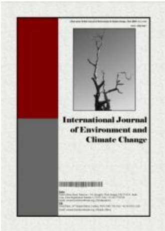

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# Development, Fruit setting and Pomological Characteristics in Strawberry (*Fragaria ananasa* Duch.) as Affected by Biofertilizers under Vertical Farming System. Cv. Winter Dawn

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

A field experiment was carried out during 2021-2022 to see the Development, Fruit setting and Pomological characteristics in Strawberry ( *Fragaria ananasa* Duch.) as affected by Biofertilizers under vertical farming system. Cv. Winter dawn with 10 treatments including control in combinations of organic and microbial sources of nutrients (Vermicompost, FYM, *Azotobacter*, *Azospirillum* and PSB) replicated thrice with 3 plants per replication in Randomized Block Design. Observations were recorded for vegetative growth, fruit yield, quality. In different combinations (biofertilizers and organic manure) the treatment $T_9$ (Soil (50%) +Vermicompost (50%) + *Azotobacter* (2g) + *Azospirillum* (2g) recorded highest plant height, plant spread, number of leaves and leaf area as compared to $T_7$ (Soil (50%) + FYM (50%) + PSB (2g) + *Azotobacter* (2g). Plant treatment $T_9$ (Soil (50%) +Vermicompost (50%) + *Azotobacter* (2g) + *Azospirillum* (2g)) registered earliest flowering and also highest number of flowers per plant. The maximum fruit weight, number of fruits per plant and yield were recorded with plants treated with $T_9$ (Soil (50%) +Vermicompost (50%) + *Azotobacter* (2g) + *Azospirillum* (2g) followed by $T_7$ (Soil (50%) + FYM (50%) + PSB (2g) + *Azotobacter* (2g) at 90 DAP followed by $T_8$ (Soil (50%) + coir pith (50%) + *Azospirillum* (2g) + PSB (2g) treatment. The maximum Benefit: Cost ratio (1: 3.39) was recorded in the $T_9$ (Soil (50%) +Vermicompost (50%) + *Azotobacter* (2g) + *Azospirillum* (2g) than $T_7$ (Soil (50%) + FYM (50%) +

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PSB (2g) + *Azotobacter* (2g) due to its lower cost of production. The highest yield and best quality fruit were recorded in the combination of $T_9$ (Soil (50%) +Vermicompost (50%) + *Azotobacter* (2g) + *Azospirillum* (2g).

*Keywords: Strawberry; vertical farming; organic manure; biofertilizers.*

## 1. INTRODUCTION

Strawberry (*Fragaria* × *ananassa* Duch.) belongs to the family Rosaceae. The cultivated strawberry (*Fragaria* × *ananasaa* Duch.) was originated from the hybridization of two American species viz., *Fragaria chilioensis* Duch. and *Fragaria verginiana* Duch. All the cultivated varieties of strawberry are octaploid (2n = 8x = 56) in nature. It is herbaceous crop with prostate growth habit, which behaves as an annual in sub-tropical region and perennial in temperature region [1].

Strawberry is used as fresh fruit being rich in vitamin C (30-120 mg/100g fruit pulp) and ellagic acid, which has anti cancerous property. Fruits are attractive with distinct pleasant aroma and flavour, consumed as dessert and also have a special demand by the fruit processing units for the preparation of jams, ice cream, syrups etc. Vermicompost contains plant growth regulating materials, such as humic acids and plant growth regulators like auxins, gibberellins and cytokinin's [2], which are responsible for increased plant growth and yield of strawberry fruit crops. Biofertilizers are one of the best modern tools for agriculture and are used to improve the fertility and quality of the soil. It offers an economically attractive and ecologically sound route for augmenting nutrient supply that enables to plant growth and development of strawberry [3-6].

Keeping these facts in view, the present investigation was initiated to study. Low-enter agricultural gadget which is based at the input of natural substances preserve terrific promise now no longer simplest to limit the usage of artificial fertilizer, however additionally to enhance crop productiveness and to make sure surroundings sustainability towards nutrient mining and degradation of soil and water resources [7,8].

Among the natural amendment, farmyard manure (FYM) has been extensively utilized in agricultural fields and the composted shape of this manure is desired over clean manure to dispose of the hazard of N loss thru leaching and floor runoff, boom soil natural matter, suppress soil-borne pathogens and to mitigate greenhouse gas emissions [9] Vermicompost is organic material that has been broken down in a mesophilic process by interactions between microorganisms and earthworms to produce fully stabilized organic soil amendments [10,11]. Vermicompost contains significant amounts of nutrients, a large valuable microbial population, and biologically active metabolites (gibberellins, cytokinins, auxins), as well as vitamins B, which can be used alone or in combination with other inorganic or organic fertilizers to improve crop in soils is influenced by soil physicochemical properties (organic matter, pH, temperature, soil depth, soil moisture) and microbiological properties (microbial interactions).is a well-studied plant growth promoting bacteria due to its ability to colonise the roots of various plant species, the majority of which are agriculturally important [12].

Vertical farming is crop husbandry in which crops are planted in vertically managed layers in order to harness the untapped vertical area that is otherwise overlooked in almost all cultivation practises. Furthermore, approximately 80% of total arable land is currently underutilized globally [13]. Some urban planners and agricultural leaders have argued that cities must produce food internally in order to manage the demand-supply ratio and avoid falling food prices, harmful pollution, and inflation [14]. Growing media/substrates are the materials in which the plant will grow and play an important role in productivity [15-17]. They provide anchorage for plant roots, air spaces for respiration, and the ability to retain enough available water for plant growth. For growing plants, a variety of growth substrates are available [18-20]. For growing plants, the growing medias are used solely or in combinations [21]. The types of media combinations vary depending on the plant species, as well as the grower and stage of growth, such as nursery raising or transplanting. Nowadays, various types of growing media are available on the market, such as coco-peat, coir, vermicompost, perlite, bagasse, sawdust, and so on, but some media performed well despite being insignificant in yield. (Rawahya *et al.,* 2009).

## 2. MATERIALS AND METHODS

The area of Prayagraj district comes under subtropical belt in the South East of Uttar Pradesh, which experience extremely hot summer and fairly cold winter. The maximum temperature of the location reaches up to 46$^o$ C – 48$^o$ C and seldom falls as low as 4$^o$ C – 5$^o$ C. The relative humidity ranged between 20–94 percent. The average rainfall in this area is around 1013.4 mm annually. However, occasional precipitation is also not uncommon during winter months. The experiment was conducted in the vertical system at the experimental site of Department of Horticulture, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Prayagraj during 2021 2022. Treatments namely $T_0$ CONTROL (sand, soil, coir pith), $T_1$ Sand (25%) + Soil (50%) + Vermicompost (25%) + *Azotobacter* (2g), $T_2$ Sand (25%) + Soil (50%) + Vermicompost (25%) + PSB (2g), $T_3$ Sand (25%) + Soil (50%) + Vermicompost (25%) + *Azospirillum* (2g), $T_4$ Soil (50%) + coir pith (25%) + FYM (25%) + *Azotobacter* (2g), $T_5$ Soil (50%) + coir pith (25%) + FYM (25%) + PSB (2g), $T_6$ Soil (50%) + coir pith (25%) + FYM (25%) + *Azospirillum* (2g), $T_7$ Soil (50%) + FYM (50%) + PSB (2g) + *Azotobacter* (2g), $T_8$ Soil (50%) + coir pith (50%) + *Azospirillum* (2g) + PSB (2g), $T_9$ Soil (50%) +Vermicompost (50%) + *Azotobacter* (2g) + *Azospirillum* (2g) were tested in randomized block design with three replications. The observations were recorded on three randomly selected plants from each treatment. Vegetative characters [Plant height (cm), Plant spread (cm), Number of leaves per plant, Leaf Area Index (cm$^2$)], yield and economic attributes [Number of fruits per plant (90 days), Yield plant $^{-1}$(g) (90 days), Fruit diameter (cm) (90 days), Fruit length (cm) (90 days), TSS (°Brix) (90 days), Acidity (%) (90 days), Ascorbic Acid (mg/100g) (90 days), Net return (□ /100$^2$), Benefit: Cost ratio].

## 3. RESULTS AND DISCUSSION

### 3.1 Vegetative Characters

It is clear from the (Table 1) & (Graph 1) that the maximum plant height (8.56 cm, 15.79 cm, 22.89 cm) was recorded in $T_9$ (Soil (50%) +Vermicompost (50%) + *Azotobacter* (2g) + *Azospirillum* (2g)). The minimum plant hight per plant (5 cm, 9.9 cm, 16.67 cm) was recorded in $T_0$ (CONTROL (sand, soil, coir pith). Vermicompost is regarded as a more abundant source of plant nutrients (Arancon *et al.,* 2003 and 2004). Azotobacter is the most extensively studied free living nitrogen fixing bacteria, and it is known to synthesizes biologically active growth promoting substances in addition to fixing atmospheric nitrogen (Yadav *et al.,* 2010) and are further influenced by plant vegetative growth. PSB stimulated plant growth by promoting phosphate dissolution [22] as well as the biosynthesis of auxin [23] and IAA [23].

The maximum plant spread (28 cm) was recorded in $T_9$ (Soil (50%) +Vermicompost (50%) + *Azotobacter* (2g) + *Azospirillum* (2g)) The minimum plant spread (23.07 cm) was recorded in $T_0$ (CONTROL (sand, soil, coir pith)). Vermicompost is regarded as a more abundant source of plant nutrients, growth regulators, enzymes, antifungal and antibacterial compounds (Arancon *et al.,* 2003 and 2004). PSB stimulated plant growth via phosphate dissolution (Nowsheen *et al.,* 2006) and the biosynthesis of auxin [23] and IAA [23]. Vermicompost has previously been shown to have a positive effect on plant growth in strawberries (Aroncon *et al.,* 2003 and 2004) [24, 22] (Yadav *et al.,* 2010).

The maximum number of leaves (27.56) was recorded in $T_9$ (Soil (50%) +Vermicompost (50%) + *Azotobacter* (2g) + *Azospirillum* (2g)) and the minimum number of leaves per plant (20.11) was recorded in $T_0$ (CONTROL (Sand, soil, coir pith)). The memoir fertilisers had a significant impact on the number of strawberry leaves per plant *Azotobacter* is the most hugely studied tone-ruling living nitrogen setting up bacteria, and in addition to its goods to dispose atmospheric nitrogen, it's grasped to synthesise biologically alive excrescence advancing quiddities likewise as IAA, GA, and others (Yadav *et al.,* 2010). The developments acquired are in attestation with the judgments of Yadav *et al.,* (2010) who reported that conjugated exercise of life conditions, vermicompost with inorganic conditions significantly compounded the number of leaves and flake demesne of strawberry and Nowsheen *et al.,* (2006) plant that the exercise of P.S.B.

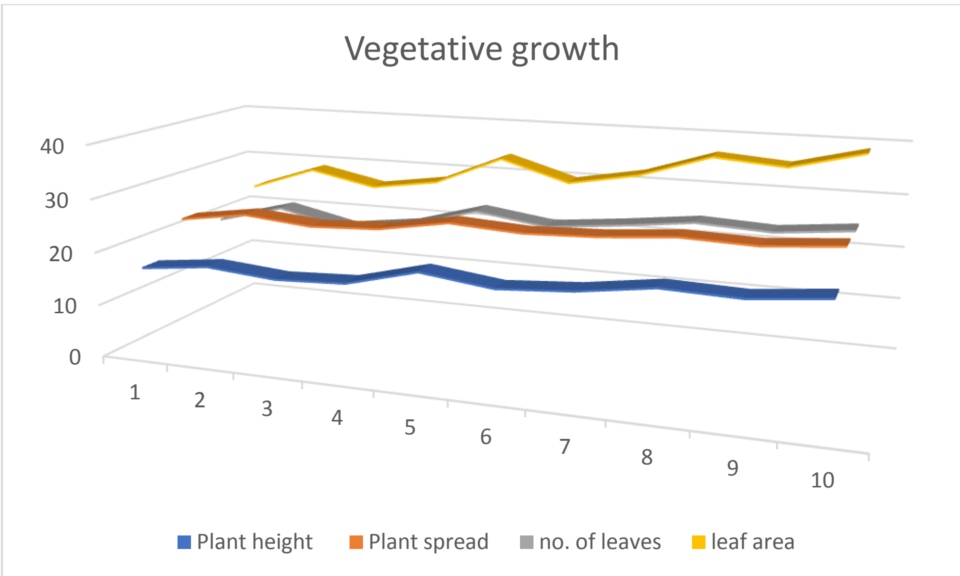
The maximum leaf area (38.8 cm) was recorded in $T_9$ (Soil (50%) +Vermicompost (50%) + *Azotobacter* (2g) + *Azospirillum* (2g)). The minimum leaf area (24.41 cm2) was recorded in $T_0$ (CONTROL (sand, soil, coir pith)). The mechanisms by which PSB stoked plant growth is through phosphate dissolution (Nowsheen *et al.,* 2006) and in the biosynthesis of auxin [23] and IAA (Bareae *et al.,* 1976). Positive effect of vermicompost on plant growth has also been recorded by [23] Yadav *et al.,* 2010). Combined operation of memoir diseases, vermicompost with inorganic fertilisers significantly increased the number of leaves and splint area of strawberry (Aroncon *et al.,* 2003 & 2004) [24].

### 3.2 Fruit setting and Pomological Attributes

Numerically in (Table 2) & graphically in (Graph 2) the maximum number of fruits plant$^{-1}$ (21) was recorded in $T_9$ (Soil (50%) +Vermicompost (50%) + *Azotobacter* (2g) + *Azospirillum* (2g)) and the minimum number of fruits per plant (11.89) was recorded in T0 (CONTROL (Sand, soil, coir pith)). It is clear from the table that there are significant differences among the treatments at 90 days after planting number of fruits plant$^{-1}$ may be due to increase in the number of leaves which worked as an effective photosynthesis structure and produced high quantum of carbohydrates in the plant system. Further number of flowers, which redounded advanced fruits per plant, under present study due to capability of vermicompost in producing growth hormone, enzymes, antifungal and antibacterial composites, which in turns enhanced marketable yield over other treatments. Analogous findings also reported by Wang [25], Yadav *et al.,* (2010), Umar *et al.,* [26], Singh *et al.,* [24], Rana and Chandel [27], Zargar *et al.,* [28], Umar *et al.,* [29] Dadashpour and Jouki [30] and Verma and Rao (2013) in strawberry.

The maximum fruits yield plant$^{-1}$ (638.40 g) was recorded in $T_9$ (Soil (50%) +Vermicompost (50%) + *Azotobacter* (2g) + *Azospirillum* (2g)) and the minimum number of fruits yield per plant (216.08 g) was recorded in T0 (CONTROL (sand, soil, coir pith)). Increase in fruit yield may be due to increase in the number of leaves which worked as an effective photosynthesis structure and produced high quantum of carbohydrates in the plant system. Vermicompost contains plant growth regulating accoutrements, similar as humic acids and plant growth controllers like auxins, gibberellins and cytokinin [2], Analogous findings also reported by Wang [25], Yadav *et al.,* (2010), Umar *et al.,* [26], Singh *et al.,* [24], Rana and Chandel [27], Zargar *et al.,* [28], Umar *et al.,* [29] Dadashpour and Jouki [30] and Verma and Rao (2013) in strawberry.

The maximum fruit diameter (3.36 cm) was recorded in $T_9$ (Soil (50%) +Vermicompost (50%) + *Azotobacter* (2g) + *Azospirillum* (2g)). The minimum fruit diameter (2.47 cm) was observed in T0 (CONTROL (sand, soil, coir pith)). Increase in fruit diameter may be due to balanced clearness of macro and micronutrients and growth promoting hormones produced by different bio-fertilizers applied in different treatment combinations. This could be linked to superior fruit fillers as a result of more balanced nutrient intake, which could have led to improved metabolic conditioning in the plant, leading to a high protein and carbohydrate admixture (Singh *et al.,* 1970). Also, the different partitioning of photosynthesis towards the cesspool by *Azotobacter* inoculation increased the fruit size and fruit diameter (Rana and Chandel, 2003).



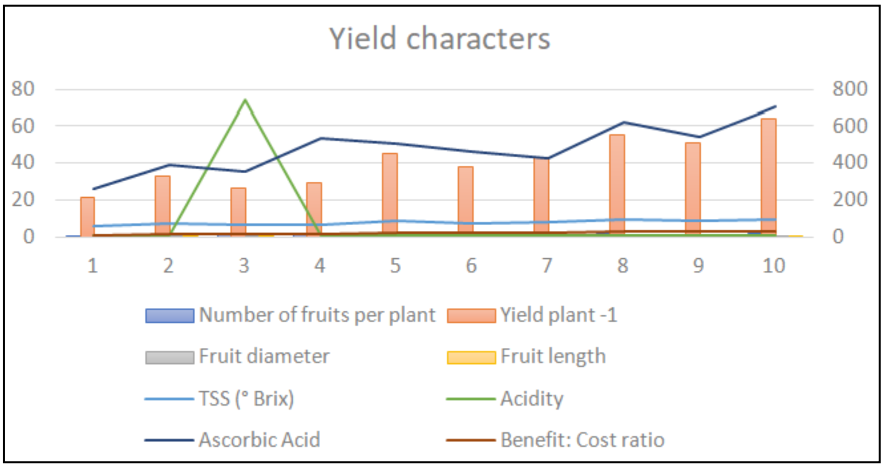

**Graph 1. Effect of biofertilizers on vegetative growth characters of strawberry**

**Table 1. Effect of biofertilizers on vegetative growth characters of strawberry under vertical system**

| Treatment | Treatment combination | Plant height (cm) (90 days) | Plant spread (cm) (90 days) | Number of leaves (90 days) | Leaf area ($cm^2$) (90 days) |
|---|---|---|---|---|---|
| **$T_0$** | CONTROL (sand, soil, coir pith) | 16.67 | 23.07 | 20.11 | 24.41 |
| $T_1$ | Sand (25%) + Soil (50%) + VC (25%) + *Azoto.* (2g) | 18.11 | 24.97 | 23.44 | 28.9 |
| $T_2$ | Sand (25%) + Soil (50%) + VC (25%) + PSB (2g) | 17 | 23.77 | 20.56 | 26.17 |
| $T_3$ | Sand (25%) + Soil (50%) + VC (25%) + *Azosp.* (2g) | 17.56 | 24.37 | 22.22 | 28 |
| $T_4$ | Soil (50%) + coir pith (25%) + FYM (25%) + *Azoto.* (2g) | 20.89 | 26.57 | 22.89 | 33.67 |
| $T_5$ | Soil (50%) + coir pith (25%) + FYM (25%) + PSB (2g) | 19.22 | 25.77 | 24 | 29.8 |
| $T_6$ | Soil (50%) + coir pith (25%) + FYM (25%) + *Azosp.* (2g) | 20.11 | 26.23 | 25.33 | 32.17 |
| $T_7$ | Soil (50%) + FYM (50%) + PSB (2g) + *Azoto.* (2g) | 22 | 27.33 | 26.89 | 36.5 |
| $T_8$ | Soil (50%) + coir pith (50%) + *Azosp.* (2g) + PSB (2g) | 21.56 | 26.9 | 26.22 | 34.41 |
| **$T_9$** | Soil (50%) + VC (50%) + *Azoto.*(2g) + *Azosp.*(2g) | 22.89 | 28 | 27.56 | 38.8 |
| F-test | | **S** | **NS** | **S** | **S** |
| SE. d (+) | | 1.01 | 2.06 | 1.87 | 2.68 |
| CD (5%) | | 2.12 | 4.33 | 3.93 | 5.7 |

*VC: vermicompost, Azoto: Azotobacter, Azosp: Azospirillum, PSB: Phosphate solubilizing bacteria*

**Fig. 1. Strawberry plants under vertical farming system**




**Graph 2. Effect of biofertilizers on fruit setting and pomological attributes of strawberry**

The maximum fruit length (4.46 cm) was recorded in $T_9$ (Soil (50%) +Vermicompost (50%) + *Azotobacter* (2g) + *Azospirillum* (2g)) & the minimum fruit length (3.1 cm) was observed in T0 (CONTROL (sand, soil, coir pith)). Fruit length growth can be because of balanced availability of macro and micronutrients and boom selling hormones produced with the aid of using unique bio-fertilizers carried out in unique remedy combinations. This can be attributed to higher fillings of culmination because of extra balanced uptake of vitamins which may also have caused higher metabolic sports withinside the plant in the long run main to excessive protein and carbohydrate synthesis (Singh *et al.,* 1970). Also, the unique partitioning of photosynthesis toward the sink with the aid of using *Azotobacter* inoculation multiplied the fruit duration [27, and 31]. Suthar (1993) confirmed that amongst diverse natural sources, vermicompost had the maximum critical position accompanied with the aid of using FYM.

The maximum (TSS 9.57°B) was recorded in $T_9$ (Soil (50%) +Vermicompost (50%) + *Azotobacter* (2g) + *Azospirillum* (2g)) and the minimum (TSS 5.31°B) was observed in T0 (CONTROL (sand, soil, coir pith)). Increased TSS and general sugars in berry with the utility of *Azotobacter* and vermicompost can be attributed because of the fast metabolic transformation of starch and pectin into soluble compounds and speedy translocation of sugars from leaves to the growing fruits. These findings trust the consequences of Singh and Singh, (2006); Haynes and Goh (1987); Singh *et al.,* [24] in strawberry; Rathi and Bist (2004) in pear and Baksh *et al.,* (2008) in guava. Badr *et al.,* [32] pronounced that sugar is produced through breaking the starch withinside the leaves and Anthocyanin will even increase with growing glucose ranges because of mobileular metabolism, ensuing withinside the accumulation of soluble sugars withinside the mobileular.

The maximum acidity 0.74% was observed in $T_0$ (CONTROL (sand, soil, coir pith)) and minimum acidity 0.59% was recorded in Soil $T_9$ (50%) +Vermicompost (50%) + *Azotobacter* (2g) + *Azospirillum* (2g). The similar findings also reported by [24] who noticed that the fruit harvested plant receiving vermicompost were TSS and ascorbic acid increases, acidity decreased and color more attractive.

The maximum ascorbic acid (71mg/100g) was observed in $T_9$ (Soil (50%) +Vermicompost (50%) + *Azotobacter* (2g) + *Azospirillum* (2g)) and minimum ascorbic acid (25.7mg/100g) was recorded in $T_0$ (CONTROL (sand, soil, coir pith)). Increased ascorbic acid at better tiers of nitrogen would possibly have resulted in view that absorption of nitrogen can be exerted regulatory function as a vital and all through ripening of culmination the carbohydrate reserves of the roots and stem are drawn upon closely through culmination which would possibly have resulted into better ascorbic acid in culmination. Increased ascorbic acid in culmination is the settlement with the findings of El-Hamid *et al.,* (2006) who mentioned that the utility of P.S.B. on strawberry resulted growth in ascorbic acid and Singh *et al.,* [24] who mentioned that the fruit harvested from plant receiving vermicompost have been farmer, TSS and ascorbic acid increases, acidity reduced and satiation greater attractive.

**Table 2. Effect of biofertilizers on fruit setting and pomological attributes of strawberry under vertical system**

| Treatment | Treatment combination | Number of fruits per plant (90 days) | Yield plant$^{-1}$(gram) (90 days) | Fruit diameter (cm) (90 days) | Fruit length (cm) (90 days) | TSS (° Brix) (90 days) | Acidity (%)(90 days) | Ascorbic Acid (mg/100g) (90 days) | Net return (□ /100$^2$) | Benefit: Cost ratio |
|---|---|---|---|---|---|---|---|---|---|---|
| **$T_0$** | CONTROL (sand, soil, coir pith) | 11.89 | 216.08 | 2.47 | 3.1 | 6.03 | 0.74 | 25.7 | 15,700 | 1.16 |
| $T_1$ | Sand (25%) + Soil (50%) + VC (25%) + *Azoto.* (2g) | 15.56 | 333.82 | 2.8 | 3.57 | 7.03 | 0.71 | 38.7 | 74,350 | 1.78 |
| $T_2$ | Sand (25%) + Soil (50%) + VC (25%) + PSB (2g) | 13.56 | 268.17 | 2.57 | 3.27 | 6.36 | 074 | 35.3 | 40,550 | 1.41 |
| $T_3$ | Sand (25%) + Soil (50%) + VC (25%) + *Azosp.* (2g) | 14.33 | 294.56 | 2.74 | 3.43 | 6.77 | 0.69 | 53.3 | 54,300 | 1.57 |
| $T_4$ | Soil (50%) + coir pith (25%) + FYM (25%) + *Azoto.* (2g) | 18.33 | 457.72 | 3.23 | 3.97 | 8.44 | 0.64 | 50.7 | 1,37,170 | 2.41 |
| $T_5$ | Soil (50%) + coir pith (25%) + FYM (25%) + PSB (2g) | 16.89 | 383.04 | 2.97 | 3.7 | 7.6 | 0.66 | 46.3 | 98,970 | 2.01 |
| $T_6$ | Soil (50%) + coir pith (25%) + FYM (25%) + *Azosp.* (2g) | 17.56 | 419.79 | 3.03 | 3.84 | 8.06 | 0.65 | 42.3 | 1,17,920 | 2.21 |
| $T_7$ | Soil (50%) + FYM (50%) + PSB (2g) + *Azoto.* (2g) | 19.89 | 554.33 | 3.47 | 4.33 | 9.1 | 0.60 | 62 | 1,86,740 | 2.93 |
| $T_8$ | Soil (50%) + coir pith (50%) + *Azosp.* (2g) + PSB (2g) | 19 | 511.30 | 3.33 | 4.03 | 8.6 | 0.61 | 54.3 | 1,64,350 | 2.69 |
| **$T_9$** | Soil (50%) + VC (50%) + *Azoto.*(2g) + *Azosp.*(2g) | 21 | 638.40 | 49.56 | 4.46 | 9.57 | 0.58 | 71 | 2,29,050 | 3.34 |
| F-test | | **S** | **S** | **S** | **S** | **S** | **S** | **S** | | |
| SE. d (+) | | 1.77 | 54.45 | 1.74 | 0.23 | 0.36 | 0.04 | 2.93 | | |
| CD (5%) | | 3.71 | 114.4 | 3.66 | 0.47 | 0.76 | 0.09 | 6.16 | | |

*VC: vermicompost, Azoto: Azotobacter, Azosp: Azospirillum, PSB: Phosphate solubilizing bacteria*

The greatest net return was obtained 2,29,050 Rs/100m$^2$ in $T_9$ (Soil (50%) +Vermicompost (50%) + *Azotobacter* (2g) + *Azospirillum* (2g)) and cost benefit ratio was found (3.34) in T9 (FYM+ Vermicompost+ PSB+ *Azotobacter*). The minimum cost benefit ratio was recorded (1.16) in $T_0$ (CONTROL (sand, soil, coir pith)). Many workers also reported the higher net return and cost benefit ratio with the application of organic fertilizers and bio fertilizers viz. Yadav *et al.,* (2010), Verma and Rao, (2012) in strawberry.

## 4. CONCLUSION

On the basis of present investigation, it is concluded that the treatment $T_9$ (Soil (50%) +Vermicompost (50%) + *Azotobacter* (2g) + *Azospirillum* (2g)) was found the best in terms of vegetative growth (Plant height (cm), Plant spread (cm), Number of leaves, Leaf area)(cm$^2$) and yield and quality parameters (Number of fruits per plant Yield plant $^{-}$1(gram) Fruit diameter (cm), Fruit length (cm), TSS (°Brix), Acidity (%), Ascorbic Acid (mg/100g)Net return (□ /100$^2$), Benefit: Cost ratio).The maximum gross return (Rs. 3,26,800), net return (Rs. 2,29,050) and Benefit cost ratio (1: 3.34) was also observed in treatment $T_9$ followed by (2.93) in $T_7$ (Soil (50%) + FYM (50%) + PSB (2g) + *Azotobacter* (2g)) under vertical farming system.

Some urban planners and agricultural leaders have argued that cities must produce food internally in order to manage the demand-supply ratio and avoid falling food prices. From the above research work it is also resulted that how vertical farming can play a beneficial role in urban farming. Not only it will utilize the land requirement in urban areas but also helpful in doubling the income through the vertical farming. It can be easily set up on the home’s wall and roofs by reducing the space.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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