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Assessment of mulching and organic fertilizers on yield and quality of strawberry (*Fragaria × ananassa* Duch.) cv. camarosa under shade net condition

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Abstract

A field experiment was conducted during 2024-2026 under shade net conditions to evaluate the integrated effect of mulching and organic nutrient sources on yield, and quality of strawberry (*Fragaria × ananassa* Duch.) cv. Camarosa. The experiment comprised sixteen treatment combinations of mulching materials (silver mulch, transparent mulch and paddy straw) and organic inputs (vermicompost, vermiwash, Jeevamrut and Ghanjeevamrut), arranged in a completely randomized design with three replications. The results revealed significant variation among treatments for all yield attributes. Treatment T₅ (silver mulch + vermicompost @ 21 g plant⁻¹ + vermiwash @ 4%) recorded the highest fruit weight (21.64 g), number of fruits per plant (25.85) and yield per plant (557.42 g), which was statistically superior over most treatments. It was followed by T₆ and T₉, which also exhibited improved performance. The enhanced performance under T₅ may be attributed to improved nutrient availability, enhanced microbial activity, and favourable soil microclimate due to mulching. The study concludes that integrated application of organic inputs along with mulching, particularly silver mulch, significantly enhances strawberry productivity under protected conditions and can be recommended as a sustainable production strategy.

Keywords: Strawberry, organic nutrient management, mulching, vermicompost, vermiwash, yield attributes, protected cultivation, sustainable agriculture

1. Introduction

Strawberry (*Fragaria × ananassa* Duch.), a member of the family Rosaceae, is an important soft fruited herbaceous perennial crop widely cultivated for its attractive appearance, unique flavour, and high nutritional value. It is rich in vitamins, antioxidants, and bioactive compounds, making it highly desirable among consumers. The crop thrives well under temperate and subtropical climatic conditions, with optimum temperatures ranging from 22–25 °C during the day and 7–13 °C at night. Among the commercially cultivated varieties, cv. Camarosa is widely preferred due to its high yield potential and superior fruit quality.

In recent years, increasing concerns over environmental degradation and soil health deterioration due to excessive use of chemical fertilizers have led to a growing interest in sustainable and organic farming practices. Organic nutrient management offers an eco-friendly alternative by improving soil fertility, enhancing microbial activity, and producing high-quality fruits with better nutritional composition and shelf life (Reganold *et al.*, 2010) ^[11]. Organic inputs such as vermicompost, vermiwash, Jeevamrut, and Ghanjeevamrut have been reported to play a significant role in improving soil health and plant growth. Vermicompost, in particular, enhances soil structure, nutrient availability, and microbial activity, thereby promoting plant growth and yield (Arancon *et al.*, 2004) ^[1]. Similarly, traditional organic formulations like Jeevamrut and Ghanjeevamrut, derived from cow-based products, have gained attention for their role in improving soil biological activity and nutrient cycling, which supports sustainable crop production (Palekar, 2006; Natarajan, 2007) ^[8, 7].

Mulching is another important agronomic practice that contributes significantly to improved crop performance by conserving soil moisture, regulating soil temperature, and suppressing weed growth. Both organic and inorganic mulches create a favourable microclimate that enhances plant growth and productivity. The combined application of mulching and organic

nutrient sources has been shown to improve soil physical properties, nutrient availability, microbial activity, and water use efficiency, ultimately leading to enhanced yield and fruit quality (Kushwah *et al.*, 2018; Pradeep and Saravanan, 2018) [10].

Despite the well documented individual benefits of organic inputs and mulching, limited information is available regarding their integrated effect under protected cultivation systems, particularly under shade net conditions. Protected cultivation provides a modified microenvironment that can significantly influence crop growth, yield, and quality, thereby necessitating the evaluation of integrated nutrient and moisture management strategies.

Therefore, the present study was undertaken to evaluate the combined effect of mulching and organic nutrient sources on growth, yield, and quality of strawberry (*Fragaria × ananassa* Duch.) cv. Camarosa under shade net conditions, with the aim of developing a sustainable and efficient production strategy.

2. Materials and Methods

The present investigation was conducted during 2024-2026 at School of Agriculture, Galgotias University, Greater Noida, Uttar Pradesh, India. The experiment was carried out under shade net conditions to evaluate the integrated effect of mulching and organic nutrient sources on growth, yield, and quality of strawberry (*Fragaria × ananassa* Duch.) cv. Camarosa.

2.1 Experimental Site and Soil Characteristics

The experimental site is located in the subtropical region of North India, characterized by warm summers and cool winters. The prevailing environmental conditions during the cropping period were favourable for strawberry cultivation under protected conditions. The soil of the experimental site was well-drained and moderately fertile in nature. The soil was suitable for strawberry cultivation under protected conditions.

2.2 Experimental Design and Treatments

The experiment was laid out in a Completely Randomized Design (CRD) comprising sixteen treatments with three replications. Healthy and uniform runners of strawberry cv. Camarosa were transplanted at a spacing of 30 cm × 30 cm. Each treatment was randomly allocated within each replication to minimize experimental error.

The treatments consisted of different combinations of organic nutrient sources and mulching materials as detailed below:

T₁: Control

T₂: Vermicompost (21 g plant⁻¹) + Vermiwash (4%) at flowering and fruiting stage

T₃: Jeevamrut (500 mL plant⁻¹) at flowering and fruiting stage

T₄: Ghanjeevamrut (80 g plant⁻¹) at flowering and fruiting stage

T₅: Silver mulch + Vermicompost (21 g plant⁻¹) + Vermiwash (4%)

T₆: Silver mulch + Jeevamrut (500 mL plant⁻¹)

T₇: Silver mulch + Ghanjeevamrut (80 g plant⁻¹)

T₈: Silver mulch

T₉: Transparent mulch + Vermicompost (21 g plant⁻¹) +

Vermiwash (4%)

T₁₀: Transparent mulch + Jeevamrut (500 mL plant⁻¹)

T₁₁: Transparent mulch + Ghanjeevamrut (80 g plant⁻¹)

T₁₂: Transparent mulch

T₁₃: Paddy straw mulch + Vermicompost (21 g plant⁻¹) + Vermiwash (4%)

T₁₄: Paddy straw mulch + Jeevamrut (500 mL plant⁻¹)

T₁₅: Paddy straw mulch + Ghanjeevamrut (80 g plant⁻¹)

T₁₆: Paddy straw mulch

2.3 Application of Treatments and Crop Management

Organic inputs (vermicompost and ghanjeevamrut) were applied to the soil as per treatment specifications. Liquid organic formulations, including vermiwash and jeevamrut, were applied at flowering and fruiting stages through foliar spray and soil drenching. Mulching materials (silver mulch, transparent mulch, and paddy straw) were applied immediately after transplanting to ensure proper soil coverage, moisture conservation, and weed suppression. All recommended agronomic practices, including irrigation, weeding, and plant protection measures, were uniformly followed for all treatments throughout the crop growth period to maintain experimental consistency.

2.4 Observations Recorded

Observations on growth parameters such as plant height, number of leaves, and plant spread were recorded at regular intervals. Yield attributes, including fruit length (cm), fruit width (cm), fruit weight (g), number of fruits per plant, and yield per plant (g), were recorded at the time of harvest using standard procedures.

2.5 Statistical Analysis

The experimental data were subjected to analysis of variance (ANOVA) appropriate for a Completely Randomized Design (CRD) as described by Panse and Sukhatme (1985) [9]. The significance of treatment effects was tested using the F-test at the 5% level of significance. Treatment means were compared using the Critical Difference (CD) test at the same level of probability. The standard error of mean (SEM±) was calculated to assess the precision of the experiment.

3. Results and Discussion

3.1 Number of fruits per plant

The number of fruits per plant was significantly influenced by different treatments during both years as well as in pooled analysis (Table 1). Among the treatments, T₅ (Silver mulch + Vermicompost @ 21 g plant⁻¹ + Vermiwash @ 4%) recorded the highest number of fruits per plant (24.50 and 27.20 during 2024–25 and 2025–26, respectively) with a pooled mean of 25.85. This treatment was found to be statistically at par with T₆ and T₉, but significantly superior over the remaining treatments. The next best treatments were T₆ (Silver mulch + Jeevamrut) and T₉ (Transparent mulch + Vermicompost + Vermiwash), indicating the beneficial effect of integrated nutrient management along with mulching. The lowest number of fruits per plant was recorded in T₁ (Control).

Table 1: Variation in fruit number per plant as influenced by organic inputs and mulching in strawberry (*Fragaria × ananassa*) cv. Camarosa

Treatments	Number of fruits per plant		
	2024-25	2025-26	Pooled
T ₁ : Control	14.77	16.12	15.45
T ₂ : Vermicompost (21 g plant ⁻¹) + Vermiwash (4%) at flowering and fruiting stage	17.51	18.28	17.90
T ₃ : Jeevamrut (500 mL plant ⁻¹) at flowering and fruiting stage	17.27	17.68	17.48
T ₄ : Ghanjeevamrut (80 g plant ⁻¹) at flowering and fruiting stage	16.97	17.08	17.03
T ₅ : Silver mulch + Vermicompost (21 g plant ⁻¹) + Vermiwash (4%)	24.50	27.20	25.85
T ₆ : Silver mulch + Jeevamrut (500 mL plant ⁻¹)	23.80	26.68	25.24
T ₇ : Silver mulch + Ghanjeevamrut (80 g plant ⁻¹)	22.30	24.28	23.29
T ₈ : Silver mulch	16.10	16.58	16.34
T ₉ : Transparent mulch + Vermicompost (21 g plant ⁻¹) + Vermiwash (4%)	23.10	25.48	24.29
T ₁₀ : Transparent mulch + Jeevamrut (500 mL plant ⁻¹)	19.30	20.08	19.69
T ₁₁ : Transparent mulch + Ghanjeevamrut (80 g plant ⁻¹)	21.10	23.08	22.09
T ₁₂ : Transparent mulch	18.97	19.48	19.23
T ₁₃ : Paddy straw mulch + Vermicompost (21 g plant ⁻¹) + Vermiwash (4%)	20.80	21.88	21.34
T ₁₄ : Paddy straw mulch + Jeevamrut (500 mL plant ⁻¹)	20.00	20.68	20.34
T ₁₅ : Paddy straw mulch + Ghanjeevamrut (80 g plant ⁻¹)	21.77	23.68	22.73
T ₁₆ : Paddy straw mulch	18.53	18.88	18.71
SEm±	0.0741	0.0307	0.0397
CD at 5%	0.2141	0.0886	0.1145

The significant increase in fruit number under T₅ may be attributed to the synergistic effect of vermicompost and vermiwash in improving nutrient availability and enhancing microbial activity, which promotes better flowering and fruit set. Vermicompost improves soil structure and nutrient dynamics, thereby enhancing root growth and nutrient uptake (Atiyeh *et al.*, 2002; Arancon *et al.*, 2004) [3, 1]. Vermiwash contains plant growth regulators such as auxins and cytokinins, which play a crucial role in flowering and fruit development (Edwards *et al.*, 2010) [4]. In addition, silver mulch helps in conserving soil moisture, moderating soil temperature, and suppressing weed growth, thereby creating a favourable microenvironment for reproductive growth (Kasirajan and Ngouajio, 2012; Kaur and

Singh, 2019) [5, 6].

Lower fruit numbers in control may be due to poor nutrient availability and suboptimal soil conditions, which limit flowering and fruit set (Singh *et al.*, 2015) [12]. These findings are in agreement with earlier reports indicating enhanced fruiting with integrated organic nutrient management.

3.2 Fruit weight (g)

Fruit weight differed significantly among treatments during both years and in pooled analysis (Table 2). The maximum fruit weight was recorded in T₅ (21.64 g), which was statistically at par with T₆, but significantly superior over all other treatments. This was followed by T₉, which also showed comparatively higher fruit weight.

Table 2: Effect of organic nutrient sources and mulching on average fruit weight (g) of strawberry (*Fragaria × ananassa*) cv. Camarosa

Treatments	Fruit weight (gm)		
	2024-2025	2025-2026	Pooled
T ₁ : Control	12.14	12.71	12.43
T ₂ : Vermicompost (21 g plant ⁻¹) + Vermiwash (4%) at flowering and fruiting stage	13.54	14.83	14.19
T ₃ : Jeevamrut (500 mL plant ⁻¹) at flowering and fruiting stage	12.47	14.48	13.48
T ₄ : Ghanjeevamrut (80 g plant ⁻¹) at flowering and fruiting stage	12.50	14.18	13.34
T ₅ : Silver mulch + Vermicompost (21 g plant ⁻¹) + Vermiwash (4%)	22.89	20.38	21.64
T ₆ : Silver mulch + Jeevamrut (500 mL plant ⁻¹)	21.23	20.08	20.66
T ₇ : Silver mulch + Ghanjeevamrut (80 g plant ⁻¹)	17.74	19.03	18.39
T ₈ : Silver mulch	12.34	14.05	13.20
T ₉ : Transparent mulch + Vermicompost (21 g plant ⁻¹) + Vermiwash (4%)	19.34	19.38	19.36
T ₁₀ : Transparent mulch + Jeevamrut (500 mL plant ⁻¹)	15.04	16.58	15.81
T ₁₁ : Transparent mulch + Ghanjeevamrut (80 g plant ⁻¹)	16.11	17.98	17.05
T ₁₂ : Transparent mulch	14.63	15.88	15.26
T ₁₃ : Paddy straw mulch + Vermicompost (21 g plant ⁻¹) + Vermiwash (4%)	15.98	17.28	16.63
T ₁₄ : Paddy straw mulch + Jeevamrut (500 mL plant ⁻¹)	15.27	16.93	16.10
T ₁₅ : Paddy straw mulch + Ghanjeevamrut (80 g plant ⁻¹)	17.26	18.33	17.80
T ₁₆ : Paddy straw mulch	14.54	15.53	15.04
SEm±	0.7939	0.0265	0.4006
CD at 5%	2.2930	0.0764	1.1570

The increase in fruit weight under T₅ may be attributed to improved nutrient availability and enhanced physiological activity resulting from the combined application of vermicompost and vermiwash. Vermicompost provides essential macro- and micronutrients along with humic substances that improve nutrient uptake and translocation (Atiyeh *et al.*, 2002; Arancon *et al.*, 2004) [3, 2]. Vermiwash enhances metabolic

activities and promotes cell division and enlargement, leading to better fruit development (Edwards *et al.*, 2011) [4]. Furthermore, silver mulch plays a vital role in maintaining soil moisture and regulating temperature, thereby improving root activity and nutrient absorption. The combined effect of these factors results in increased accumulation of photosynthates in fruits, leading to higher fruit weight. The lowest fruit weight observed in control

may be due to limited nutrient availability and reduced physiological efficiency, which restricts the development of fruits (Singh *et al.*, 2008) ^[12].

3.3 Yield per plant (g)

Yield per plant was significantly affected by different treatments

during both years and in pooled analysis (Table 3). The highest yield per plant was recorded in T₅ (557.42 g), which was found to be statistically at par with T₆, but significantly superior over all other treatments. This was followed by T₉, which also exhibited higher yield compared to other treatments.

Table 3: Productivity of strawberry (*Fragaria × ananassa*) cv. Camarosa as affected by integrated organic inputs and mulching (yield per plant, g)

Treatments	Yield/plant (g)		
	2024-2025	2025-2026	Pooled
T ₁ : Control	179.20	204.96	192.08
T ₂ : Vermicompost (21 g plant ⁻¹) + Vermiwash (4%) at flowering and fruiting stage	237.18	271.22	254.2
T ₃ : Jeevamrut (500 mL plant ⁻¹) at flowering and fruiting stage	215.51	256.13	235.82
T ₄ : Ghanjeevamrut (80 g plant ⁻¹) at flowering and fruiting stage	212.16	242.32	227.24
T ₅ : Silver mulch + Vermicompost (21 g plant ⁻¹) + Vermiwash (4%)	560.62	554.22	557.42
T ₆ : Silver mulch + Jeevamrut (500 mL plant ⁻¹)	504.85	535.91	520.38
T ₇ : Silver mulch + Ghanjeevamrut (80 g plant ⁻¹)	395.36	462.21	428.785
T ₈ : Silver mulch	198.79	232.97	215.88
T ₉ : Transparent mulch + Vermicompost (21 g plant ⁻¹) + Vermiwash (4%)	446.41	493.97	470.19
T ₁₀ : Transparent mulch + Jeevamrut (500 mL plant ⁻¹)	290.07	333.07	311.57
T ₁₁ : Transparent mulch + Ghanjeevamrut (80 g plant ⁻¹)	340.09	415.14	377.615
T ₁₂ : Transparent mulch	277.62	309.48	293.55
T ₁₃ : Paddy straw mulch + Vermicompost (21 g plant ⁻¹) + Vermiwash (4%)	332.08	378.24	355.16
T ₁₄ : Paddy straw mulch + Jeevamrut (500 mL plant ⁻¹)	305.11	350.26	327.685
T ₁₅ : Paddy straw mulch + Ghanjeevamrut (80 g plant ⁻¹)	375.44	434.22	404.83
T ₁₆ : Paddy straw mulch	269.43	293.34	281.385
SEm±	16.958	1.3920	8.4677
CD at 5%	48.9795	4.0204	24.4565

The increased yield under T₅ can be attributed to the combined effect of higher fruit number and greater fruit weight. The integrated use of vermicompost and vermiwash enhances soil fertility, microbial activity, and nutrient availability, which collectively improve plant growth and productivity (Atiyeh *et al.*, 2002; Arancon *et al.*, 2004) ^[3, 2]. Vermiwash further enhances physiological processes such as photosynthesis and nutrient assimilation (Edwards *et al.*, 2011) ^[4]. In addition, the use of silver mulch helps in conserving soil moisture, regulating soil temperature, and reducing weed competition, thereby creating a favourable environment for plant growth and fruit development (Kasirajan and Ngouajio, 2012) ^[5]. These factors together contribute to improved yield performance. The lowest yield recorded in control and mulch-alone treatments may be due to inadequate nutrient supply and less favourable soil conditions, resulting in reduced growth and productivity (Singh *et al.*, 2008) ^[12].

4. Conclusion

The present investigation clearly demonstrated that the combined application of organic nutrient sources along with mulching significantly enhanced the growth and yield attributes of strawberry. Among all treatments, T₅ (Silver mulch + Vermicompost @ 21 g plant⁻¹ + Vermiwash @ 4%) proved to be the most effective, recording the highest number of fruits per plant, fruit weight, and yield per plant. The treatment was found to be statistically at par with T₆ but remained superior over the rest of the treatments.

The improved performance under T₅ can be attributed to the synergistic effect of vermicompost and vermiwash in enhancing nutrient availability, microbial activity, and plant physiological processes, coupled with the beneficial role of silver mulch in conserving soil moisture, regulating soil temperature, and

suppressing weeds. This integrated approach creates a favourable microenvironment for better flowering, fruit development, and overall productivity.

Based on the findings, it can be concluded that the integration of organic nutrient sources with mulching is an effective and sustainable strategy for improving strawberry yield. The adoption of such practices can reduce dependency on chemical fertilizers and contribute to environmentally sustainable horticultural production.

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