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Impact of Bio-stimulants and Organic Mulch on Vegetative growth, flowering and Yield of Strawberry cv. Katrain Sweet in plains of Uttar Pradesh, India

Anushi[1], V. K. Tripathi*[1], Sanjeev Kumar[2], Riddhima Tripathi[1] and Abhishek Singh[3]

[1]*Department of Fruit Science, CS Azad University of Agriculture and Technology, Kanpur, (Uttar Pradesh) India*
[2]*Department of Agronomy CS Azad University of Agriculture and Technology, Kanpur, (Uttar Pradesh) India*
[3]*Department of Agricultural Economics CS Azad University of Agriculture and Technology, Kanpur, (Uttar Pradesh) India*

ABSTRACT

To investigates the impact of biostimulants and organic mulch on enhancing growth, flowering, and yield of the strawberry cv. 'Katrain Sweet' in plains of Uttar Pradesh, India, an experiment was carried out in the Garden, Department of Fruit Science, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, during two subsequent years i.e.,2022-2023 and 2023-2024 is randomized block design using13 treatments (T_1-Azotobacter (5g/plant) + Trichoderma harzianum (5g/plant) + paddy straw, T_2-Azotobacter (8g/plant) + Trichoderma harzianum (6g/ plant) + paddy straw, T_3-Azotobacter (5g/plant) + Trichoderma harzianum (5g/plant) + dried leaves, T_4-Azotobacter (8g/plant) + Trichoderma harzianum (6g/plant) + dried leaves, T_5-Azotobacter (5g/plant) + PSB (5g/plant) + paddy straw, T_6-Azotobacter (8g/plant) + PSB (8g/plant) + paddy straw, T_7-Azotobacter (5g/plant) + PSB (5g/plant) + dried leaves, T_8-Azotobacter (8g/plant) + PSB (8g/plant) + dried leaves, T_9-Azotobacter (5g/plant) + PSB (5g/plant) + Trichoderma harzianum (5g/plant) + paddy straw, T_{10}-Azotobacter (8g/plant) + PSB(8g/plant) + Trichoderma harzianum (6g/plant) + paddy straw, T_{11}-Azotobacter (5g/plant) + PSB (5g/plant) + Trichoderma harzianum (5g/plant) + dried leaves, T_{12}-Azotobacter (8g/plant) + PSB (8g/plant) + Trichoderma harzianum (6g/plant) + dried leaves, T_{13}-Control), each replicated at least three times. The results showed substantial enhancements in vegetative and reproductive characteristics along with yield when Azotobacter, Trichoderma harzianum and Phosphorous Solubilizing Bacteria (PSB)were applied in combined with organic mulch, particularly in treatment T_{12}-Azotobacter (8g/plant) + PSB (8g/plant) + Trichoderma harzianum(6g/plant) + dried leaves, the maximum influence was recorded for these parameters. The findings underscore the potential for the use of biostimulants and organic mulches to enhance strawberry production, offering a sustainable approach for improving yield and plant growth.

Keywords: *Azotobacter, PSB, Trichoderma harzianum, dried leaves, paddy straw, reproductive.*

INTRODUCTION

Strawberry is considered the most commercially and important soft fruit globally due to their exceptional flavour, crisp and juicy texture and vibrant red colour. They are also used in the food and agricultural sectors due to their nutritional value (Prasad *et al.*, 2002). Tulipani *et al.* (2008) reported that strawberry contain all necessary nutrients for a well-rounded diet, including vitamin C, antioxidants, fiber, and phenolic compounds. Crespo *et al.* (2010)also found that strawberries contain more vitamin C than citrus fruits, and high magnesium and potassium content has potential benefits for lowering blood pressure and linked to a reduced likelihood of acquiring cardiovascular illnesses, as suggested by studies conducted by Azodanlou *et al.* (2003).Sesso *et al.* (2007) and Tudor *et al.* (2015) also recommend that strawberries be included in a diverse and well-balanced diet to promote good health. The chemical composition of a strawberry consists of water, carbohydrates, proteins, lipids, fiber, glucose, fructose, sucrose, potassium, phosphorus, calcium and anthocyanins(Gündüz, K., 2016).Strawberries are widely cultivated due to their high demand for fresh consumption and fruit-processing industries(Tyagi *et al.,* 2015). Tagliavini *et al.* (2005) suggest that strawberry crop growth and development is more favourable in sandy or loamy sand, loose soils with good drainage.

Azotobacter is characterized by being gram-negative, motile and aerobic bacteria, which is capable of surviving independently in nature. *Azotobacter* exhibits optimal development between temperatures of 20 and 30°C and thrives well in soil with a pH of 6.5–7.5, preferably neutral to alkaline. However, it does not thrive when the pH drops below 6. Factors such as pH, temperature, oxygen levels and inorganic salts disrupt the growth and nitrogen-fixing capabilities of *Azotobacter*. It is crucial for the process of mineralizing plant nutrients, the natural cycling of nitrogen (N), and the binding of atmospheric nitrogen. This leads to the release of ammonium ions into salty soils, a process known as nitrogen fixation. *Azotobacter*, when used as a biofertilizer, has shown favourable results in enhancing seed germination, promoting plant development and increasing root and shoots length with improving crop production. Furthermore, studies have demonstrated the benefits of using different phosphate-solubilizing bacteria to improve the quality of compost. Essentially, *Azotobacter*, as a biofertilizer, is advantageous for agriculture compared to

Corresponding Author:* ***V. K. Tripathi*

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chemical fertilizers and amendments. Additionally, its environmentally favourable properties provide a solution to the problem of widespread agriculture and its detrimental effects on the environment, particularly in salty conditions (Dar *et al.,* 2021).

Phosphate solubilizing bacteria also have a crucial role in transforming inorganic phosphorus sources like rock phosphate, meal of bones, simple ash and chemically fixed soil phosphorus which can be challenging to dissolve. However, they may be transformed into a more easily used form. Consequently, by implementing agricultural practices that utilizes microbes, which solubilize phosphate, the significant expenses associated with producing phosphatic fertilizers can be mitigated. In addition, these practices can activate the normally inactive phosphorus in both the stimulants *i.e.,* Bio and the soils, when they are applied too. The mechanism of insoluble phosphate dissolution involves the secretion of organic acid and the phosphatase enzyme. This process has been extensively studied and documented by researchers Vessey, (2003) and Mahantesh *et al.*(2015).

As endophytes, several *Trichoderma harzianum* strains can create a sophisticated molecular interaction network between other rhizosphere microbes and the plant, improving plant stress response and crop growth and yield (Hermosa *et al.,*2012 and Lombardi, 2018). Additionally, several *Trichoderma harzianum* species are used as biofungicides and substitutes for chemical phytosanitary products synthesis which have been shown effective antagonists for strawberry disease carrying agents like *Botrytis*, *Colletotrichum acutatum* and *Colletotrichum gloeosporioides* (Freeman *et al.*, 2004and Porras *et al.*, 2007).

Mulching, a process of primarily utilizing agricultural residues, can be applied either prior to or after crop cultivation. This approach is known to decrease the proliferation of weeds through physical suppression and the utilization of allelopathy, as elucidated by El-Metwally and El-Wakeel in their study conducted in 2019. Research has shown that mulches can impede weed photosynthesis by blocking the penetration of light into the crop canopy. Additionally, mulches have the potential to eliminate weed seeds by capturing and retaining heat. Furthermore, it has been found that the use of mulches can enhance soil physical and chemical properties (Govaerts *et al.*, 2007), improve nitrogen accessibility and facilitate optimal plant growth, ultimately leading to increased yields. Keeping these all in view, the present investigation was planned to assess the "impact of biostimulants and organic mulch on the vegetative growth, flowering and yield of strawberry cv. 'Katrain Sweet' in the plains of north India.

Materials and Methods

The research was carried out in the Garden, Department of Fruit Science, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.), during two subsequent years *i.e.,* 2022-2023 and 2023-2024. The Kanpur district is located at an elevation of 135 meters above sea level. It is situated in a subtropical zone with coordinates between 25.26° & 26.58° North latitude & 79.31° and 80.34° Eastern longitude. Several treatments were employed for optimal results, which includes paddy straw and dried leaves as organic mulch and application of5-8 g of *Azotobacter*, 5-8 g of *Trichoderma harzianum* and 5-8 g of PSB per plant.

The characteristics of the soil (both before and after crop harvesting), vegetative growth parameters, height of plant (cm), plant spread (cm), number of leaves per plant, number of crowns per plant, number of runners, leaf area(cm^2), flowering and fruiting characteristics such as days to produce the first bloom (50%), number of flowers per plant, duration of flowering (days), total days from blooming to fruit setting, number of days to first fruit set, duration of harvesting (days), number of fruit sets per plant and berry yield per plant (g) were carefully measured and documented at 120 days after transplanting of plants. The parameters were assessed using the standard and recommended techniques.

Treatments application

The weighed treatments, Azotobacter, PSB and Trichoderma harzianum were combined with FYM and Gur (jaggery powder) and applied to strawberry plants after transplanting in soil.

1st application after 45 days of transplanting

2nd application after 75 days of transplanting

All treatments were given manually to each plant. Paddy straw and dried leaves were laid after 30 days of transplanting.

Other experimental details

Experimental Design	RBD (Randomized Block Design)
Number of Treatments	13
Number of Replications	03
Total number of plots	39
Number of plants/treatment	06
Total Number of plants	234
Planting spacing	45 x 20 cm
Size of single plot/bed	90 x 60 cm
Size of irrigation channel	50 cm
Date of transplanting	22 October 2022 and 17 October 2023

Mechanical, Physical and Chemical analysing of soil sample collected during experimental period (2022-2023 and 2023-2024)

Components	Percentage		Methods use
	2022-2023	2023-2024	
Sand (%)	54.03	54.98	International Pipette method **(Piper, 1966)**
Silt (%)	27.78	28.29	International Pipette method **(Piper, 1966)**
Clay (%)	23.26	23.69	International Pipette method **(Piper, 1966)**
Texture	Sandy loam		
pH	7.49	7.51	Glass electrode pH method (1:2 soil water suspension) **(Jackson, 1973)**
Organic carbon (%)	0.43	0.44	International pipette method **Walkley and Black (1934)**
Available N (kg/ha)	211.51	211.76	Alkaline potassium permanganate **(Subbiah and Asija, 1956)**
Available P (kg/ha)	12.81	12.86	Olsen's method **(Olsen, 1954)**
Available K (kg/ha)	153.49	154.14	Flame photometer method **(Jackson, 1973)**

Figure 1 - Plants with fruits in T10 -Azotobacter (8g/plant) + PSB (8g/plant) + Trichoderma harzianum (6g/plant) + paddy straw

Figure 2- Healthy plants in T10 treatments

Figure 3- Plants in T12-Azotobacter (8g/plant) + PSB (8g/plant) + Trichoderma harzianum (6g/plant) + dried leaves

Figure 4- Plants with fruiting stage in T12 treatment

Statistical analysis

The data is analyzed using RBD (Randomized Block Design) as per the method of the "Analysis of variance" technique (Panse and Sukhatame, 1985). The significant difference between the treatment means tested at a 5% level of significance.

The study was employed in randomized block design, adhering to the guidelines established by Fisher in 1950. We replicated each of the 13 treatment combinations three times. The plant development, blooming and fruiting traits of the *Fragaria* x *ananassa* Dutch cv. 'Katrain Sweet' were assessed statistically.

Results and Discussion

The results suggest that implementing different treatments led to a significant improvement in all measured attributes. The statistical analysis revealed a significant variance, with the evaluated F-value (F Cal) surpassing the F-value (F Tab), demonstrating the effectiveness of the administered treatments.

Growth attributes

The data in Table 1clearly showed that the various treatments had noticeable differences in their vegetative growth characteristics. Using a combination of *Azotobacter*, PSB, *Trichoderma harzianum* and dried leaves mulches a treatment, we observed that the tallest plants measuring 19.08, 16.76 and 17.92 cm during both years and in pooled, respectively. These plants also had the widest spread, measuring 18.69, 13.72 and 16.21 cm, respectively. Additionally, they also have more number of leaves per plant *i.e.,* 20.8, 18.26 and 19.53, respectively, during both years of experimentation and in pooled data. The tiniest plants, measuring 14.47, 13.07 and 13.76 cm, with the fewest leaves counts of 14.4, 11.13 and 12.8, and smallest spread, measuring 14.53, 9.96 and 12.24 cm, respectively. These measurements were observed under the control when the doses of biofertilizers (*Azotobacter*, PSB and *Trichoderma harzianum*) with dried leaves mulch were reduced. It might be possible that the plant height and leaf count experienced a boost by lowering weed competition. It is possible that the bacteria in rhizosphere produces plant growth regulators that are ingested by the roots, leading to an increase in vegetative growth. Therefore, the enhanced development of root system, increased biological N_2 fixation and exploring the potential of producing plant bio-regulators (PBRs) such as IAA, GA_3 and cytokinin's may have a positive impact on enhancing vegetative growth. Several factors contribute to the improved nutrient absorption, such as the highersoil temperature, decreased weed development and greater moisture reachability. These conditions may likely promote root activity and boosted plant growth when mulching was employed (Nathawat *et al*., 2021). Multiple studies, such as Mishra and Tripathi (2011), Rana and Chandel (2003) and Wange *etal.*(1998), have discovered a correlation between treating strawberries with a higher concentration of *Azotobacter* and observed an increase in petiole length. These findings further validate the notion that incorporating *Azotobacter* and organic mulch treatment during the study can lead to a noticeable boost in plant height and leaf count per plant. PSB enhanced plant growth by facilitating phosphate dissolution (Nowsheen *et al.*, 2006) and promoting the production of auxin (Sattar and Gaur, 1987) and IAA (Sattar and Gaur, 1987) and Bareae *et al.*(1976). In addition, it also helps in protection against root pathogens that are not parasitic and transforms mineral and organic compounds into forms that can be used by the soil.

Due to this mechanism, the plant experiences a boost in its vegetative growth. It also provides an ample supply of macronutrients and micronutrients to foster the growth, yield and quality of horticultural crops.

The present research displayed that the use of biofertilizers at different doses, in conjunction with organic mulch, significantly enhanced the quantity of runners and crowns per plant along with the increase in leaf area (Table 2). Application of *Azotobacter (*8g/plant) *+ PSB (*8g/plant) *+ Trichoderma harzianum (*6g/plant) + dried leaves (*T_{12})* exhibited highest leaf area (18.73, 16.32 and 17.52 cm^2, respectively) with highest number of runners (7.00, 6.46 and 6.73, respectively) and number of crowns (3.40, 2.60 and 3.00, respectively) per plant in both trial years and in pooled data. Further perusal of data clearly shows that the untreated plants exhibited reduced leaf area (14.53, 9.99 and 12.26 cm^2, respectively), fewest count of runners (2.66, 2.13 and 2.4, consecutively) with lowest number of crowns (1.53, 0.67 and 1.10, respectively). The increased N_2 fixing culture (Bambal *et al.*, 1998) and the ability of the organism to release growth-stimulating substances, namely cytokinins, are likely responsible for the observed increase in the production of runners and crowns per plant.Mishra and Tripathi (2011), Tripathi *et al.* (2015), Nazir *et al.* (2006), Kumar and Tripathi (2020) also confirm the results of present findings in strawberry.

Table 3 clearly shows that applying a higher dose of *Azotobacter (*8g/plant) *+ PSB (*8g/ plant) *+ Trichoderma harzianum (*6g/plant) + dried leaves(*T_{12}*) resulted in a shorter time to produce first flower (64.46, 68.06 and 66.26 days, respectively), whereas, plants which were kept under control (T_{13}), took maximum number of days (71.6, 74.53 and 73.06 days, respectively) for the same. It is possible that this phenomenon is due to an increased growth with *Azotobacter* application which boosts the production of natural plant hormones and plays a crucial role in fixing N_2. Wange *et al.* (1998), Mishra and Tripathi (2011), Tripathi *et al.* (2015) and Tripathi *et al.* (2016) conducted research in the field of strawberry and reported results aligned with these findings.

Data from Table 3 also revealed that plants treated with *Azotobacter* (8g), PSB (8g), *Trichoderma harzianum* (6g) and dried leaves mulch had the highest number of flowers per plant (29.86, 27.66, and 28.76, respectively) during both years of the investigation and in pooled data. However, the lowest count of flowers (15.06, 13, and 14.03 respectively) was found in untreated plants. It is probable that biofertilizers application led to an increase in inflorescence and leaf number development during the autumn season. This, in turn, had a positive impact on the count of flowers and fruits that appeared in the subsequent spring. Possible reasons for the increased flower in abundance include a noticeable rise in the total number of crowns $plant^{-1}$. Various authors in the field of strawberry studies align these reports with their research. Gupta and Acharya (1993) found that mulches can modify the hydro-thermal condition of soil, thereby creating a favourable environmental condition for the plants for transition into the reproductive stage. Furthermore, organic mulch was found to provide even more advantageous conditions for flowering. Researchers such as Tripathi *et al.* (2010) found that giving each strawberry plant more *Azotobacter* and PSB (7 kg/ha) improves in the production of total flowers.

Based on the data presented in Table 3, it is evident that the combination of *Azotobacter* (8g), PSB (8g), *Trichoderma harzianum* (6g) and dried leaves mulch results in significantly longer duration of flowering. Memorandum treatment, specifically the application of biofertilizers, accelerates the flowering process, resulting in the early initiation of flowers. It is believed that the efficient absorption of nutrients and transportation of growth-stimulating substances contributed to the improvement of plant's growth and development. This led to a quicker utilization of energy and an earlier transition from the vegetative to the reproductive phase which result more duration for flowering. Previous research such as Nazir *et al.* (2006), Zargar *et al.* (2008) and Yadav *et al.*, (2010) on strawberry are also aligns with these findings.

Plants treated with *Azotobacter* (8g), PSB (8g), *Trichoderma harzianum* (6g) and dried leaves mulch results in the shortest time from flowering to fruit setting (6.00, 5.33 and 5.60 days, respectively). On the other hand, untreated (control) plants showed the longest duration (9.00, 8.46 and 8.73 days, respectively) as showed in Table 4. The combination of *Azotobacter* (8g), PSB (8g), *Trichoderma harzianum* (6g) and organic mulch reduced the duration between flowering and fruit setting in strawberry plants by improving nutrient availability and overall soil health. *Azotobacter* is a bacterium that has the amazing ability to convert atmospheric nitrogen into available forms that plants can easily absorb. This process helps plants to grow faster and develop better, including their reproductive processes. *Trichoderma harzianum*, a beneficial fungus also plays a vital role in breaking down organic matter. In addition, biofertilizers have the ability to enhance soil structure and promote overall soil health. This, in turn, leads to improved root growth and increased efficiency in nutrient uptake. Organic mulch enhances these advantages by ensuring ideal soil moisture, maintaining soil temperature and inhibiting weed growth, resulting in a more conducive environment for plant growth. With the assistance of these components, the transition from flowering to fruit setting becomes more efficient and faster, ultimately reducing the number of days needed for this critical phase. Tripathi *et al.* (2015) conducted research in the field of strawberry that aligns with these findings.

The plants treated with the combination of *Azotobacter* (8g), PSB (8g), *Trichoderma harzianum* (6g) and dried leaves mulch results in the reduced time to the first fruit setting (70.46, 73.40 and 71.93 days, respectively), as shown in Table 4. However, the untreated control plants showed the longest duration for the first fruit setting (80.60, 83.00 and 81.80 days, respectively). It is evident that treatment T_{12} greatly expedites the time taken for the first fruit to set, in comparison to the control. Decrease in the number of days for initial fruit formation in strawberry plants treated with *Azotobacter* (8g) + PSB(8g) + *Trichoderma harzianum*(6g)+ dried leaves mulch can be attributed to various synergistic effects. *Azotobacter* plays an important role in improving nitrogen availability in the soil. By fixing atmospheric nitrogen, it helps to speed up plant growth and development. *Trichoderma harzianum* and PSB also plays a crucial role in breaking down organic matter, releasing important nutrients such as phosphorus and potassium that are essential for promoting flowering and fruit development. In addition to this *Trichoderma harzianum* and PSB also enhances root health and growth, leading to better nutrient absorption. Organic mulch enhances these advantages by ensuring the ideal soil moisture, regulating temperature and preventing weed growth, thus fostering a favourable environment for plants to thrive. Through these treatments, the plants experience improved nutrient supply and optimal growing conditions, resulting in a shortened duration for them to reach the first fruit setting stage.

These findings align with the research conducted by Gajbhiye *et al.* (2003) who demonstrated that increased levels of *Azotobacter* and PSB resulted in improved fruit set in Tomato and Tripathi *et al.* (2016) in strawberry.

In current study, duration of fruit harvesting was found to be significantly longer when treated with *Azotobacter*, PSB and *Trichoderma harzianum* treatments combined with organic mulch (Table 4). During both years, the plants treated with T_{12}-*Azotobacter (*8g/plant) *+ PSB (*8g/plant) *+ Trichoderma harzianum (*6g/plant) + dried leaves had the longest harvesting duration (60.06, 57.66 and 58.86 days, respectively). On the other hand, the plants had the shortest harvesting duration *i.e.,* 48.73, 45.53 and 47.13 days, successively. These results are aligned with the previous studies conducted on strawberries by various other researchers such as Sahoo and Singh (2005); Mishra and Tripathi (2011); Gupta and Tripathi (2012) Singh and Singh (2009) and Tripathi *et al.* (2010). They were able to achieve an earlier harvest by about one month, which significantly extended the harvesting season.

The plants treated with *Azotobacter (*8g/plant) *+ PSB (*8g/plant) *+ Trichoderma harzianum(*6g/plant) + dried leaves (T_{12}) showed the highest number of fruits set per plant (27.73, 25.60 and 26.66, respectively) closely behind were the plants treated with T_{10}-*Azotobacter (*8g/plant) *+ PSB(*8g/plant) *+ Trichoderma harzianum(*6g/plant) + paddy straw(26.46, 23.86, and 25.16, respectively). On the other hand, the untreated plants had the lowest number of fruits set per plant (11.33, 9.20 and 10.26, respectively) during both years of experimentation (Fig. 1). Other workers such as Wange *et al.* (1998) and Mishra and Tripathi (2011) also observed that higher levels of *Azotobacter* and PSB led to increased fruiting with heavier fruits. *Azotobacter* is anticipated to accelerate plant development, leading to increased fruit production. Additionally, organic mulch can help suppress weed growth and reduce competition with the main plants. Similar effects were noted in strawberries with *Azotobacter* and PSB applications (Sharma *et al.*, 2022; Tripathi *et al.*, 2014).

Based on the evaluation provided in Fig. 1, it is clearly evident that the plants fertilized with *Azotobacter (*8g/plant) *+ PSB (*8g/plant) *+ Trichoderma harzianum(*6g/plant) + dried leaves (T_{12}) achieved the highest fruit yield per plant (510, 447 and 479g, respectively). However, the control plants (FYM @ 5 kg/bed) yielded the minimum amount (100.00, 77.00 and 89.00 g, respectively) per plant during both years of the experimentation. It is possible that the boost in strawberry yield observed in this study can be attributed to factors such as improved berry set, larger berry size and weight, as well as enhanced vegetative growth. The current findings align with the research conducted by Mishra and Tripathi (2011), Tripathi *et al.* (2014), Tripathi *et al.* (2015) in the field of strawberry and Nayyer *et al.* (2014) in Banana.

CONCLUSION

In conjunction with organic mulch, the application of biostimulants, specifically *Azotobacter* (8g), PSB (8g), *Trichoderma harzianum* (6g) and dried leaves mulch significantly enhances strawberry plants growth, flowering and yield which included higher doses of these biostimulants, consistently showed superior performance across all measured parameters during both year of experimentation. Organic mulch not only improved soil conditions, but also contributed to better plant health and increased productivity. These findings suggest that integrating biostimulants and organic mulches in strawberry cultivation practices can lead to more sustainable and efficient production, benefiting both growers and the environment in the plains of North India.

SUPPLEMENTARY DATA

Given in tables

AUTHOR CONTRIBUTION STATEMENT

The given experiment was conducted by Anushi who is Ph.D. Scholar in CSAUAT, Kanpur, Uttar Pradesh, India. From transplanting to harvesting was done by Anushi. Dr. V.K. Tripathi is advisor and professor under whom supervision trial was conducted.

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V. K. Tripathi,
Professor and Head, Dept. of Fruit Science,
CS Azad University of Agriculture and Technology, Kanpur, (Uttar Pradesh) India
EMAIL = drvktripathicsa@gmail.com

COMPLIANCE WITH ETHICAL STANDARDS

Manuscript is solely written by main author. And there is no conflict of interest between authors

DATA AVAILABILITY

As given in table. Data of 2 subsequent years. Data is taken by authors. So no data is copied.

Table 1: Impact of biofertilizer with organic mulch on the fruit Vegetative growth parameters

Treatment	Plant Height cm^{-1}			Leaves count plant^{-1}			Plant spread cm^{-1}		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
T_1-*Azotobacter*(5g/plant) + *Trichoderma harzianum* (5g/plant) + paddy straw	16.08	15.01	15.55	16.40	13.47	14.93	16.99	11.79	14.39
T_2-*Azotobacter*(8g/plant) + *Trichoderma harzianum*(6g/ plant) + paddy straw	16.24	15.19	15.71	15.40	13.13	14.27	17.08	11.88	14.47
T_3-*Azotobacter*(5g/plant) + *Trichoderma harzianum*(5g/plant) + dried leaves	16.52	14.95	15.73	17.40	13.40	15.40	17.96	12.26	15.10
T_4-*Azotobacter*(8g/plant)+ *Trichoderma harzianum*(6g/plant) + dried leaves	17.05	15.41	16.23	18.40	14.00	16.20	17.39	12.36	14.88
T_5-*Azotobacter(5g/plant) + PSB(5g/plant) + paddy straw*	16.58	15.99	16.28	17.60	13.33	15.47	17.72	12.79	15.25
T_6-*Azotobacter(8g/plant) + PSB(8g/plant) + paddy straw*	17.29	15.65	16.47	18.40	12.93	15.67	17.96	12.84	15.40
T_7-*Azotobacter(5g/plant) + PSB (5g/plant) + dried leaves*	17.41	15.85	16.63	16.60	13.73	15.17	17.83	12.56	15.19
T_8-*Azotobacter*(8g/plant) + *PSB*(8g/plant) + dried leaves	17.39	15.99	16.69	17.40	13.00	15.20	18.19	12.69	15.43
T_9-*Azotobacter*(5g/plant) + *PSB*(5g/plant) + *Trichoderma harzianum*(5g/plant) + paddy straw	17.46	15.89	16.68	18.87	15.67	17.27	18.17	12.90	15.54
T_{10}-*Azotobacter*(8g/plant) + *PSB*(8g/plant) + *Trichoderma harzianum*(6g/plant) + paddy straw	18.02	16.43	17.23	20.20	17.13	18.67	18.31	13.36	15.84

T_{11}-Azotobacter(5g/plant) + PSB(5g/plant) + Trichoderma harzianum(5g/plant)+ dried leaves	17.50	16.06	16.79	19.33	16.06	17.70	18.12	13.30	15.77
T_{12}-Azotobacter(8g/plant) + PSB(8g/plant) + Trichoderma harzianum(6g/plant) + dried leaves	19.08	16.77	17.92	20.80	18.26	19.53	18.67	13.73	16.21
T_{13}-Control	14.46	13.00	13.77	14.47	11.13	12.80	14.53	11.78	12.24
CD at 5% level	0.30	0.188	0.62	0.28	0.95	1.39	0.38	0.17	0.45
CV%	1.06	0.72	1.75	0.96	3.97	3.99	1.28	0.84	1.37

Table 2: Impact of biofertilizer with organic mulch on different fruit physical and reproductive parameters

Treatment	Number of crownsplant^{-1}			Runners countplant^{-1}			Leaf area (cm^2)		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
T_1-Azotobacter (5g/plant) + Trichoderma harzianum (5g/plant) + paddy straw	2.20	1.33	1.77	4.93	3.27	4.10	15.18	11.07	13.13
T_2-Azotobacter (8g/plant) + Trichoderma harzianum(6g/ plant) + paddy straw	2.27	1.40	1.84	5.00	4.20	4.60	15.40	11.05	13.23
T_3-Azotobacter (5g/plant) + Trichoderma harzianum(5g/plant) + dried leaves	2.13	1.60	1.87	5.20	4.13	4.67	15.65	10.96	13.30
T_4-Azotobacter (8g/plant) + Trichoderma harzianum(6g/plant) + dried leaves	2.40	1.26	1.83	4.80	4.33	4.57	15.97	10.78	13.36
T_5-Azotobacter (5g/plant) + PSB (5g/plant) + paddy straw	2.46	1.67	2.06	5.53	4.80	5.16	16.20	11.03	13.62
T_6-Azotobacter (8g/plant) + PSB (8g/plant) + paddy straw	2.53	1.53	2.03	5.73	5.13	5.43	16.51	11.59	14.05
T_7-Azotobacter (5g/plant) + PSB (5g/plant) + dried leaves	2.60	1.46	2.03	5.53	5.13	5.33	16.74	11.55	14.14
T_8-Azotobacter (8g/plant) + PSB (8g/plant) + dried leaves	2.80	1.74	2.26	5.46	5.20	5.33	16.57	11.39	13.99
T_9-Azotobacter (5g/plant) + PSB (5g/plant) + Trichoderma harzianum(5g/plant) + paddy straw	2.94	1.80	2.36	6.13	5.60	5.87	16.97	12.84	14.91
T_{10}-Azotobacter (8g/plant) + PSB(8g/plant) + Trichoderma harzianum(6g/plant) + paddy straw	3.26	2.20	2.74	6.60	6.13	6.36	17.31	15.37	16.34
T_{11}-Azotobacter (5g/plant) + PSB (5g/plant) + Trichoderma harzianum(5g/ plant) + dried leaves	3.00	2.00	2.50	6.40	5.73	6.06	17.09	13.36	15.23
T_{12}-Azotobacter (8g/plant) + PSB (8g/ plant) + Trichoderma harzianum(6g/plant) + dried leaves	3.40	2.60	3.00	7.00	6.46	6.73	18.73	16.32	17.52
T_{13}-Control	1.53	0.67	1.10	2.67	2.13	2.40	14.53	9.99	12.26
CD at 5% level	0.32	0.38	0.27	0.48	0.65	0.55	0.06	0.80	1.61
CV%	7.37	13.99	5.90	5.28	8.16	4.95	0.24	3.94	5.21

Table 3: Impact of biofertilizer with organic mulch on the flowering phenological parameters

Treatment	Days to first flowering (days)			Total number flowersplants^{-1}			Duration of flowering (days)		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
T_1-Azotobacter (5g/plant) + Trichoderma harzianum (5g/plant) + paddy straw	68.40	72.26	70.33	22.93	15.80	19.36	41.20	38.00	39.60
T_2-Azotobacter (8g/plant) + Trichoderma harzianum(6g/ plant) + paddy straw	69.40	71.74	70.57	22.87	19.93	21.40	42.13	36.93	39.53
T_3-Azotobacter (5g/plant) + Trichoderma harzianum(5g/plant) + dried leaves	69.74	71.67	70.70	24.67	20.93	22.80	41.80	38.73	40.26
T_4-Azotobacter (8g/plant) + Trichoderma harzianum(6g/plant) + dried leaves	68.13	72.87	70.50	24.46	22.00	23.23	41.93	37.73	39.83
T_5-Azotobacter (5g/plant) + PSB (5g/plant) + paddy straw	67.00	71.93	69.46	22.87	18.73	20.80	43.27	39.60	41.43
T_6-Azotobacter (8g/plant) + PSB (8g/plant) + paddy straw	68.20	71.46	69.83	22.80	17.00	19.90	46.73	40.13	43.43
T_7-Azotobacter (5g/plant) + PSB (5g/plant) + dried leaves	68.13	71.20	69.67	24.60	20.67	22.64	43.47	40.33	41.90
T_8-Azotobacter (8g/plant) + PSB (8g/plant) + dried leaves	67.74	71.53	69.60	24.93	23.60	24.27	44.00	40.87	42.43
T_9-Azotobacter (5g/plant) + PSB (5g/plant) + Trichoderma harzianum(5g/plant) + paddy straw	66.67	70.33	68.50	25.87	23.93	24.90	48.00	44.87	46.43
T_{10}-Azotobacter (8g/plant) + PSB(8g/plant) + Trichoderma harzianum(6g/plant) + paddy straw	65.33	68.94	67.13	28.53	25.94	27.23	49.66	48.20	48.93
T_{11}-Azotobacter (5g/plant) + PSB (5g/plant) + Trichoderma harzianum(5g/ plant) + dried leaves	65.94	69.67	67.80	27.13	24.33	25.73	48.87	46.67	47.77
T_{12}-Azotobacter (8g/plant) + PSB (8g/ plant) + Trichoderma harzianum(6g/plant) + dried leaves	64.46	68.06	66.26	29.87	27.67	28.77	49.67	48.87	49.26
T_{13}-Control	71.60	74.53	73.06	15.06	13.00	14.03	37.40	35.20	36.30
CD at 5% level	1.78	1.17	1.27	2.09	5.86	2.52	5.17	2.39	2.33
CV%	1.56	0.97	0.84	5.10	16.50	5.10	6.90	3.43	2.50

Table 4: Impact of biofertilizer with organic mulch on the fruit phenological parameters

Treatment	Flowering to fruit set (Days)			1st fruit setting (Days)			Harvesting duration (days)		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
T_1-*Azotobacter* (5g/plant) + *Trichoderma harzianum* (5g/plant) + paddy straw	8.20	7.53	7.88	76.60	79.80	78.20	51.33	48.33	49.83
T_2-*Azotobacter* (8g/plant) + *Trichoderma harzianum*(6g/ plant) + paddy straw	8.06	7.46	7.77	77.46	79.20	78.33	52.20	47.26	49.73
T_3-*Azotobacter* (5g/plant) + *Trichoderma harzianum*(5g/plant) + dried leaves	7.93	7.73	7.83	77.67	79.40	78.53	51.86	49.06	50.46
T_4-*Azotobacter* (8g/plant) + *Trichoderma harzianum*(6g/plant) + dried leaves	8.00	7.26	7.63	76.13	80.13	78.13	52.20	48.06	50.13
T_5-*Azotobacter* (5g/plant) + *PSB* (5g/plant) + *paddy straw*	8.06	6.93	7.50	75.06	78.87	76.97	52.80	49.93	51.36
T_6-*Azotobacter* (8g/plant) + *PSB* (8g/plant) + *paddy straw*	7.87	7.26	7.57	76.06	78.73	77.40	52.93	50.46	51.70
T_7-*Azotobacter* (5g/plant) + *PSB* (5g/plant) + *dried leaves*	7.87	7.88	7.87	76.00	79.06	77.53	53.13	50.66	51.90
T_8-*Azotobacter* (8g/plant) + *PSB* (8g/plant) + dried leaves	7.93	7.67	7.80	75.67	79.20	77.43	52.86	51.20	52.03
T_9-*Azotobacter* (5g/plant) + *PSB* (5g/plant) + *Trichoderma harzianum*(5g/plant) + paddy straw	7.06	6.06	6.56	73.74	76.40	75.06	56.13	52.86	54.50
T_{10}-*Azotobacter* (8g/plant) + *PSB*(8g/plant) + *Trichoderma harzianum*(6g/plant) + paddy straw	6.33	5.60	5.97	71.67	74.53	73.10	58.93	56.20	57.56
T_{11}-*Azotobacter* (5g/plant) + *PSB* (5g/plant) + *Trichoderma harzianum*(5g/ plant) + dried leaves	6.53	5.87	6.20	72.46	75.53	74.00	57.73	54.66	56.20
T_{12}-*Azotobacter* (8g/plant) + *PSB* (8g/ plant) + *Trichoderma harzianum*(6g/plant) + dried leaves	6.00	5.33	5.66	70.46	73.40	71.93	60.06	57.66	58.86
T_{13}-*Control*	9.00	8.46	8.73	80.60	83.00	81.80	48.73	45.53	47.13
CD at 5% level	0.51	0.45	0.47	1.87	1.29	1.05	2.59	2.09	1.26
CV%	3.99	3.88	2.97	1.47	0.97	0.63	6.90	3.43	2.50

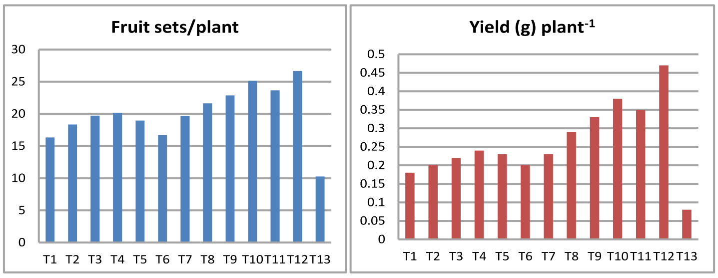

Fig. 1: Impact of biofertilizer with organic mulch on the yield parameters (Fruit set and yield (g) plant^{-1})

(T1-Azotobacter (5g/plant) + Trichoderma harzianum (5g/plant) + paddy straw, T2-Azotobacter (8g/plant) + Trichoderma harzianum (6g/ plant) + paddy straw, T3-Azotobacter (5g/plant) + Trichoderma harzianum (5g/plant) + dried leaves, T4-Azotobacter (8g/plant) + Trichoderma harzianum (6g/plant) + dried leaves, T5-Azotobacter (5g/plant) + PSB (5g/plant) + paddy straw, T6-Azotobacter (8g/plant) + PSB (8g/plant) + paddy straw, T7-Azotobacter (5g/plant) + PSB (5g/plant) + dried leaves, T8-Azotobacter (8g/plant) + PSB (8g/plant) + dried leaves, T9-Azotobacter (5g/plant) + PSB (5g/plant) + Trichoderma harzianum (5g/plant) + paddy straw, T10-Azotobacter (8g/plant) + PSB(8g/plant) + Trichoderma harzianum (6g/plant) + paddy straw, T11-Azotobacter (5g/plant) + PSB (5g/plant) + Trichoderma harzianum (5g/ plant) + dried leaves, T12-Azotobacter (8g/plant) + PSB (8g/ plant) + Trichoderma harzianum (6g/plant) + dried leaves, T13-Control)

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