



E-ISSN: 2663-1067

P-ISSN: 2663-1075

NAAS Rating (2026): 4.74

www.hortijournal.com

IJHFS 2026; 8(7): 01-07

Received: 02-04-2026

Accepted: 06-05-2026

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Influence of bio-enhancers and bio-fertilisers on growth, yield and quality of strawberry (*Fragaria × Ananassa Duch.*) cv. winter dawn

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DOI: <https://www.doi.org/10.33545/26631067.2026.v8.i6a.772>

Abstract

The research titled "Influence of Bio-enhancers and Bio-fertilisers on Growth, Yield and Quality of Strawberry (*Fragaria X ananassa Duch*) cv. Winter Dawn" was carried out at the Horticulture Experiment Field, Department of Horticulture, School of Advanced Agriculture Sciences and Technology, Chhatrapati Shahu Ji Maharaj University, Kanpur, in the year 2025-26. The main aim was to assess the impact of Bio-enhancers and Bio-fertilizers on strawberry growth, yield, and quality.

The experiment comprised nine treatments featuring various combinations of *Panchagavya*, *Jeevamrit*, and *Azotobacter*, PSB. The results indicated significant enhancements in plant growth, yield, and fruit quality when compared to the control group. The application of bio-enhancers and bio-fertilizers resulted in increased plant height, leaf area, and chlorophyll content, which in turn facilitated improved photosynthesis and fruit production. Yield characteristics such as fruit weight, size, and quantity were also positively affected. Additionally, bio-enhancers and bio-fertilizers enhanced fruit quality metrics, including total soluble solids. This study proposes that utilizing bio-enhancers and bio-fertilizers represents a sustainable and environmentally friendly method to enhance strawberry cultivation, thereby decreasing reliance on chemical fertilizers and pesticides.

Statistical evaluation of the collected data indicated significant variations among treatments for all assessed parameters. Particularly, the treatment T₆ *Panchagavya* @3%+ *Azotobacter* @ 2.5 kg/ha, followed by treatment T₈ *Jeevamrit* @20% + *Azotobacter* @ 2.5 kg/ha, consistently surpassed other treatments across the majority of parameters.

Another notably effective treatment was T₅ *Jeevamrit* @20% + *Azotobacter* @ 2.5 kg/ha, which consistently outperformed other treatments across most parameters, achieving the highest plant spread (25.00 cm), number of plants (28.00), and days to flowering (32.66 days). The findings highlight the efficacy of *Panchagavya* and *Jeevamrit*, which can further enhance growth and fruit quality by promoting growth quality and enhancing fruit set.

The favorable effects of biofertilizers, particularly those that include nitrogen-fixing bacteria, can enhance the availability of vital nutrients such as *nitrogen*, *phosphorus*, and *potassium* (NPK) in the soil. Consequently, this can result in higher plant yields and better overall plant health. Additionally, certain Biofertilizers assist in the *solubilization of phosphorus*, thereby making it more accessible to the roots of plants. In summary, the incorporation of bio-enhancers and bio-fertilizers in the growth, yield, and quality of strawberries, especially those containing *PSB*, significantly enhances growth and quality attributes such as plant height, plant spread, and yield.

Keywords: Microgreens, antioxidants, bioactive compounds, health benefits, functional food

Introduction

Strawberry (*Fragaria × ananassa Duch.*) is a temperate fruit crop a member of family Rosaceae, with a chromosome number 2n = 56, is a hybrid of genus *Fragaria*. It was bred for the first time in Brittany, France in 1750 s by crossing two American diploids namely, *Fragaria virginiana* of North America and *Fragaria chiloensis* which was brought from Chile (Staudt, 1989). The present cultivars of (*Fragaria ananassa Duch*) cv. Winter Dawn. There are about 20 recognized species of strawberries in five chromosome groups (x=7): ten diploid, one pentaploid, one hexaploidy and four Octaploids. (Staudt, 1999; Jiajun *et al.* 2005) [9] which behaves as an annual in sub-tropical region and perennial in temperate region of strawberry. It is an herbaceous crop with prostrate growth habit, being one of the most important soft fruits of the world after grape. Being nutritional composition rich.

In vitamin A (60 IU/100g), vitamin C (30-120 mg /100g), fibre iron pectin content (0.55%) and *ellagic acid*, which has anti cancerous property, strawberry is mainly use as fresh fruit beside antioxidant, it also contains very good amount of phenol, flavonoids, which also exhibit a high level of antioxidant capacity against free radical species.

Production of strawberry is presently cultivated in about 75 countries (FAO, 2007). NHB data 2018-19 shows that area and production of strawberry was 1,000 ha. And 5,000 MT respectively. Strawberry is basically a fruit of temperate climate, but during the recent years, Strawberry is being grown in the hilly. Regions of Himachal Pradesh, Uttar Pradesh, Maharashtra, West Bengal, Nilgeeri hills. Delhi, Haryana, Punjab and Rajasthan, Shimla, Solan, Kangra, Kull, Palampur of Himachal Pradesh, Muzaffarnagar, Ghaziabad and Bilaspur of Uttar Pradesh, Kashmir and Uttarakhand About highest level grown countries USA, Spain, Italy, Poland, Mexico and China, particularly between 1200 to 2100m about mean sea level highly grown in strawberry, It is an herbaceous crop with prostrate growth habit, which behaves as an annual in sub-tropical region and perennial in temperate region and has gained the status of being one of the most important soft-fruit of the world after grape and ellagic acid, which has anti cancerous property, strawberry is mainly used as fresh fruit. Besides, antioxidants.it also contain very good number of phenols, flavonoids, which also exhibit a high level of antioxidant capacity against free radical species. Bio-fertilizers such as *Azotobacter*, phosphate-solubilizing bacteria (PSB), *potassium-solubilizing bacteria* (KSB) and *arbuscular mycorrhizal fungi* (AMF) play a vital role in enhancing nutrient availability during winter when mineralization of nutrients is slow, the use of bio-enhancers such as Panchagavya and Jeevamrit has been commercially adopted to enhance both the production and quality of strawberries.

Materials and Methods

Experimental site

Geographical Location

The experimental work was performed at the Horticulture Experiment Field of the Department of Horticulture, School of Advanced Agriculture Sciences and Technology, Chatrapati Shahu Ji Maharaj University, Kalyanpur. This location is positioned at 26°44'N latitude and 82°33'E longitude. The average altitude is 318 meters above sea level. Geographically, it is situated on the right bank of the Ganga River in the central-western region of Uttar Pradesh, within the flat Indo-Gangetic Plains.

Climatic and Weather Conditions

The climate in Kanpur is characterized as a humid subtropical climate influenced by monsoons (Cwa). Summers are marked by high temperatures and humidity, with mercury levels potentially climbing to 48.2°C. Winters are cool and arid, with average temperatures hovering around 25.3°C. The monsoon period contributes substantial precipitation, with an annual rainfall averaging approximately 939mm. Temperatures begin to decline in November and remain low until February. During the winter months, the average temperature is recorded at 14°C.

Planting Material

The plant material utilized consisted of healthy Tissue culture plant of the strawberry cultivar 'Winter Dawn,'

which were sourced from (CISH) Central Institute for Subtropical Horticulture Lucknow.

Selection of Cultivar

The Winter Dawn strawberry cultivar is significant due to its excellent performance within the Kanpur climate, offering superior fruit production compared to alternative cultivars. Consequently, the Winter Dawn cultivar was chosen for this particular investigation.

Experimental field preparation

The experimental site for planting strawberry plants underwent thorough preparation, involving repeated ploughing and removal of weeds, grasses, and plant residue. Raised beds of 15-20 cm in height were created for the purpose of planting the strawberry plants,

Mulching:

A beneficial practice for strawberries, was employed to enhance fruit quality and yield, improve soil conditions, and protect the plants from pests and diseases., Black polythene sheets were used to mulch the beds, effectively managing weeds, maintaining soil temperature, preventing rotting, retaining moisture, and ultimately improving fruit quality.,

Experimental treatments details

S. No.	Symbol	Treatment details
1	T ₁	Control (without bio-fertilizers and Bio-enhancers)
2	T ₂	Panchagavya @3%
3	T ₃	Jeevamrit @20%
4	T ₄	Azotobacter @2.5kg/ha
5	T ₅	PSB@2.5kg/kg
6	T ₆	Panchagavya @3% + Azotobacter @2.5kg/ha
7	T ₇	Panchagavya @3% PSB@2.5kg/kg
8	T ₈	Jeevamrit @20%+ Azotobacter @2.5kg/ha
9	T ₉	Jeevamrit @20%+ PSB@2.5kg/kg
10	T ₁₀	Azotobacter @2.5kg/ha+PSB@2.5kg/kg

Statistical analysis

The data were analysed according to the procedure for analysis randomized block design (R.B.D.). The overall Significance of Differences among the treatments was tested, using critical difference (C.D.) at 5% level of significance. The data are presented in the form of tables and graphs

Results and Discussion

This chapter details the findings from the current research project, titled "influence of Bio-enhancers and Bio-fertilizers on growth, yield and quality of strawberry (*Fragaria x Ananassa duch*) cv. winter dawn" This study was conducted from 2025 to 2026 at the Horticulture experiment field, within the Department of Horticulture at the School of Advanced Agriculture Sciences and Technology, Chhatrapati Shahu Ji Maharaj University, Kanpur, Uttar Pradesh.

The gathered data, pertaining to various indicators assessed to determine the impact of "influence of Bio-enhancers and Bio-fertilizers on growth, yield and quality of strawberry (*fragaria x ananassa duch*)" on the Winter Dawn strawberry cultivar, underwent statistical analysis using established methodologies to ascertain their significance. Furthermore, the influence of biofertilizer on soil fertility levels was also examined within the scope of this investigation. The

outcomes for all experimental conditions are presented in this chapter. In addition to tabular representations, experimental results have been illustrated with plates were deemed appropriate. The findings of this research are organized and presented under relevant subheadings.

The greatest plant height was recorded in treatment T₆, which involved the application of Panchagavya at a 3% concentration combined with *Azotobacter* at 2.5 kg/ha. This was closely followed by treatment T₈, which utilized Panchagavya, a 3% concentration along with *Azotobacter* at 2.5 kg/ha. In contrast the control group exhibited an average plant height of 14.21 cm, which was not statistically different from some of the treatment groups.

. The recorded data concerning vegetation expanse at 60, 90, and 120 days after planting (DAP) showed a significant impact from the application of Bio-fertilizers and Bio-enhancers within the scope of this study. Treatment T₆ (Panchagavya at 3% along with *Azotobacter* at 2.5 kg/ha) yielded the greatest vegetation expanse, measuring 22.23 cm. This was followed by treatment T₈, which recorded 21.60 cm. Furthermore, treatments T₂ and T₃, with vegetation expanses of 17.93 cm and 19.16 cm respectively,

The highest leaf count per plant was observed in the treatment group receiving *Jeevamrit* at 20% combined with *PSB* at 2.5 kg/ha, which yielded 24.11 leaves. This result was statistically comparable to several other treatment groups, including those treated with *Jeevamrit* at 20% plus *Azotobacter* at 2.5 kg/ha; *Panchagavya* at 3%; *Jeevamrit* at 20% plus *Azotobacter* at 2.5 kg/ha; *PSB* at 2.5 kg/ha; *Panchagavya* at 3% plus *PSB* at 2.5 kg/ha; and *Jeevamrit* at 20% plus *PSB* at 2.5 kg/ha.

According to the findings, the highest flower count per plant (28.33) was recorded with treatment T₆, which involved Panchagavya at 3% concentration combined with *Azotobacter* at 2.5 kg/ha. Consequently, Panchagavya is indicated to enhance beneficial microbial activity in the soil, leading to improvements in soil structure and general well-being.

The earliest initiation of flowering was observed in plants treated with *Azotobacter* at a rate of 2.5 kg/ha (recorded at 26.66 days), a result that was statistically comparable to the application of *Panchagavya* at 3% combined with *Azotobacter* at 2.5 kg/ha (observed at 24.66 days).

Table 1: Effect of Bio-enhancers and Bio-fertilizers on growth and flowering parameters of strawberry.

Treatment	Plant height (cm)	Plant spread (cm)	Number of leave/plant	Days taken to produce first flower	Number of flowers/plant
Control	10.51	16.50	15.44	30.00	18.53
Panchagavya @3%	11.66	19.46	17.22	22.00	21.55
Jeevamrit@20%	12.35	21.30	19.11	26.66	22.22
Azotobactor@2.5kg/ha	11.56	19.95	18.11	26.66	23.44
PSB@2.5kg/ha	13.06	19.70	21.22	25.33	22.55
Panchagavya@3%+Azotobactor@2.5kg/ha	14.21	24.43	22.22	24.66	27.11
Panchagavya @3% + PSB@2.5kg/ha	12.60	23.70	23.00	22.00	25.66
Jeevamrit @20% + Azotobactor@2.5kg/ha	12.10	23.58	20.22	21.66	25.10
Jeevamrit @20% + PSB@2.5kg/ha	13.03	23.46	24.11	20.33	26.44
Azotobactor@2.5kg/ha+ PSB@2.5kg/ha	12.80	24.16	23.00	22.33	28.33
C.D	1.11	0.44	0.52	1.56	0.80
SE(m)	0.37	0.14	0.17	0.52	0.26

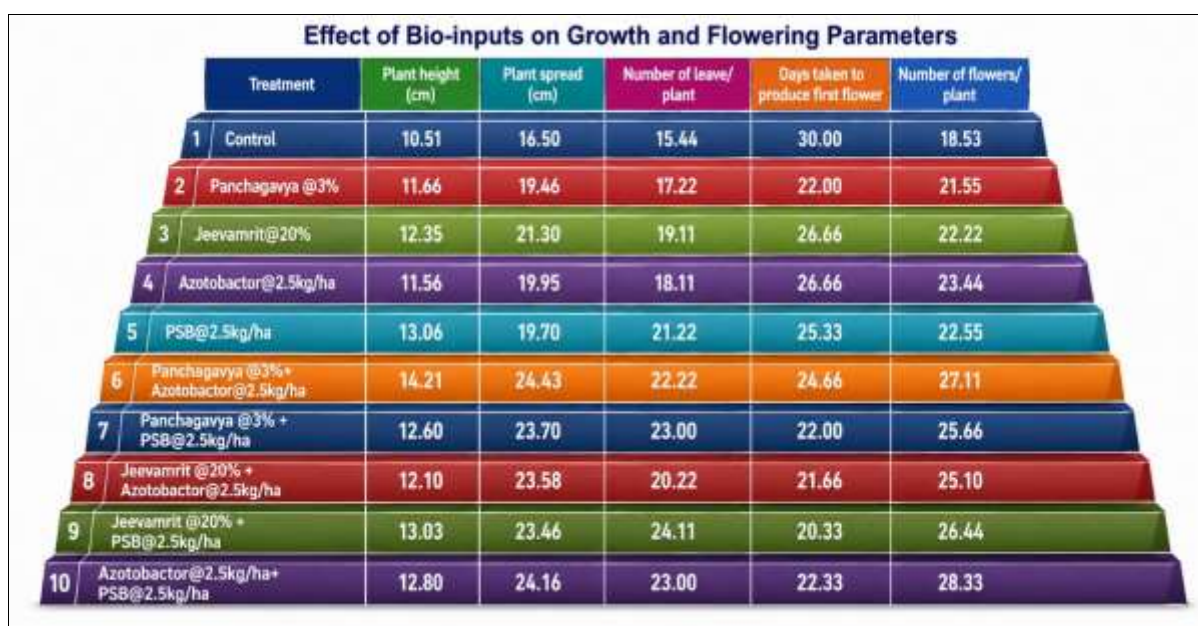


Fig 1: Effect of Bio-enhancers and Bio-fertilizers on growth and flowering parameters of strawberry.

Exhibited a significant influences across the diverse treatments examined within the scope of this investigation. The shortest period to first fruiting, recorded at 18.66 days, the data clearly indicates that the application of bio-enhancers and bio-fertilizers at 2.5 kg/ha, along with *Azotobacter* at 2.5 kg/ha, resulted in these varied outcomes. the highest flower count per plant (28.33) was recorded with treatment T₆, which involved Panchagavya at 3% concentration combined with *Azotobacter* at 2.5 kg/ha. Treatments including Panchagavya at 3%, Jeevamrit at 20%, *Azotobacter* at 2.5 kg/ha, PSB at 2.5 kg/ha, Panchagavya at 3% plus *Azotobacter* at 2.5 kg/ha, Panchagavya at 3% plus PSB at 2.5 kg/ha, and Jeevamrit at 20% plus PSB at 2.5 kg/ha, the largest fruit diameter (41.43 cm) was recorded

with treatment T₆, which involved Panchagavya at 3% and *Azotobacter* at 2.5 kg/ha. This measurement was statistically distinct from all other treatments. The smallest fruit diameter (35.10) was noted in the control group, designated as T₁ (Control).

The findings that the application of various bio-enhancer and bio-fertilizer treatments had a notable impact on yield within the scope of this study. The highest yield, measuring 133.38 q, was achieved with treatment T₆, which involved Panchagavya at a 3% concentration combined with *Azotobacter* at 2.5 kg/ha. Conversely, the lowest yield, observed at 182.06 g, was recorded under treatment T₄, consisting solely of *Azotobacter* at 2.5 kg/ha.

Table 2: Effect of Bio-enhancers and Bio-fertilizers on fruiting and yielding parameters of strawberry.

Treatment	No. Days to 1 st fruiting	Fruit diameter (cm)	Fruit yield/plant (gm)	Fruit yield/ha (kg)	Fruit yield/ha (q)
Control	31.00	26.66	165.36	7.15	81.70
Panchagavya @3%	26.33	28.53	182.70	9.36	110.03
Jeevamrit@20%	28.33	29.23	192.03	10.27	96.50
<i>Azotobacter</i> @2.5kg/ha	27.00	31.43	202.06	9.35	107.50
PSB@2.5kg/ha	28.00	36.03	182.06	8.65	105.96
Panchagavya@3%+ <i>Azotobacter</i> @2.5kg/ha	26.66	38.33	223.10	11.41	133.38
Panchagavya @3% + PSB@2.5kg/ha	25.66	35.10	212.20	10.33	122.03
Jeevamrit @20% + <i>Azotobacter</i> @2.5kg/ha	24.33	38.06	213.93	10.31	122.93
Jeevamrit @20% + PSB@2.5kg/ha	23.33	36.96	225.60	11.18	130.33
<i>Azotobacter</i> @2.5kg/ha+ PSB@2.5kg/ha	23.00	35.93	212.33	12.31	130.50
C.D	1.25	0.68	4.90	0.30	4.00
SE(m)	0.42	0.22	1.63	0.10	1.33



Fig 2: Effect of Bio-enhancers and Bio-fertilizers on fruiting and yielding parameters of strawberry.

The highest concentration of total soluble solids, measuring 9.78 %, was documented in the T₆ treatment group, which involved *Panchagavya* at a 3% concentration combined with *Azotobacter* at a rate of 2.5 kg/ha. Conversely, the lowest observed value for total soluble solids was 8.20%, recorded under treatment T₅, which solely utilized PSB at a rate of 2.5 kg/ha. Bio-Enhancers and Bio-fertilizers demonstrated statistical significance concerning the percentage of total sugars within the scope of this study. The highest concentration of total sugars (4.93%) was observed in treatment T₆, which involved *Panchagavya* at a 3%

application rate combined with *Azotobacter* at 2.5 kg/ha. Conversely, the lowest total sugar content (4.33%) was noted in treatment T₄, which consisted solely of *Panchagavya* applied at 2.5 kg/ha. The highest concentration of *Ascorbic acid* (0.82(mg/100g)) was observed in treatment T₆, which involved *Panchagavya* at a 3% application rate combined with *Azotobacter* at 2.5 kg/ha. Conversely, the lowest total *Ascorbic acid* (0.76(mg/100g)) was noted in treatment T₄, which consisted solely of *Panchagavya* applied at 2.5 kg/ha.

Table 3: Effect of Bio-enhancers and Bio-fertilizers on Quality parameters of strawberry.

Treatment	TSS (Brix)	Titrateable acidity (%)	Ascorbic acid (mg/100g)	Total sugar (%)
Control	7.16	0.72	0.74	4.30
Panchagavya @3%	8.71	0.77	0.76	4.33
Jeevamrit@20%	8.25	0.78	0.77	4.40
Azotobactor@2.5kg/ha	8.63	0.78	0.78	4.46
PSB@2.5kg/ha	8.20	0.80	0.78	4.46
Panchagavya@3%+Azotobactor@2.5kg/ha	9.78	0.82	0.82	4.93
Panchagavya @3% + PSB@2.5kg/ha	9.23	0.78	0.80	4.50
Jeevamrit @20% + Azotobactor@2.5kg/ha	9.26	0.81	0.81	4.93
Jeevamrit @20% + PSB@2.5kg/ha	9.30	0.84	0.78	4.66
Azotobactor@2.5kg/ha+ PSB@2.5kg/ha	9.26	0.83	0.78	4.56
C.D	0.25	0.014	0.03	0.026
SE(m)	0.08	0.005	0.009	0.175



Fig 3: Effect of Bio-enhancers and Bio-fertilizers on Quality parameters of strawberry.

Conclusion

The current study substantiates prior results concerning the effectiveness of a treatment combining *Panchagavya* at 3% and *Azotobacter* at 2.5 kg/ha for enhancing the vegetative growth quality of the strawberry cultivar Winter Dawn. Furthermore, these two treatments contributed to an elevated soil fertility status, specifically through an increase in soil organic carbon. Consequently, treatments T₆ (*Panchagavya* @3% + *Azotobacter* @ 2.5 kg/ha) and T₈ (*Jeevamrit* @ 20% + *Azotobacter* @ 2.5 kg/ha) are recommended as optimal interventions for augmenting the yield potential of strawberry cv. Winter Dawn while preserving soil fertility. *Panchagavya*, an organic

formulation, demonstrates capacity for fostering plant growth and bolstering plant immunity. *Jeevamrit*, being entirely organic, exerts no adverse effects on soil health. Signifying its role in promoting production and sustaining soil vitality. Bio-enhancers and Bio-fertilizers leading the better growth, yield and high improved quality base production of the strawberry. “Better Production and Environment”.

Acknowledgements

The authors acknowledge the support rendered by Professor Dr. Shiwanand Pandey, Head, Department of Horticulture, School of Advanced Agriculture Sciences and Technology,

Chhatrapati Shahu ji Maharaj University Kanpur Uttar Pradesh India, for granting permission to conduct the experiment at the Horticultural Experiment Field. This work forms part of the M.Sc. thesis of the first author submitted to Chhatrapati Shahu Ji Maharaj University, Kanpur, Uttar Pradesh, India. The guidance provided by advisor Dr. Shiwanand Pandey throughout the course of the experiment is gratefully acknowledged to provide the necessary facilities to conduct the research work.

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