

8 **Efficacy of *Pseudomonas fluorescens* and organic amendments against**  
 9 **black root rot disease caused by *Rhizoctonia solani* in strawberry**  
 10 **(*Fragaria xananassa* Duch.)**

11 12

12 **ABSTRACT**

13  
 14 Black root rot of strawberry caused by *Rhizoctonia solani* is one of the devastating soil-borne diseases. An experiment  
 15 was conducted to evaluate the efficacy of organic amendments, PGPR (*Pseudomonas fluorescens*) and botanical  
 16 treatment for the management of *R. solani* in strawberry. The study was laid out in Randomized Block design (RBD)  
 17 including 4 replications with 8 treatments in pot condition at the greenhouse of Department of Plant Pathology, Sam  
 18 Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, during Rabi season  
 19 2023-2024. The treatments consisted of combination of FYM, vermicompost, biomix compost, neem cake, cocopeat and  
 20 botanical neem leaf extract were used as soil amendments and *P. fluorescens* as root treatment for evaluation on the  
 21 plant growth yield, physicochemical parameters (TSS and total ascorbic acid), disease intensity (%) and benefit cost  
 22 ratio of strawberry. The present investigation results revealed that T<sub>7</sub>-*P. fluorescens* (0.3%) + FYM @ 100g + biomix  
 23 compost @ 15g + vermicompost @ 15g + neem leaf extract @ 10% had the most promising results in terms of maximum  
 24 plant height (14.9 cm), maximum leaf number (15.75), day taken to first flowering (86 days), berry length (4.08 cm),  
 25 berry diameter (2.84 cm), yield (38.87 q ha<sup>-1</sup>), TSS (8.80° Brix), total ascorbic acid (51.60 mg/100g) and B:C ratio (1:2.24).  
 26 It was also observed that T<sub>7</sub> superior over other treatments giving least percent disease intensity (30.75%) followed by  
 27 T<sub>6</sub>-FYM @ 100g + *P. fluorescens* (0.3%) + biomix compost @ 15g + neem cake @ 15g + neem leaf extract @ 10%  
 28 (35.50%). These findings highlight the potential of organic amendments, PGPR (*P. fluorescens*) and botanical  
 29 treatments, as effective alternatives for managing black root rot disease caused by *R. solani* in strawberry cultivation.

30  
 31 **Keywords:** Black root rot, *Rhizoctonia solani*, *Pseudomonas fluorescens*, FYM, vermicompost, biomix compost, neem  
 32 cake, neem leaf extract

33  
34 **1. INTRODUCTION**

35  
 36 Strawberry (*Fragaria xananassa* Duch.) cv. Chandler is an important fruit that belongs to the family Rosaceae and genus  
 37 *Fragaria*. It occupies an important place among the small fruit plants and it is grown throughout the world. Strawberry  
 38 occupies an important place among the small fruit plants and it is grown throughout the world. The fruit is attractive, luscious,  
 39 tasty, highly nutritious, deep red in colour, highly perishable with a unique shape and it has a distinct, pleasant aroma and  
 40 delicate flavour. Besides being an attractive fruit due to its colour and flavour, it is economically and commercially important  
 41 and widely consumed fresh or in processed forms such as jams, juices, jellies etc. The strawberry represents a relevant  
 42 source of micronutrients such as minerals, vitamin C, folate and phenolic substances that contribute to the high nutritional  
 43 quality of the fruit. It is a good source of essential nutrients, antioxidants, bioactive compounds and beneficial  
 44 phytochemicals, which have relevant biological activity in human (Nishu *et al.*, 2021).  
 45 Strawberries are grown worldwide in approximately 80 countries with a worldwide production of more than 9.5 million tons  
 46 (FAOSTAT, 2023). In India, it occupies an estimated area of around 3310 ha with a total production of 19.84 metric tonnes  
 47 (Horticultural Statistics at a glance, 2021).  
 48 Strawberry is one of the temperate fruits in India and its successful cultivation requires an optimum day temperature of 22-  
 49 23°C and night temperature of 7-13°C in India (Tripathi *et al.*, 2015). The Panchgani-Mahabaleshwar region of Maharashtra  
 50 grows more than 85 percent of the country's strawberries. Presently, strawberry cultivation is spreading in plain of Indian climatic  
 51 condition (Meena *et al.*, 2018).  
 52 Strawberry plants are affected by a large number of diseases caused by fungi, bacteria, viruses, nematodes and arthropods.  
 53 These pathogens cause damage to the leaves, roots, crowns and fruits. Among different diseases, black root rot is a  
 54 common, yield-limiting and serious disease complex that adversely affects strawberry production in many regions of the

55 world. It is considered to be a complex disease, caused by these several pathogens (*Rhizoctonia* spp., *Pythium* spp., *Fusarium*  
 56 spp. and *Cylindrocarpon* spp.), environmental factors and nematodes on strawberry (Matsumoto and Yoshida, 2006). The  
 57 organism that is most commonly associated with the black root rot complex is *Rhizoctonia solani* and *R. fragariae*. These  
 58 pathogens, single or in combination fill the vascular system of strawberries, resulting in the prevention of nutrient and water  
 59 uptake (Demiretal., 2023).

60 This disease can cause yield losses of 30-50% in strawberries, decline in vigour and productivity of the plant stand causing  
 61 damage to the host and considerable reduction in the yield (Ahmed et al., 2017). Black root rot disease of strawberry  
 62 characterised by stunted growth, brittle, wilt under heat stress and blackened root systems. The infected plants showed  
 63 fewer crowns of reduced diameter compared with unaffected plants and produced less fruit of reduced quality. Affected  
 64 plants leaves are generally smaller and few numbers of runners are reproduced (Kumari and Thakur, 2022).

65 The major approach to control crown and root-rot in strawberry cultivation has dependent on injecting artificial fungicides  
 66 (Coque et al., 2020). However, the usage application of fungicides raises a number of problems, including the buildup of  
 67 resistance in the diseases that are being targeted, harmful residue on fruits and adverse outcomes on the environment  
 68 (Mheid et al., 2023). In recent years, plant extracts derivatives become the importance for the control of the plant diseases  
 69 due to their antifungal and antibacterial properties. The application of botanical extracts for disease management could be  
 70 less expensive, less polluting and ecofriendly (Rahila et al., 2020).

71 Use of organic by-products as a amendment to reduce soil borne plant diseases is gaining the interest of plant pathologists,  
 72 manufacturing and processing industries, regulators, consumers and growers. The potentiality of Plant growth-promoting  
 73 rhizobacteria in agriculture is steadily increased as it offers an attractive way to replace the use of chemical fertilizers,  
 74 pesticides and other supplements. Biocontrol of strawberry root rot triggered by the *Rhizoctonia* genus can be accomplished  
 75 by either boosting native antagonists like those present in organic manure like vermicompost, FYM etc. to a density  
 76 adequate for suppression of pathogen(s) or inserting alien antagonists. Amid the many antagonists investigated by scientists  
 77 are the *Bacillus* in addition to *Pseudomonas* genera, which have been proved to be beneficial for lowering the spread of  
 78 numerous soil-borne diseases (Attia, 2019). Thus, the present study aimed to evaluate the effect of selected organic  
 79 amendments and PGPR (*Pseudomonas fluorescens*) for the management of black root rot caused by *Rhizoctonia solani* in  
 80 strawberry. Keeping the above in view the study was undertaken during Rab season 2023, at the greenhouse, Department  
 81 of Plant Pathology, Sam Higginbottom University of Agriculture, Technology and Sciences,

Prayagraj. 82

83

## 84 2. MATERIAL AND METHODS

85 The experiment was carried out in pot condition at the greenhouse, Department of Plant Pathology, Sam Higginbottom  
 86 University of Agriculture, Technology and Sciences, Prayagraj during Rab season 2023. The study was laid out in  
 87 Randomized Block Design (RBD) with four replications. The treatments include the combination of different organic  
 88 amendments like FYM, vermicompost (VC), biomix compost (BC) – organic compost mixed with biofertilizers like PSB and  
 89 *Azotobacter chroococcum*, neem cake (NC) and cocopeat (CP) were applied as soil amendments (SA) during the soil  
 90 preparation, botanical neem leaf extract (NLE) was applied as soil drenching (SD) and liquid formulation *Pseudomonas*  
 91 *fluorescens* (Pf) in broth was applied as root dip (RD) of the runners for 30 mins before planting of the runners. 8 treatment  
 92 combinations viz., T<sub>0</sub> control, T<sub>1</sub>-FYM@ 100g(SA)+Pf@0.3%(RD)+VC@ 15g(SA)+NLE@ 10%(SD), T<sub>2</sub>-FYM93 @ 100g + Pf  
 93 @ 0.3% (RD) + BC @ 15g (SA) + NLE @ 10% (SA), T<sub>3</sub> - FYM @ 100g + Pf @ 0.3% (RD) + CP @ 15g (SA)  
 94 + 94NLE @ 10%(SA), T<sub>4</sub>-FYM@ 100g+Pf@0.3%(RD)+NC@ 15g(SA)+NLE@ 10%(SD). T<sub>5</sub>-FYM@ 100g+Pf@0.3%  
 95 (RD)+BC@ 15g(SA)+CP@ 15g(SA)+NLE@ 10%(SD), T<sub>6</sub>-FYM@ 100g+Pf@0.3%(RD)+BC@ 15g(SA)+NC  
 96 @ 15g(SA)+NLE@ 10%(SD) and T<sub>7</sub>-FYM@ 100g+Pf@0.3%(RD)+BC@ 15g(SA)+VC@ 15g(SA)+NLE@ 10%  
 97 (SD) were adopted. The data recorded of different parameters during experiment were pooled and analyzed. Observation  
 98 on plant height and numbers of leaves were recorded at 30, 60, 90 and 120 DAT. At each picking, data of berry weight and  
 99 yield were recorded. The length and width of five randomly selected berries were by using vernier callipers. 100

### 101 2.1 Isolation and identification of the pathogen

102 Diseased plants were collected from different places during the cropping season and isolation of pathogen was carried out  
 103 in the laboratory. Firstly, collected plant disease samples (roots) were washed thoroughly with distilled water and cut off to  
 104 the part with the symptom of 2mm. Surface sterilized with the 1 percent sodium hypochlorite (NaOCl) solution for 1 min,  
 105 then washed with sterilized distilled water thrice to remove any sodium hypochlorite traces and dried by sterilized filter paper  
 106 and then transferred to the petri plates with potato dextrose agar media (1 piece for each plate) with the help of sterilized  
 107 needle and incubated in incubator at 28±2°C for 2-3 days and examined at frequent interval to check the growth of the  
 108 fungal pathogen..

109 The fungal colony culture was initially white, cottony and abundant in aerial mycelium, but it progressively turned into brown  
 110 colour. Sclerotia of the cultural type were scattered separately or sometimes joined laterally on PDA. They were dark brown  
 111 to black, subspherical to irregular and 0.6-6.0 mm in diameter. The hyphae are typically wide (6-12 µm) and exhibit

112 rightangledbranchingwithacharacteristicconstrictionatthepointofbranchingandaseptumnearthebranch.Thecells  
113 are

93 multinucleate and the hyphal walls are generally smooth. The fungus does not produce spores, which is unusual for many  
 94 fungal pathogens, but instead forms shreds of sclerotia, darkly pigmented structures that allow it to survive in harsh conditions.  
 95 The fungus was identified as *R. solani* based on cultural appearance on media, sclerotial morphology and other  
 96 physiological characteristics of mycelium (Kim *et al.*, 1994). 97

### 98 **2.1.1 Purification and maintenance of the pathogen**

99 The cultures of the fungus were sub-cultured on petri plates and kept in laboratory at  $28 \pm 1^\circ\text{C}$  for 15 days. Such mother  
 100 cultures were preserved at  $4^\circ\text{C}$  in refrigerator. Further, these cultures were sub-cultured once in a month and used for  
 101 future purpose (Toussoun and Nelson, 1976). 10

### 103 **2.2 Preparation of Phyto-extracts**

104 Fresh and healthy neem leaves were collected and washed with running tap water followed by sterile distilled water and 105 air dry  
 at  $27^\circ\text{C}$ . The plant materials and water were used at a ratio of 1:1 (weight: volume) and ground the mixture by  
 using 106 pestle and mortar to obtain extract. The extracts were then filtered through double-layered muslin cloth and then with  
 107 filter paper. The concentrated filtrate of neem leaf extract was considered as standard solution (100%). The neem leaf extract 108 at 10% pre-  
 pared from standard was drenched at the rhizosphere region of the plant (Bambode and Shukla, 1973).  
 109

### 110 **2.3 Measurement of total soluble solids (TSS) along with total ascorbic acid (vitamin C)**

111 A digital hand refractometer was utilized to figure out the total soluble solids content of the strawberry (Paul *et al.*, 2010).  
 112 Ascorbic acid content was calculated by using 2,6-Dichlorophenol indophenol visual titration method. Dye solution was  
 113 prepared by dissolving 42 mg of  $\text{NaHCO}_3$  in a small amount of distilled water and added 52 g of 2,6-dichlorophenol  
 114 indophenol and diluted with distilled water to 200 ml. Standard vitamin C solution was prepared by taking 100 mg of vitamin  
 115 C mixed with 100 ml of 3 percent oxalic acid in 100 ml volumetric flask. 10 ml of standard vitamin C solution was taken in a  
 116 conical flask and it was titrated with prepared dye from burette until the solution turns into light pink and recorded dye used  
 117 while titration process ( $V_1$  ml). 5 g of strawberry sample was taken and grinded into strawberry juice and filtered by using  
 118 double layering muslin cloth and added 4 percent oxalic acid to a known volume (100 ml), then pipetted 5 ml of the  
 119 supernatant and added 10 ml 4 percent oxalic acid and titrating against dye ( $V_2$  ml). The content of vitamin C in strawberry  
 120 was calculated using the formula (Sadasivam and Balasubraminan, 1987) which is given below

$$121 \quad \text{Content of vitamin C (mg/100g)} = \frac{V_1 \times 5 \text{ml} \times \text{weight of the sample}}{0.05 \times V_2 \text{ml} \times 100 \text{ml}} \times 100$$

### 122 **2.4 Disease assessment**

123 Plants per treatment per replication were regularly watched for first appearance of disease. The observation on disease  
 124 intensity was recorded using a progressive 0-5 scale, as shown in (Table 1 and Plate 1). Numerical ratings scale was given  
 125 on the basis of percentage of area infected by pathogen on the root (Fang *et al.*, 2011) as described below 126

127 **Table 1 Disease ratings scale**

Scale	Description
0	root well developed, no discoloration
1	<25% root discoloured
2	$\geq 25\%$ , <50% root discoloured
3	$\geq 50\%$ , <75% root discoloured
4	$\geq 75\%$ root discoloured
5	all root discoloured (rotted)

138 **Plate1.Diseaseratingscale**  
 139



140  
 141  
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 144 **2.4.1 PerCent Disease Intensity (PDI)**

145 Percent disease intensity was recorded at 150 DAT at the end of the experiment. Percent disease intensity was calculated  
 146 in accordance with following formula (Mckinney, 1923) which was given below

147 
$$\text{Disease intensity (\%)} = \frac{\text{Sum of all individual disease ratings}}{\text{Total no. of plants observed} \times \text{Maximum disease grade}} \times 100$$

150  
 151 **2.5 Benefit cost ratio**

152 Cost of cultivation, gross return, net return and benefit cost ratio was worked out to evaluate the economics of each  
 153 treatment, based on the existing market prices of input and output (Reddy and Reddi, 2004). The benefit cost ratio was  
 154 calculated by using the following formula

155 
$$\text{B:C ratio} = \frac{\text{Gross return (Rs/ha)}}{\text{Cost of cultivation (Rs/ha)}}$$

159 **3. RESULTS AND DISCUSSION**

160 Under greenhouse condition, plant height and numbers of leaves were recorded at 30, 60, 90 and 120 DAT. At each picking,  
 161 data of berry weight and yield were recorded. The length and width of five randomly selected berries were by using vernier  
 162 callipers.

164 **3.1 Plant growth parameters**

165 The data presented in the table 2 and depicted in figure 1 revealed that plant height (cm) of strawberries significantly increased  
 166 Pf@0.3%+BC@15g+NC@15g+NLE@10% (13.97cm), T<sub>1</sub>-FYM@100g+Pf@0.3%+VC@15g+NLE@10% (13.22cm), T<sub>5</sub>-FYM@100g+Pf@0.3%+BC@15g+CP@15g+NLE@10% (13.10cm), T<sub>2</sub>-FYM@100g+Pf@0.3%  
 168 +BC@15g+NLE@10% (12.42cm), T<sub>4</sub>-FYM@100g+Pf@0.3%+NC@15g+NLE@10% (11.70cm), T<sub>3</sub>-FYM@100g  
 169 +Pf@0.3%+CP@15g+NLE@10% (11.00cm) as compared to (untreated checked) T<sub>0</sub>-control (8.60cm).

171 Comparing the treatments with the CD value (0.66) all the treatments (T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub>, T<sub>5</sub>, T<sub>6</sub> and T<sub>7</sub>) were found significant  
 172 over (untreated checked) T<sub>0</sub>-control. Among the treatments (T<sub>1</sub> and T<sub>5</sub>) were found non-significant to each other, (T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub>,  
 173 T<sub>6</sub> and T<sub>7</sub>) were found to be significant over all the other treatments.

174 The data presented in the table 2 and depicted in figure 1 revealed that number of leaves of strawberries significantly  
 175 @100g+Pf@0.3%+BC@15g+NC@15g+NLE@10% (14.37), T<sub>5</sub>-FYM@100g+Pf@0.3%+BC@15g+CP@15g  
 176 +NLE@10% (13.00), T<sub>1</sub>-FYM@100g+Pf@0.3%+VC@15g+NLE@10% (12.50), T<sub>2</sub>-FYM@100g+Pf@0.3%+

178 BC @ 15g+NLE @ 10%(11.87), T<sub>4</sub>-FYM @ 100g+Pf @ 0.3%+NC @ 15g+NLE @ 10%(10.37), T<sub>3</sub>-FYM @ 100g+Pf  
 179 @ 0.3%+CP @ 15g+NLE @ 10%(9.00) as compared to (untreated checked) T<sub>0</sub>-control (7.50).  
 180 Comparing the treatments with the CD value (1.25) all the treatments (T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub>, T<sub>5</sub>, T<sub>6</sub> and T<sub>7</sub>) were found significant  
 181 over (untreated checked) T<sub>0</sub>-control. Among the treatments (T<sub>1</sub>, T<sub>2</sub> and T<sub>5</sub>) were found non-significant to each other, (T<sub>3</sub>,  
 182 T<sub>4</sub>, T<sub>6</sub> and T<sub>7</sub>) were found to be significant over all the other  
 treatments. 183

184 As per finding from this study, the maximum plant height (cm) and maximum number of leaves was observed in T<sub>7</sub>-FYM  
 185 @ 100g+Pf @ 0.3%+BC @ 15g+VC @ 15g+NLE @ 10%. The probable reasons for this result may be due to the soil  
 186 nitrogen contents increased with the use of FYM and other organic fertilizer. Nitrogen is the constituent of chlorophyll, more  
 187 chlorophyll contents result in more photosynthesis, thus may have increased plant height and numbers of leaves in  
 188 strawberry and application of FYM (Zahid *et al.*, 2022). Vermicompost may have attributed to better availability of plant  
 189 growth regulator and humic acid which is produced by the increased activity of microbes. The microbes like fungi, bacteria,  
 190 yeast, actinomycetes, algae etc. are capable to produce auxin, gibberellin (Singh *et al.*, 2008). Application of PSB  
 contain 191 bio-mix compost may have helped in cell elongation and cell division in meristematic region of plant, this may be due to  
 192 the production of plant growth regulators such as IAA and GA (Kumar *et al.*, 2015). *Pseudomonas fluorescens* generates 193  
 194 indoleacetic acid as a growth regulator which may have helped in strawberry plant growth (Badawy, 2023). The increment  
 195 in growth parameter due to the biofertilizers application might be due to the vital role and promoting effect of bacteria present  
 196 in the applied biofertilizer on morphology and physiological of the root system, thus favouring the growth parameter and  
 197 contributing some hormones like gibberellin, auxin and cytokinin. Similar findings are consistent with research conducted  
 198 on *Moringa oleifera* Lam. plants (Youssef, 2016). Compounds from neem leaf such as isoprenoids (azadirone, gedunin,  
 199 vilasinin, azadirachtin) and non-isoprenoids (sulphurous compounds, polyphenolics like flavonoids, dihydrochalcone,  
 200 coumarin, tannins) were reported to be fungistatic in nature. Different parts of neem have demonstrated great biological  
 201 activities against microbes through the inhibition of growth and breakdown of their cell walls. Similar findings have been  
 202 reported by Bhattarai *et al.*, (2022) and Adusei and Azupio (2022). So, neem leaf extracts significantly inhibit the pathogen  
 203 and may have lead to better health of the plant which in turn may have helped the plant in attaining maximum plant height  
 and maximum numbers of leaves in strawberry. 20

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### 205 3.2 Daystaken to first flowering and yield (qha<sup>-1</sup>)

206 The data presented in the table 2 and depicted in figure 1 revealed that minimum daystaken to first flowering was observed 207  
 208 +Pf @ 0.3%+BC @ 15g+NC @ 15g+NLE @ 10% (88.00 days), T<sub>1</sub>-FYM @ 100g+Pf @ 0.3% +VC @ 15g+NLE @ 10% 0g  
 209 (91 days), T<sub>5</sub>-FYM @ 100g+Pf @ 0.3%+BC @ 15g+CP @ 15g+NLE @ 10% (91.25 days), T<sub>4</sub>-FYM @ 100g+Pf @ 0.3%  
 210 +NC @ 15g+NLE @ 10% (93.50 days), T<sub>2</sub>-FYM @ 100g+Pf @ 0.3%+BC @ 15g+NLE @ 10% (93.75 days), T<sub>3</sub>-FYM  
 211 @ 100g+Pf @ 0.3%+CP @ 15g+NLE @ 10% (95.25 days) as compared to (untreated checked) T<sub>0</sub>-control (105.5 days).  
 212 Comparing the treatments with the CD value (1.67) all the treatments (T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub>, T<sub>5</sub>, T<sub>6</sub> and T<sub>7</sub>) were found significant  
 213 over (untreated checked) T<sub>0</sub>-control. Among the treatments (T<sub>2</sub> and T<sub>4</sub>); (T<sub>1</sub> and T<sub>5</sub>) were found non-significant to each  
 214 other, (T<sub>3</sub>, T<sub>6</sub> and T<sub>7</sub>) were found to be significant over all the other treatments.

215 The data presented in the table 3 and depicted in figure 3 revealed that yield (qha<sup>-1</sup>) of strawberry significantly increased 216  
 217 @ 100g+Pf @ 0.3%+BC @ 15g+NC @ 15g+NLE @ 10% (35.86 qha<sup>-1</sup>), T<sub>1</sub>-FYM @ 100g+Pf @ 0.3% +VC @ 15g+  
 218 NLE @ 10% (33.86 qha<sup>-1</sup>), T<sub>5</sub>-FYM @ 100g+Pf @ 0.3%+BC @ 15g+CP @ 15g+NLE @ 10% (32.06 qha<sup>-1</sup>), T<sub>2</sub>-FYM  
 219 @ 100g+Pf @ 0.3% +BC @ 15g+NLE @ 10% (31.99 qha<sup>-1</sup>), T<sub>4</sub>-FYM @ 100g+Pf @ 0.3% +NC @ 15g+NLE @ 10%  
 220 (31.84 qha<sup>-1</sup>), T<sub>3</sub>-FYM @ 100g+Pf @ 0.3%+CP @ 15g+NLE @ 10% (30.25 qha<sup>-1</sup>), as compared to (untreated  
 221 checked) T<sub>0</sub>-control (20.60 qha<sup>-1</sup>).

222 Comparing the treatments with the CD value (1.46) all the treatments (T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub>, T<sub>5</sub>, T<sub>6</sub> and T<sub>7</sub>) were found significant  
 223 over (untreated checked) T<sub>0</sub>-control. Among the treatments (T<sub>2</sub>, T<sub>4</sub> and T<sub>5</sub>) were found non-significant to each other, (T<sub>1</sub>, T<sub>3</sub>,  
 224 T<sub>6</sub> and T<sub>7</sub>) were found to be significant over all the other treatments.

225 As per finding from this study, minimum daystaken to flowering and yield (qha<sup>-1</sup>) was observed in T<sub>7</sub>-FYM @ 100g+Pf  
 226 @ 0.3%+BC @ 15g+VC @ 15g+NLE @ 10%. The probable reasons for this result may be due to application of FYM and  
 227 organic fertilizers may have helped in increased soil nitrogen. Nitrogen is the constituent of chlorophyll, more chlorophyll  
 228 contents result in more photosynthesis thus may have increased yield and nitrogen play vital role in the production of  
 229 gibberellic acid in roots which may have helped in breaking bud dormancy, which may have resulted in enhanced bud  
 230 production and increase flowering site in strawberry (Zahid *et al.*, 2022). The release of nutrient and primary nitrogen from  
 231 the vermicompost may have conceded with the period of flowering differentiation (Cabilovski *et al.*, 2023). *Pseudomonas*  
 232 *fluorescens* generates indoleacetic acid as a growth regulator which may have helped in strawberry yield (Badawy, 2023).  
 233 The increment in growth parameter due to the biofertilizers application might be due to the vital role and promoting effect of  
 234 bacteria present in the applied biofertilizer on morphology and physiological of the root system, thus favouring the growth  
 235 parameter and contributing some hormones like gibberellin, auxin and cytokinin. Similar findings are consistent with

236 research conducted on *Moringa oleifera* Lam. plants (Youssef, 2016). Vermicompost and *Azotobacter chroococcum* present 237  
 238 (Tripathi et al., 2015). PSB and vermicompost may have extended photosynthetic capacity of plant which may have returned 239  
 240 in accumulation of dry matter in strawberry (Yashasvi et al., 2021).

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**Table 2. Effect of selected treatments on plant height (cm), number of leaves, days taken to first flowering (days), berry length (cm) and berry diameter (cm)**

Treatments	Plant Height (cm)	Numbers of leaves	Days taken to first flowering (days)	Berry length (cm)	Berry diameter (cm)
T <sub>0</sub> -Control (untreated checked)	8.60	7.5	105.50	2.02	1.72
T <sub>1</sub> -FYM@100g+Pf@0.3%+VC@15g+NLE@10%	13.22 <sup>a</sup>	12.50 <sup>a</sup>	91.00 <sup>b</sup>	3.80 <sup>a</sup>	2.54 <sup>a</sup>
T <sub>2</sub> -FYM@100g+Pf@0.3%+BC@15g+NLE@10%	12.42	11.87 <sup>a</sup>	93.75 <sup>a</sup>	3.42	2.52 <sup>a</sup>
T <sub>3</sub> -FYM@100g+Pf@0.3%+CP@15g+NLE@10%	11.00	9.00	96.75	3.18	2.30 <sup>b</sup>
T <sub>4</sub> -FYM@100g+Pf@0.3%+NC@15g+NLE@10%	11.70	10.37	93.50 <sup>a</sup>	3.62	2.28 <sup>b</sup>
T <sub>5</sub> -FYM@100g+Pf@0.3%+BC@15g+CP@15g+NLE@10%	13.15 <sup>a</sup>	13.00 <sup>a</sup>	91.12 <sup>b</sup>	3.82 <sup>a</sup>	2.58 <sup>a</sup>
T <sub>6</sub> -FYM@100g+Pf@0.3%+BC@15g+NC@15g+NLE@10%	13.97	14.37	88.00	3.86 <sup>a</sup>	2.60 <sup>a</sup>
T <sub>7</sub> -FYM@100g+Pf@0.3%+BC@15g+VC@15g+NLE@10%	14.90	15.75	86.00	4.08	2.84
<b>CD at 5%</b>	0.66	1.25	1.67	0.17	0.20

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**Table 3. Effect of selected treatments on TSS (°Brix), total ascorbic acid (mg/100g), yield (q/ha), disease intensity (%) and B:C ratio**

Treatments	TSS (°Brix)	Total ascorbic acid (mg/100g)	Yield (q/ha)	Disease intensity (%) at 150 DAT	B:C ratio
T <sub>0</sub> -Control (untreated checked)	6.50	46.00	20.60	50.75	1:1.63
T <sub>1</sub> -FYM@100g+Pf@0.3%+VC@15g+NLE@10%	8.13 <sup>a</sup>	49.66 <sup>a</sup>	33.86	35.75 <sup>a</sup>	1:2.11
T <sub>2</sub> -FYM@100g+Pf@0.3%+BC@15g+NLE@10%	8.03	49.00 <sup>b</sup>	31.99 <sup>a</sup>	40.50 <sup>b</sup>	1:1.93
T <sub>3</sub> -FYM@100g+Pf@0.3%+CP@15g+NLE@10%	7.16	47.17	30.25	45.25	1:1.86
T <sub>4</sub> -FYM@100g+Pf@0.3%+NC@15g+NLE@10%	7.36	48.57 <sup>b</sup>	31.84 <sup>a</sup>	42.75	1:1.87
T <sub>5</sub> -FYM@100g+Pf@0.3%+BC@15g+CP@15g+NLE@10%	8.16 <sup>a</sup>	50.00 <sup>a</sup>	32.06 <sup>a</sup>	39.25 <sup>b</sup>	1:1.82

T<sub>6</sub>-FYM@100g+Pf@0.3%+  
BC@15g+NC@15g+NLE@10%

8.43<sup>a</sup>

50.93

35.86

35.50<sup>a</sup>

1:2.14

T<sub>7</sub>-FYM@100g+Pf@0.3%+  
BC@15g+VC@15g+NLE@10%

8.80

51.60

38.87

30.75

1:2.24

CDat5%

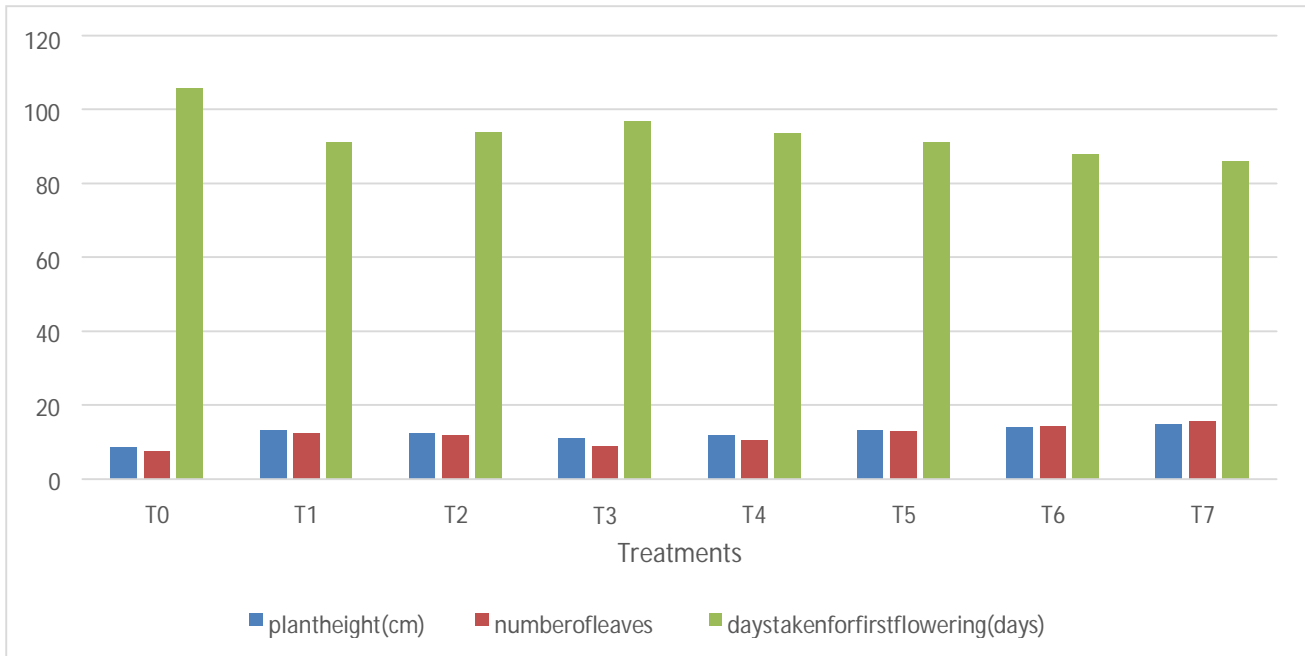
0.18

0.55

1.46

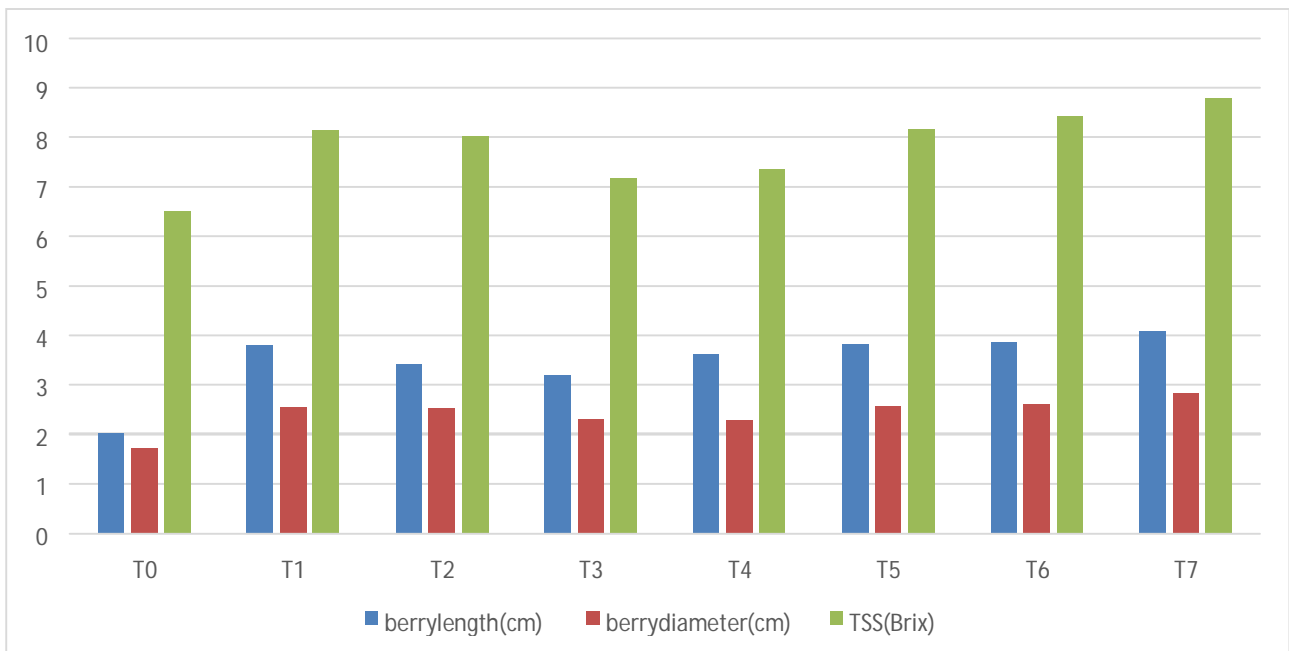
2.23

255  
256



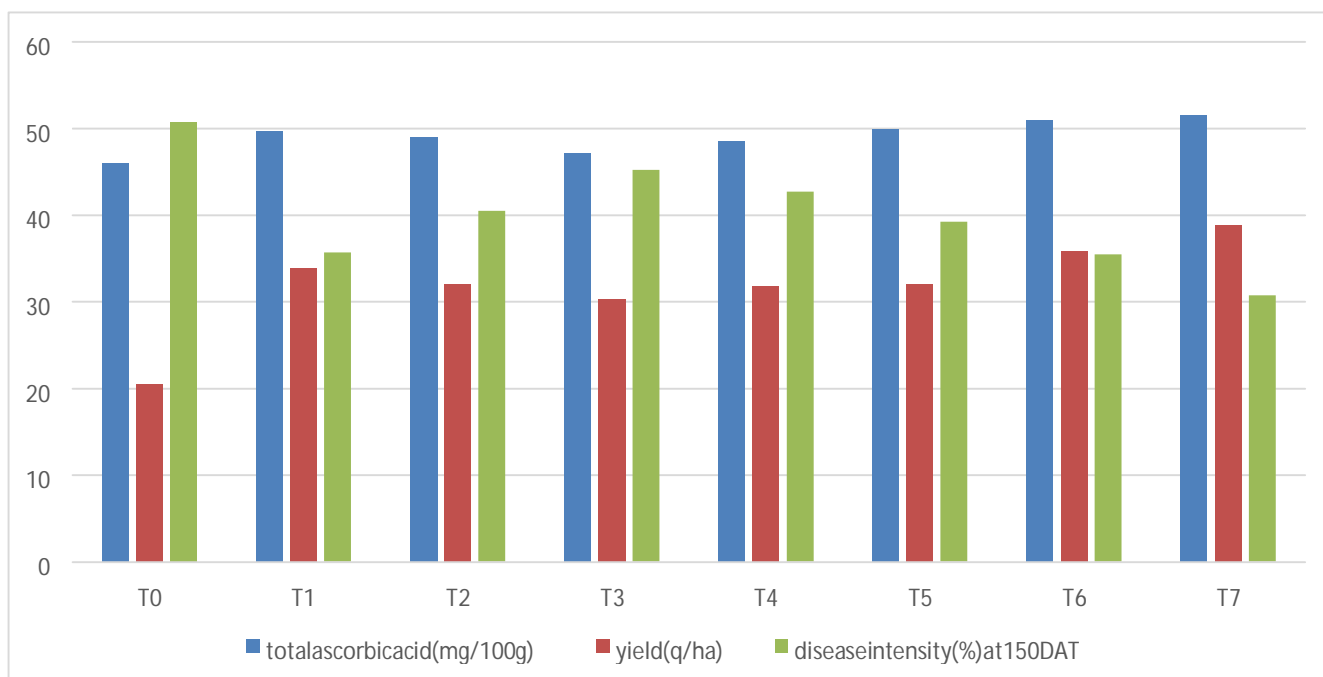
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Fig.1.Effectofselectedtreatmentsonplantheight (cm),numberofleavesanddaystakentofirstflowering (days)



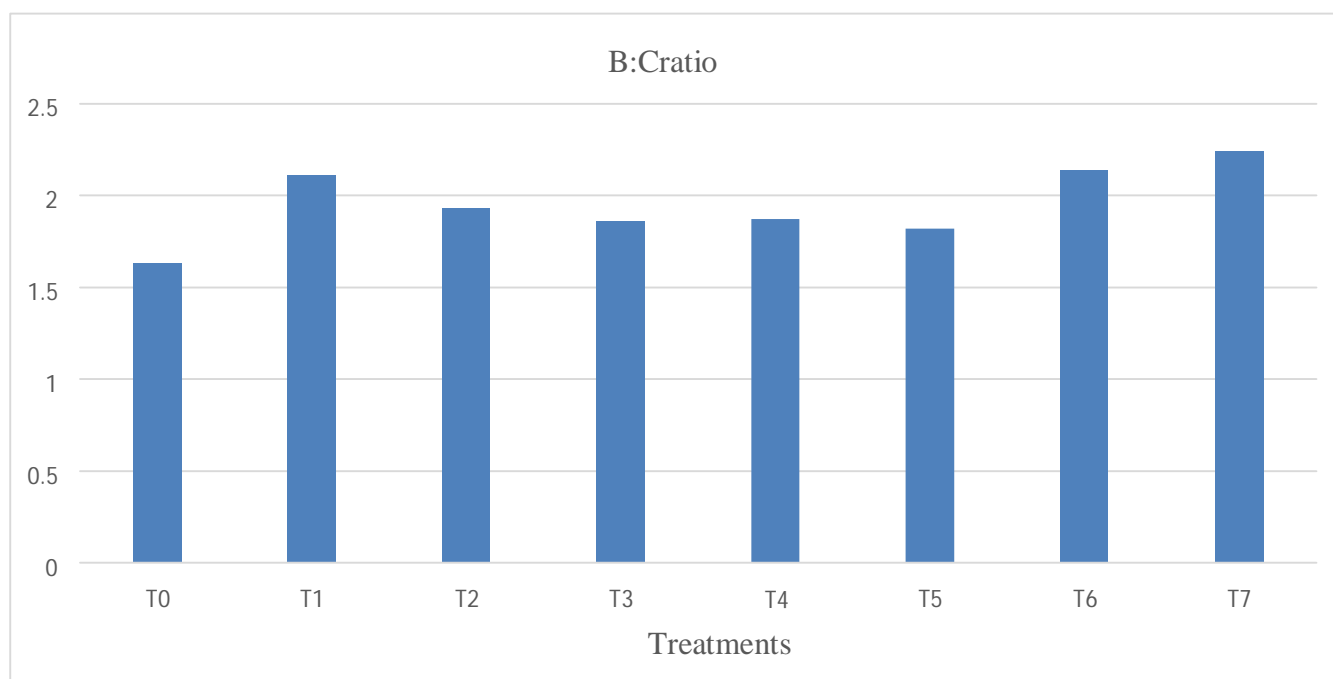
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Fig.2.Effectofselectedtreatmentsonberrylength(cm),berrydiameter(cm)andTSS(°Brix)



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**Fig.3.Effectofselectedtreatmentsontotalascorbicacid(mg/100g),yield(q/ha)anddiseaseintensity(%)at150 DAT**



270  
271

**Fig.4.EffectofselectedtreatmentsonB:Cratio**

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273

274

### 3.3Berrylength(cm)andberrydiameter ofstrawberry

275

276

277

FYM278

CP279

Pf280

281

The data presented in the table 2 and depicted in figure 2 revealed that berry length (cm) of strawberry significantly increased in treatment T<sub>7</sub> - FYM @100g + Pf @0.3% + BC @15g + VC @15g + NLE @10% (4.08 cm) followed T<sub>6</sub> - FYM @100g + Pf @0.3% + BC @15g + NC @15g + NLE @10% (3.86 cm), T<sub>5</sub> - FYM @100g + Pf @0.3% + BC @15g + CP @15g + NLE @10% (3.82 cm), T<sub>1</sub> - FYM @100g + Pf @0.3% + VC @15g + NLE @10% (3.80 cm), T<sub>4</sub> - FYM @100g + Pf @0.3% + NC @15g + NLE @10% (3.62 cm), T<sub>2</sub> - FYM @100g + Pf @0.3% + BC @15g + NLE @10% (3.42 cm), T<sub>3</sub> - FYM @100g + Pf @0.3% + CP @15g + NLE @10% (3.18 cm) as compared to (untreated checked) T<sub>0</sub> - control (2.02 cm).

282 Comparing the treatments with the CD value (0.17) all the treatments (T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub>, T<sub>5</sub>, T<sub>6</sub> and T<sub>7</sub>) were found significant  
 283 over (untreated checked) T<sub>0</sub>-control. Among the treatments (T<sub>1</sub>, T<sub>5</sub> and T<sub>6</sub>) were found non-significant to each other, (T<sub>2</sub>,  
 284 T<sub>3</sub>, T<sub>4</sub> and T<sub>7</sub>) were found to be significant over all the other treatments.

285 The data presented in the table 2 and depicted in figure 2 revealed that berry diameter of strawberry significantly increased 286  
 287 Pf @ 0.3% + BC @ 15g + NC @ 15g + NLE @ 10% (2.60 cm), T<sub>5</sub>- FYM @ 100g + Pf @ 0.3% + BC @ 15g + CP @ 15g + NLE @ 10% (2.58  
 cm), T<sub>1</sub> - FYM @ 100g + Pf @ 0.3% + VC @ 15g + NLE @ 10% (2.54 cm), T<sub>2</sub> - FYM @ 100g + Pf @ 0.3% +  
 BC @ 15g + NLE @ 10% (2.52 cm), T<sub>3</sub>- FYM @ 100g + Pf @ 0.3% + CP @ 15g + NLE @ 10% (2.30 cm), T<sub>4</sub>- FYM @ 100g + Pf  
 290 @ 0.3% + NC @ 15g + NLE @ 10% (2.28 cm), as compared to (untreated checked) T<sub>0</sub>-control (1.72 cm).

291 Comparing the treatments with the CD value (0.20) all the treatments (T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub>, T<sub>5</sub>, T<sub>6</sub> and T<sub>7</sub>) were found significant  
 292 over (untreated checked) T<sub>0</sub>-control. Among the treatments (T<sub>1</sub>, T<sub>2</sub>, T<sub>5</sub> and T<sub>6</sub>); (T<sub>3</sub> and T<sub>4</sub>), were found non-significant to  
 293 each other, T<sub>7</sub> was found to be significant over all the other treatments.

294 As per finding from this study, the maximum berry length (cm) and berry diameter (cm) was observed in T<sub>7</sub>- FYM @ 100g +  
 295 Pf @ 0.3% + BC @ 15g + VC @ 15g + NLE @ 10%. The probable reasons for this result may be due to the soil nitrogen  
 296 contents increased with the use of FYM and other organic fertilizer. Nitrogen is the constituent of chlorophyll, more  
 297 chlorophyll contents result in more photosynthesis, thus may have increased in fruits weight and fruits diameter in strawberry  
 298 (Zahid *et al.*, 2022). Vermicompost and *Azotobacter chroococcum* present in bio mix compost may have increased the  
 299 accumulation of dry matter. Berry size, weight and volume are highly co-related with the dry matter content and balanced 300  
 301 may have turned in accumulation of dry matter in strawberry (Yashasvi *et al.*, 2021). Compounds from neem leaf such  
 as 302 isoprenoids (azadirone, gedunin, vilasinin, azadirachtin) and non-isoprenoids (sulphurous compounds, polyphenolics like  
 303 flavonoids, dihydrochalcone, coumarin, tannins) were reported to be fungistatic in nature. Different parts of neem have  
 304 demonstrated great biological activities against microbes through the inhibition of growth and breakdown of their cell walls.  
 305 Similar findings have been reported by Bhattarai *et al.* (2022) and Adusei and Azupio (2022). So, neem leaf extract  
 306 significantly inhibits the pathogen and may have leads to better health of the plant. 307  
 308

### 309 3.4 TSS (°Brix) and total ascorbic acid (mg/100g) of strawberry

310 The data presented in the table 3 and depicted in figure 2 revealed that total soluble solids (°Brix) of strawberry significantly 311  
 312 @ 100g + Pf @ 0.3% + BC @ 15g + NC @ 15g + NLE @ 10% (8.43°Brix), T<sub>5</sub>- FYM @ 100g + Pf @ 0.3% + BC @ 15g + CP  
 313 @ 15g + NLE @ 10% (8.16°Brix), T<sub>1</sub>- FYM @ 100g + Pf @ 0.3% + VC @ 15g + NLE @ 10% (8.13°Brix), T<sub>2</sub>- FYM @ 100g +  
 314 Pf @ 0.3% + BC @ 15g + NLE @ 10% (8.03°Brix), T<sub>4</sub>- FYM @ 100g + Pf @ 0.3% + NC @ 15g + NLE @ 10% (7.36°Brix), T<sub>3</sub>  
 315 - FYM @ 100g + Pf @ 0.3% + CP @ 15g + NLE @ 10% (7.16°Brix), as compared to (untreated checked) T<sub>0</sub>-control (6.5  
 316 °Brix).

317 Comparing the treatments with the CD value (0.18) all the treatments (T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub>, T<sub>5</sub>, T<sub>6</sub> and T<sub>7</sub>) were found significant  
 318 over (untreated checked) T<sub>0</sub>-control. Among the treatments (T<sub>1</sub>, T<sub>2</sub> and T<sub>5</sub>) were found non-significant to each other, (T<sub>3</sub>,  
 319 T<sub>4</sub>, T<sub>7</sub> and T<sub>6</sub>) were found to be significant over all the other treatments.

320 The data presented in the table 3 and depicted in figure 3 revealed that total ascorbic acid (mg/100g) of strawberry  
 321 significantly increased in treatment T<sub>7</sub> - FYM @ 100g + Pf @ 0.3% + BC @ 15g + VC @ 15g + NLE @ 10% (51.60 mg/100g)  
 322 followed T<sub>6</sub>- FYM @ 100g + Pf @ 0.3% + BC @ 15g + NC @ 15g + NLE @ 10% (50.93 mg/100g), T<sub>5</sub>- FYM @ 100g + Pf 323  
 @ 0.3% + BC @ 15g + CP @ 15g + NLE @ 10% (50 mg/100g), T<sub>1</sub> - FYM @ 100g + Pf @ 0.3% + VC @ 15g + NLE @ 10% 324 (49.67  
 mg/100g), T<sub>2</sub> - FYM @ 100g + Pf @ 0.3% + BC @ 15g + NLE @ 10% (49 mg/100g), T<sub>4</sub> - FYM @ 100g + Pf @ 0.3%  
 + 325 NC @ 15g + NLE @ 10% (48.57 mg/100g), T<sub>3</sub>- FYM @ 100g + Pf @ 0.3% + CP @ 15g + NLE @ 10% (47.17 mg/100g), as  
 326 compared to (untreated checked) T<sub>0</sub>-control (46.00 mg/100g).

327 Comparing the treatments with the CD value (0.55) all the treatments (T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub>, T<sub>5</sub>, T<sub>6</sub> and T<sub>7</sub>) were found significant  
 328 over (untreated checked) T<sub>0</sub>-control. Among the treatments (T<sub>1</sub> and T<sub>5</sub>); (T<sub>2</sub> and T<sub>4</sub>) were found non-significant to each  
 329 other, (T<sub>3</sub>, T<sub>6</sub> and T<sub>7</sub>) were found to be significant over all the other treatments.

330 As per finding from this study, the maximum TSS (°Brix) value and total ascorbic acid contents was observed in T<sub>7</sub>- FYM  
 331 @ 100g + Pf @ 0.3% + BC @ 15g + VC @ 15g + NLE @ 10%. The probable reasons for this result may be due to the  
 332 application of FYM in soils resulted in an increased chlorophyll production and more chlorophyll contents may have 333  
 334 potassium present in the soil also may have helped in increased vitamin C content in fruits (Zahid *et al.*, 2022). Application  
 335 *Azotobacter* spp. and vermicompost may have increased TSS and sugar contents due to the quick metabolic transformation  
 336 of starch and pectin into soluble compound and rapid translocation of sugar from leaves to developing fruits in strawberry  
 337 (Tripathi *et al.*, 2015). The microbial inoculant like *Azotobacter* may have increased in availability of phosphorus and secrete  
 338 of growth promoting substance which may have accelerated the physiological process like carbohydrates synthesis and may  
 339 have helped in increased ascorbic acid content (Tripathi *et al.*, 2015).

### 340 3.9 Disease intensity (%) at 150 DAT

341

342 The data presented in the table 3 and depicted in figure 3 revealed that disease intensity (%) of strawberries significantly  
 343 minimum in treatment T<sub>7</sub> - FYM @ 100g + Pf @ 0.3% + BC @ 15g + VC @ 15g + NLE @ 10% (30.75%) followed T<sub>6</sub> -  
 FYM344 @ 100g + Pf @ 0.3% + BC @ 15g + NC @ 15g + NLE @ 10% (35.50%), T<sub>1</sub> - FYM @ 100g + Pf @ 0.3% + VC @ 15g +  
 NLE345 @ 10% (35.75%), T<sub>5</sub> - FYM @ 100g + Pf @ 0.3% + BC @ 15g + CP @ 15g + NLE @ 10% (39.25%), T<sub>2</sub> - FYM @ 100g +  
 Pf346 @ 0.3% + BC @ 15g + NLE @ 10% (40.50%), T<sub>4</sub> - FYM @ 100g + Pf @ 0.3% + NC @ 15g + NLE @ 10% (42.75%), T<sub>3</sub> - FYM  
 347 @ 100g + Pf @ 0.3% + CP @ 15g + NLE @ 10% (45.25%), as compared to (untreated checked) T<sub>0</sub> - control (50.75%).

348 Comparing the treatments with the CD value (2.23) all the treatments (T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub>, T<sub>5</sub>, T<sub>6</sub> and T<sub>7</sub>) were found significant  
 349 over (untreated checked) T<sub>0</sub> - control. Among the treatments (T<sub>1</sub> and T<sub>6</sub>); (T<sub>2</sub> and T<sub>5</sub>) were found non-significant to each  
 350 other, (T<sub>3</sub>, T<sub>4</sub> and T<sub>6</sub>) were found to be significant over all the other treatments.

351 As per finding from this study, the least disease intensity (%) was observed in T<sub>7</sub> - FYM @ 100g + Pf @ 0.3% + BC @ 15g +  
 352 VC @ 15g + NLE @ 10%. The probable reasons for this result may be due to PGPR can create several kinds of antibiotics,  
 353 which may have related to the bacterial capacity to suppress plant pathogen development. A variety of PGPR can produce  
 354 enzymes like proteases, chitinases, glucanases, and lipases, which can lyse a section of the cell walls of numerous  
 355 dangerous fungi. The activities of *Pseudomonas fluorescens* and *Azotobacter chroococcum* may have the abilities to produce  
 356 several antibiotic such as catalase, siderophores, somycin A and pyrrolnitrin. Similar findings have been reported by  
 357 **Badawy (2023)** and **Juber et al. (2016)**. Compounds from neem leaf such as isoprenoids (azadirone, gedunin, vilasinin,  
 358 azadirachtin) and non-isoprenoids (sulphurous compounds, polyphenolics like flavonoids, dihydrochalcone, coumarin,  
 359 tannins) were reported to be fungistatic in nature. Different parts of neem have demonstrated great biological activities  
 360 against microbes through the inhibition of growth and breakdown of their cell walls. Similar findings have been reported by  
 361 **Bhattarai et al. (2022)** and **Adusei and Azupio (2022)**. So, neem leaf extracts significantly inhibit the pathogen which may  
 362 have lead to minimum disease intensity percent. 363

364

365

366

### 399 3.10 Benefit cost ratio

400  
 401 The treatment wise economic of strawberry production were estimated and the results have been presented in table 3 and  
 402 figure 4 the economic analysis of the data over the session that (treated check) T<sub>7</sub>-FYM@100g+Pf@0.3%+BC@15g  
 403 +VC@15g+NLE@10% was recorded highest gross returns Rs.971750, net returns Rs.539200 with C:B ratio 1:2.24  
 404 followed with T<sub>6</sub>- FYM @100g + Pf @0.3% + BC @15g + NC @15g + NLE @10% recorded gross returns Rs 896500, net  
 405 returns Rs. 478950 with B:C ratio 1:2.14 as compared to (untreated checked) T<sub>0</sub> - Control gross returns Rs.  
 406 515000, net returns Rs.199200 with B:C ratio 1:1.63.

407

408

### 409 4. CONCLUSION

410 The findings of this study identified the causal organism responsible for black root rot of strawberry (*Fragaria x ananassa*  
 411 *duch.*) was *Rhizoctonia solani*. Among the treatments, T<sub>7</sub>-FYM at 100g + *Pseudomonas fluorescens* (0.3%) + bio mix  
 412 compost at 15g + vermicompost at 15g + neem leaf extract at 10 percent per pot recorded the highest plant height (cm),  
 413 total leaf number, berry length (cm), berry diameter (cm), total soluble solid (°Brix), ascorbic acid (g/100mg), yield (qha<sup>-1</sup>),  
 414 benefit cost ratio and recorded the lowest day stalk to first flowering (days) as well as percent disease intensity (%) of  
 415 strawberry. It is worth mentioning that the conclusions drawn from this study are based on observations made during a  
 416 specific cropping season spanning December 2023 to May 2024, within the agroclimatic conditions of Prayagraj, U.P. As  
 417 such, further research and more experimentation over many seasons should be conducted in future for further  
 418 recommendations.

419

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### 424 REFERENCES

425

426

Nishu, Sood M, Bandral JD, Duwa. Nutritional benefits and value added products of strawberry. Indian farmer. 2021;8(1):67-73.

427

429

430

FAO STAT. Food and Agriculture Organization of the United Nations Statistics Division. 2023. Accessed 16 March 2024.

Available: <https://www.fao.org/faostat/es/#data/QCL/visualize>.4

31

Horticultural statistics at a glance. Horticulture Statistic Division. Department of Agriculture and Farmers Welfare.

MinistryofAgricultureandFarmerwelfare.GovernmentofIndia;2021.

434

435 TripathiVK,KumarS, GuptaAK.Influence of *Azotobacter* and vermicompost on growth, flowering, yield and quality of  
436 strawberry cv. Chandler. Indian Journal of Horticulture. 2015; 72(2): 207-10. 437

438 MeenaC, MauryaB, BhatnagarP, KumarA. Black root rot is a great menace to strawberry cultivation. International Journal  
439 of Science, Environment and Technology. 2018; 7(2): 517-

20.440

441 MatsumotoM, YoshidaT. Characterization of isolates of binucleate *Rhizoctonia* spp. associated with strawberry black root  
442 rot complex using fatty acid methyl ester (FAME) profiles. Journal of General Plant Pathology. 2006; 72(5): 318-22. 443

444 DemirS, DurakED, GüneSH, BoynoG, MuletMJ, DaneshYR, PorcelR. Biological control of three fungal diseases in  
445 strawberry (*Fragaria x ananassa*) with arbuscular mycorrhizal fungi. Agronomy. 2023; 13(9): 24-

39.446

447 AhmedMFA, El-FikiAI. Effect of biological control of root rot diseases of strawberry using *Trichoderma* species. Middle  
448 East Journal of Applied Sciences. 2017; 7(3): 482-92. 449

450 Kumari N, Thakur A. Black root rot of strawberry: A disease complex. International Journal of Economic Plants.  
2022; 451 9(2): 158-63.

452

453 CoqueJJR,Álvarez-PérezJM,CobosR,González-GarcíaS,IbáñezAM,GalánAD,Calvo-PeñaC.Advancesinthecontrol  
454 ofphytopathogenicfungithatinfecrcropsthroughtheirrootssystem.AdvancesinAppliedMicrobiology.2020;111:123-70.455

456 MheidiUH,AbdulkafoorAH,AliIM.Application of *Erucasativa*Mill.fororganicfertilizationandsprayingwitharginine,their  
457 effectsongrowthcharacteristicsandseedyieldalongwithidentifyingtheircontentofsomemedicallyeffectivecompounds.

458 CaspianJournalofEnvironmentalSciences.2023;21(1):161-67.

- 459 RahilaR, YamunaraniK, KalyanasundaramA. *In vitro* antifungal potency of neem and weed extracts against *Rhizoctonia*  
460 *solani*, the causal agent of sheath blight of rice. Journal of Entomology and Zoology Studies. 2020; 8(6): 153-  
156.461
- 462 AttiaAMF. Role of combination among bioagents, compost and soil solarization on the management of some root infecting  
463 fungi responsible for crown and root-rot diseases of strawberry. Journal of Biotechnology and Bio-engineering. 2019; 3(2): 464  
54-63.
- 465 KimWG, ChoWD, LeeYH. Anastomosis groups and cultural characteristics of *Rhizoctonia solani* isolates from crops in  
466 Korea. Korean Journal of Mycology. 1994; 22(4): 309-24.468
- 469 ToussounTA, NelsonPE. A pictorial guide to the identification of *Fusarium* species. Australian Plant Pathology Society 470  
Newsletter. 1976; 6: 11-13.
- 471
- 472 BemboRS, ShuklaVN. Antifungal properties of certain plant extracts against some fungi. Punjabrao Krishi Vidyapeet  
473 Research Journal. 1973; 2(1): 1-  
8.474
- 475 PaulV, SinghA, PandeyR. Estimation of total soluble solids (TSS). Laboratory manual on post-harvest physiology of fruits  
476 and flowers. Division of plant physiology. Indian Agricultural Research Institute. New  
Delhi; 2010.477
- 478 SadasivamS, BalasubraminanT. In: practical manual in biochemistry. Tamil Nadu agricultural University, Coimbatore; 1987.479
- 480 FangXL, PhillipsD, LiH, SivasithamparamK, BarbettiMJ. Severity of crown and root diseases of strawberry and associated  
481 fungal and oomycete pathogens in western Australia. Australasian Plant Pathology. 2011; 40: 109-  
19.482
- 483 McKinneyHH. Influence of soil temperature and moisture on infection of wheat seedlings by *Helminthosporium sativum*.  
484 Journal of Agricultural Research. 1923; 26: 195-  
17.485
- 486 ReddyTY, ReddiGHS. Principles of agronomy. Kalyan Publishers. 2004; 4: 436-38.487
- 488 ZahidN, MaqboolM, TahirMM, HorvitzS, HamidA, KhalidMS, EjazS, JawadR, AwanSI, RehmanA, AliA. Influence of  
489 organic and inorganic fertilizer regimes on growth patterns and antioxidant capacity of strawberry (*Fragaria x Ananassa*  
490 Duch.). 2022; 2022(1). Accessed 25 march 2024.  
491 Available: <https://doi.org/10.1155/2022/8618854>.
- 492
- 493 SinghR, SharmaRR, KumarS, GuptaRK, PatilRT. Vermicompost substitution influences growth, physiological disorder,  
494 fruit yield and quality of strawberry (*Fragaria x ananassa* Duch.). Bioresource Technology. 2008; 99(17): 8507-511.495
- 496 BadawyMB. Effect of combination among vermicompost, salicylic acid and bacterial bioagents on management of  
497 rhizoctonia crown and root-rot of strawberry. Caspian Journal of Environmental Sciences. 2023; 21(5): 1073-84.498
- 499 CabilovskiR, ManojloviMS, PopovicBM, RadojcinMT, MagazinN, PetkovicK, KovacevicD, LakicevicMD. Vermicompost  
500 and vermicompost leachate application in strawberry production: impact on yield and fruit quality. Horticulturae. 2023;  
501 9(3): 501 337-49.
- 502
- 503 KumarN, SinghHK, MishraPK. Impact of organic manures and biofertilizers on growth and quality parameters of Strawberry  
504 cv. Chandler. Indian Journal of Science and Technology. 2015; 8(15): 1-6.505
- 506 Youssef MA. Impact of biofertilizers on growth and yield of *Moringa oleifera* Lam. Plants. Journal of Agricultural  
Research. 507 2016; 26: 127-38.
- 508
- 509 BhattaraiA, SharmaA, YadavRK, WagleP. Interacting effects of botanicals, biocontrol agents, and potting media on  
510 *Rhizoctonia solani* led damping-off of okra seedlings. Journal of Agriculture and Food Research. 2022; 10. Accessed 25  
511 march 2024.

512 Available: <https://doi.org/10.1016/j.jafr.2022.100410>.

513

514 JuberKS, Al-JubooryHH, Al-JuboorySB. IdentificationandcontrolofstrawberryrootandstalkrotinIraq. International  
515 JournalofEnvironmentalandAgricultureResearch. 2016;2(2):54-63. 516

517 AduseiS, AzupioS. Neem: anovelbiocideforpestanddiseasecontrolofplants. *JournalofChemistry*. 2022;2022.

518 Accessed30march2024.

519 Available: <https://doi.org/10.1155/2022/6778554>.

520

521 YashasviGN,TripathiVK,AwasthiV,Anushi.ImpactofPSB andvermicompost ongrowth,yieldandqualityof  
522 strawberry.Biological Forum - An International Journal. 2021;13(3): 314-  
18.523

524

525

526

527

