found with treatment $T_{11}$ (Sand + Vermicompost (4:1) + Bio-fertilizers (*Azotobacter* & *Pseudomonas* sp.), which was significantly highest over the other treatments. The minimum weight of the bulb (2.12 g) was found with $T_1$ (Sand) which was statistically at par with treatment $T_4$ (2.44 g), $T_6$ (2.14 g), $T_7$ (2.43 g) and $T_{10}$ (2.60 g). Treatments $T_2$ to $T_5$ and $T_7$ to $T_{10}$ were found at par with each other. The increase in bulb weight might be due to the fact that nutrients helped in increasing the amount of assimilate that are needed for the increase in bulb weight. Similar results in tuberose by Yadav *et al*. (2005) and Kumar (2015b).

## Conclusion

The minimum number of days taken for bulbs sprouting (21.75), complete bulb sprouting (24.50), spike emergence (93.00), and opening of first floret (106.75) was observed in T2 (Sand + Inorganic manures) treatment. height of Plant, length of leaf, the number of leaves, spike length, rachis length, stem diameter, the number of florets per spike, the number of florets opened per spike, spike weight, the number of bulbs per clump, the diameter of bulb and weight of bulb increased significantly with organic manures and bio-fertilizers over $T_1$ (sand). Maximum plant height (70.50 cm), length of leaves (36.98 cm), length of spike (66.58 cm), length of rachis (27.23 cm), stem diameter (1.09 cm), spike weight (75.33 g) diameter of bulb (1.20 cm), weight (3.98 g) of bulb, the maximum number of leaves per clump (25.67), number of florets per spike (35.00), number of florets opened per spike (33.67) and number of bulbs per clump (21.00) were obtained in $T_{11}$ (Sand + Vermicompost (4:1) + Bio-fertilizers (*Azotobacter* & *Pseudomonas* sp.) treatment. A minimum number of florets unopened per spike (1.33) were obtained in $T_{11}$ (Sand + Vermicompost (4:1) + Bio-fertilizers (*Azotobacter* & *Pseudomonas* sp.) treatment. Tuberose producers can adopt the treatment having Sand + Vermicompost (4:1) + Bio-fertilizers (*Azotobacter* & *Pseudomonas* sp.) to attain maximum growth and flowering.

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