

# Influence of Organic Fertilizers and Mulching on Strawberry (*Fragaria × Ananassa*) Cv. Camarosa Growth, Flowering and Fruiting Parameters

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## ABSTRACT

The study was conducted during 2024-2025 and 2025-2026 at Galgotias University, Greater Noida, Uttar Pradesh. The experiment had 16 treatments in three replications conducted in Completely Randomized Design. The influence of vermicompost, vermiwash, Jeevamrut, and Ghanjeevamrut with combination in three different mulching materials (silver mulch, transparent mulch, and paddy straw) was found significantly influenced. The T5 (Silver mulch + Vermicompost (21g/plant) + Vermiwash 4% (v/v)) was found statistically superior to rest of the treatments. The study result shows combined organic nutrient sources with mulching, especially silver mulch, is a good way to boost strawberry productivity and fruit quality when grown under shade nets.

**Keywords:** Strawberry, organic fertilizers, mulching, vermicompost, silver mulch, yield, fruit quality, shade net

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## Introduction

The strawberry (*Fragaria × ananassa* Duch.) is a low-growing, herbaceous, short-day perennial plant that belongs to the Rosaceae family and is widely cultivated across various climatic zones globally. The modern cultivated strawberry is a monoecious, octoploid hybrid ( $2n = 8x = 56$ ) (Anushi *et al.*, 2025).

Strawberries are a great source of vitamin C, antioxidants, and important minerals. They are also known for their vibrant red colour, pleasant scent, and rich nutritional profile. In marketplaces, processed goods like jams and jellies are frequently sold. Many well-known cultivars, including Chandler, Sweet Charlie, Selva, Tioga, Kalimpong Local, and Pusa Early Dwarf, are extensively grown in India. The "camarosa" cultivar, which was first created in California, is becoming more and more well-known because of its high potential production, flexibility, and excellent fruit quality in a variety of environmental settings (Darby & Islam, 2025; Roosta *et al.*, 2024). Strawberries may be grown in a variety of agroclimatic locations because temperature and photoperiod affect their flowering and fruiting.

The fruits of strawberries are consumed fresh with the epicarp. These chemical get absorbed by the fruit skin and might affect human health as it is freshly consumed. To make strawberries cultivation more sustainable and chemical-free organic fertilizers like vermiwash, Vermicompost Jeevamrut and Ghanjeevamrut were used. The strawberry plants get a lot of competition from weeds. Its fruits are very perishable and non-climatic which result

in increased soil borne microorganism infection. The mulching reduces both weed population conserve the moisture and create barrier between delicate fruit skin and soil. The study focus on reducing the use of chemical fertilizers and improving the soil organic matter and sustainable quality strawberry production.

The importance of organic nutrient management techniques that enhance soil health while maintaining crop output has been highlighted by the global shift toward sustainable agriculture. The physical, chemical, and biological characteristics of soil are greatly improved by organic inputs such vermicompost, vermiwash, Jeevamrut, and Ghanjeevamrut (Singh *et al.*, 2021; Meena *et al.*, 2022). In addition to providing vital macronutrients and micronutrients, these organic amendments also encourage the synthesis of plant growth regulators including auxins, gibberellins, and cytokinins and stimulate beneficial microbial activity (Yadav *et al.*, 2020; Sharma *et al.*, 2023).

Organic mulches and biofertilizers have demonstrated considerable potential in enhancing growth, productivity, and fruit quality parameters in strawberry production. Biofertilizers, which are made composed of organic materials and beneficial microbes, improve soil microbial dynamics, increase nutrient uptake, and increase stress tolerance (Kumar *et al.*, 2021). In the meanwhile, organic mulches enhance soil structure, retain moisture, control temperature, and inhibit weed growth, all of which eventually result in higher crop productivity and sustainability (Moreno *et al.*, 2021; Li *et al.*, 2022).

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## Materials and Methods

The study was carried out at the experimental farm, School of Agriculture, \ Galgotias University, Greater Noida, Uttar Pradesh, India, during the winter months of 2024-2025 and 2025-2026. A Completely Randomised Design (CRD) with 16 treatments and 3 replications was used to set up the experiment. The treatments were T<sub>1</sub> : Control; T<sub>2</sub> : Vermicompost (21 g plant<sup>-1</sup>) + Vermiwash 4% (v/v), T<sub>3</sub> : Jeevamrut (500 mL plant<sup>-1</sup>), T<sub>4</sub>: Ghanjeevamrut (80 g plant<sup>-1</sup>) at flowering and fruiting stage, T<sub>5</sub> : Silver mulch + Vermicompost (21 g plant<sup>-1</sup>) + Vermiwash 4% (v/v), T<sub>6</sub> : Silver mulch + Jeevamrut (500 mL plant<sup>-1</sup>), T<sub>7</sub> : Silver mulch + Ghanjeevamrut (80 g plant<sup>-1</sup>), T<sub>8</sub> : Silver mulch, T<sub>9</sub> : Transparent mulch + Vermicompost (21 g plant<sup>-1</sup>) + Vermiwash 4% (v/v), T<sub>10</sub> : Transparent mulch + Jeevamrut (500 mL plant<sup>-1</sup>), T<sub>11</sub> : Transparent mulch + Ghanjeevamrut (80 g plant<sup>-1</sup>), T<sub>12</sub> : Transparent mulch, T<sub>13</sub> : Paddy straw mulch + Vermicompost (21 g plant<sup>-1</sup>) + Vermiwash 4% (v/v) at flowering and fruiting stage, T<sub>14</sub> : Paddy straw mulch + Jeevamrut (500 mL plant<sup>-1</sup>), T<sub>15</sub> : Paddy straw mulch + Ghanjeevamrut (80 g plant<sup>-1</sup>), T<sub>16</sub> : Paddy straw mulch. The treatments were applied twice at flowering and fruiting stage.

The horizontal beds were prepared to fine tilt. Mulching was done as per the treatments. Healthy and disease-free strawberry plants were planted in three rows at 30cm and plants were planted alternately in the row at a plant-to-plant distance of 30 cm. All recommended cultural practices were followed.

The vegetative, flowering and fruiting parameters observations were recorded. Also the fruits quality parameters like TSS, Sugar, titratable Acidity were evaluated in the Horticultural Lab, School of Agriculture. TSS was recorded with a hand refractometer, Total Sugar was analysed with Anthrone methods, reducing sugar by DNS method (3,5-Dinitrosalicylic acid method, titratable acidity by acid base titration method and Vit c by 2,6-Dichlorophenol Indophenol (DCPIP) titration method.

Jeevamrut, Ghanjeevamrut, vermicompost, and vermiwash were prepared following standard procedures described by Palekar (2006), ICAR (2013), and NCOF (2009). The preparation involved controlled fermentation, organic substrate decomposition, and earthworm-mediated bioconversion under recommended conditions of moisture and temperature.

The experimental data were subjected to statistical analysis using analysis of variance (ANOVA) following the standard procedures described by Fisher and Yates (1963). The significance of treatment effects was evaluated at the 5% level of probability ( $p \leq 0.05$ ). When the F-test indicated significant differences among treatments, mean comparisons were performed using the critical difference (CD) test.

## RESULTS & DISCUSSION

The statistical analysis of two years pooled observed data shows significant effect of treatments on strawberry

vegetative, flowering and fruiting parameter along with quality parameters. The statistically analysed data is presented in Table no. 1 & 2.

### Vegetative parameters

#### 1. Plant height (cm) at 120 days after transplanting

The maximum plant height was recorded in T<sub>5</sub> (23.13 cm) (Silver mulch + Vermicompost (21g/plant) +Vermiwash 4% (v/v) , which was statistically superior over all other treatments, followed by T<sub>6</sub> (22.42 cm) Silver mulch + Jeevamrut (500mL/plant) and T<sub>9</sub> (21.54 cm) Transparent mulch + Vermicompost (21g/plant) + Vermiwash 4% (v/v) . The minimum plant height was observed in T<sub>1</sub> Control (11.90 cm). Treatments T<sub>7</sub> (20.92 cm) (Silver mulch + Ghanjeevamrut @ 80 g plant<sup>-1</sup>) and T<sub>15</sub> (20.31 cm) (Paddy straw mulch + Ghanjeevamrut @ 80 g plant<sup>-1</sup>) were found to be statistically at par with each other, except T<sub>5</sub> (Silver mulch + Vermicompost (21g/plant) +Vermiwash 4% (v/v).

#### 2. Plant spread (cm) at 120 days after transplanting

The highest plant spread was recorded under T<sub>5</sub> (44.57 cm) (Silver mulch + Vermicompost (21g/plant) +Vermiwash 4% (v/v) , followed by T<sub>6</sub> (44.57 cm) Silver mulch + Jeevamrut (500mL/plant) and T<sub>9</sub> (42.07 cm) Transparent mulch + Vermicompost (21g/plant) + Vermiwash 4% (v/v) . The lowest plant spread was observed in T<sub>1</sub> Control (27.95 cm). Treatments T<sub>7</sub> (40.89 cm) (Silver mulch + Ghanjeevamrut @ 80 g plant<sup>-1</sup>) and T<sub>15</sub> (39.52 cm) (Paddy straw mulch + Ghanjeevamrut @ 80 g plant<sup>-1</sup>) showed statistically comparable performance, except T<sub>5</sub> (Silver mulch + Vermicompost (21g/plant) +Vermiwash 4% (v/v).

#### 3. Yield (q/ha)

A significant variation in yield (q ha<sup>-1</sup>) was observed among treatments. The highest yield was recorded in T<sub>5</sub> (275.06 q ha<sup>-1</sup>) (Silver mulch + Vermicompost (21g/plant) +Vermiwash 4% (v/v), followed by T<sub>6</sub> (260.53 q ha<sup>-1</sup>) Silver mulch + Jeevamrut (500mL/plant) and T<sub>9</sub> (243.71 q ha<sup>-1</sup>) Transparent mulch + Vermicompost (21g/plant) + Vermiwash 4% (v/v) . The lowest yield was observed in T<sub>1</sub> Control (97.88 q ha<sup>-1</sup>).

It resulted in maximum plant growth (height and spread), early flowering, higher number of flowers, and significantly higher yield per plot and per hectare, indicating its effectiveness in enhancing vegetative as well as reproductive performance of strawberry. Among organic inputs, the combination of vermicompost and vermiwash proved more effective than jeevamrut and ghanjeevamrut, likely due to improved nutrient availability and microbial activity.

The combined effects of organic inputs that improve food availability, microbial activity, and hormone stimulation, resulting in enhanced vegetative growth, may be responsible for the increased plant height under T<sub>5</sub> (Silver mulch + Vermicompost (21g/plant) + Vermiwash 4% (v/v). Singh *et al.*, 2021 and Meena *et al.*, 2022 reported analogous findings, noting improved plant growth

resulting from the application of vermicompost and biofertilizer.

As demonstrated by noticeably greater plant height and spread across all growth phases, treatment T<sub>5</sub> Silver mulch + Vermicompost (21g/plant) + Vermiwash 4% (v/v) was the most successful in boosting vegetative growth overall. These findings are in agreement with those of Yadav *et al.*, 2020; Sharma *et al.*, 2023

The same pattern was seen in yield T<sub>5</sub> Silver mulch + Vermicompost (21g/plant) + Vermiwash 4% (v/v) had the highest yield (275.06 q ha<sup>-1</sup> pooled), followed by T<sub>6</sub> Silver mulch + Jeevamrut (500mL/plant) (260.53 q ha<sup>-1</sup>) and T<sub>9</sub> Transparent mulch + Vermicompost (21g/plant) + Vermiwash 4% (v/v) (243.71 q ha<sup>-1</sup>), while T<sub>1</sub> Control had the lowest (97.88 q ha<sup>-1</sup>). The notable increase in yield under T<sub>5</sub> Silver mulch + Vermicompost (21g/plant) + Vermiwash 4% (v/v), shows how well integrated organic inputs maximise productivity in shade net conditions. Similar findings were reported by Kumar *et al.*, 2021. Overall, treatment T<sub>5</sub> Silver mulch + Vermicompost (21g/plant) + Vermiwash 4% (v/v) demonstrated its superiority in increasing yield at the plant, plot, and hectare levels by consistently outperforming all other treatments across all yield measures. The promise of organic nutrient management techniques for sustainable strawberry production is highlighted by the improved yield performance, which may be ascribed to the combined effect of improved growth, improved reproductive efficiency, and improved fruit attributes.

Floral Characters

#### 4. Days to 50% flowering (Days)

The earliest flowering was recorded in T<sub>5</sub> (32.23 days) (Silver mulch + Vermicompost @ 21 g plant<sup>-1</sup> + Vermiwash @ 4%), which was significantly superior over all other treatments, followed by T<sub>6</sub> (33.32 days) (Silver mulch + Jeevamrut @ 500 mL plant<sup>-1</sup>), T<sub>7</sub> (34.61 days) (Silver mulch + Ghanjeevamrut @ 80 g plant<sup>-1</sup>), and T<sub>9</sub> (34.62 days) (Transparent mulch + Vermicompost @ 21 g plant<sup>-1</sup> + Vermiwash @ 4%). The maximum days to flowering (late flowering) were observed in T<sub>1</sub> (42.49 days) (Control). Treatments T<sub>11</sub> (35.62 days) (Transparent mulch + Ghanjeevamrut @ 80 g plant<sup>-1</sup>), T<sub>13</sub> (35.58 days) (Paddy straw mulch + Vermicompost @ 21 g plant<sup>-1</sup> + Vermiwash @ 4%), and T<sub>15</sub> (35.31 days) (Paddy straw mulch + Ghanjeevamrut @ 80 g plant<sup>-1</sup>) were found to be statistically at par with each other, except T<sub>5</sub>.

#### 5. Number of flower per plant

The maximum number of flowers per plant was recorded in T<sub>5</sub> (27.10) (Silver mulch + Vermicompost @ 21 g plant<sup>-1</sup> + Vermiwash @ 4%), followed by T<sub>6</sub> (26.61) (Silver mulch + Jeevamrut @ 500 mL plant<sup>-1</sup>), T<sub>9</sub> (25.97) (Transparent mulch + Vermicompost @ 21 g plant<sup>-1</sup> + Vermiwash @ 4%), and T<sub>7</sub> (25.65) (Silver mulch + Ghanjeevamrut @ 80 g plant<sup>-1</sup>). The minimum number of flowers was observed in T<sub>1</sub> (18.60) (Control). Yadav *et al.* (2020) found that the application of bio-fertilisers and mulching over the course of both experimental years

significantly increased strawberry berry diameter cv. Katrain. This increase in fruit diameter may be related to improved photosynthetic efficiency, which likely led to increased dry matter accumulation and reduced weed competition.

Quality Parameters

#### 6. Total Soluble solid (TSS) (°B)

The maximum TSS was recorded in T<sub>5</sub> (9.56 °B) (Silver mulch + Vermicompost @ 21 g plant<sup>-1</sup> + Vermiwash @ 4%), which was significantly superior over all other treatments, followed by T<sub>6</sub> (9.26 °B) (Silver mulch + Jeevamrut @ 500 mL plant<sup>-1</sup>), T<sub>9</sub> (9.04 °B) (Transparent mulch + Vermicompost @ 21 g plant<sup>-1</sup> + Vermiwash @ 4%), and T<sub>7</sub> (8.83 °B) (Silver mulch + Ghanjeevamrut @ 80 g plant<sup>-1</sup>). The minimum TSS was observed in T<sub>1</sub> (6.36 °B) (Control), which was closely followed by T<sub>8</sub> (6.38 °B) (Silver mulch). Treatments T<sub>11</sub> (8.38 °Brix) (Transparent mulch + Ghanjeevamrut @ 80 g plant<sup>-1</sup>), T<sub>15</sub> (8.60 °B) (Paddy straw mulch + Ghanjeevamrut @ 80 g plant<sup>-1</sup>), and T<sub>13</sub> (8.09 °B) (Paddy straw mulch + Vermicompost @ 21 g plant<sup>-1</sup> + Vermiwash @ 4%) were found to be statistically at par with each other. These findings are in agreement with Moreno *et al.*, 2021; Li *et al.*, 2022.

#### 7. Titratable acidity (g/L)

The maximum acidity was recorded in T<sub>5</sub> (1.48 g L<sup>-1</sup>) (Silver mulch + Vermicompost @ 21 g plant<sup>-1</sup> + Vermiwash @ 4%), followed by T<sub>6</sub> (1.34 g L<sup>-1</sup>) (Silver mulch + Jeevamrut @ 500 mL plant<sup>-1</sup>), T<sub>9</sub> (1.31 g L<sup>-1</sup>) (Transparent mulch + Vermicompost @ 21 g plant<sup>-1</sup> + Vermiwash @ 4%), and T<sub>7</sub> (1.28 g L<sup>-1</sup>) (Silver mulch + Ghanjeevamrut @ 80 g plant<sup>-1</sup>). The minimum acidity was observed in T<sub>1</sub> (0.76 g L<sup>-1</sup>) (Control), followed by T<sub>8</sub> (0.78 g L<sup>-1</sup>) (Silver mulch).

#### 8. TSS:TA

The TSS:TA ratio showed significant variation among treatments. The maximum TSS:TA ratio was recorded in T<sub>1</sub> (8.37) (Control), followed by T<sub>8</sub> (8.18) (Silver mulch). The minimum ratio was observed in T<sub>5</sub> (6.48) (Silver mulch + Vermicompost @ 21 g plant<sup>-1</sup> + Vermiwash @ 4%). Treatments T<sub>2</sub> (7.26) (Vermicompost + Vermiwash), T<sub>12</sub> (7.24) (Transparent mulch), and T<sub>13</sub> (7.23) (Paddy straw mulch + Vermicompost + Vermiwash) were found to be statistically at par with each other, except T<sub>1</sub>.

With respect to mulching, silver mulch emerged as the most efficient, followed by transparent mulch, whereas paddy straw mulch showed comparatively moderate performance. The superiority of silver mulch may be attributed to better soil moisture conservation, temperature regulation, and enhanced nutrient uptake.

In terms of fruit quality, treatment T<sub>5</sub> also recorded higher TSS and titratable acidity, indicating improved biochemical attributes. However, the TSS:TA ratio was comparatively lower, suggesting a balanced sugar-acid composition. In general, fruits with higher sugar content (TSS) and a moderate to lower TSS:TA ratio are

considered superior in quality, as they provide better flavor, sweetness, and consumer acceptability. Kilic *et al.*, (2023) reported treatment combination with vermicompost, PGPR and AMF has significantly influenced TSS. The researchers additionally stated that the observed rise in TSSs levels could be attributed to the fast metabolic conversion of the manure, vermicompost, and biofertilizer combination into soluble starch and pectin compounds. Furthermore, they suggested that the transition of sugar from leaves to developing fruits might result from converting polysaccharides into simpler sugars.

### CONCLUSION

The T5 (silver mulch+vermicompost+vermiwash) significantly improved growth, flowering, yield, and quality of strawberry compared to other treatments. Among organic inputs, vermicompost with vermiwash proved most effective, while silver mulch performed better than transparent and paddy straw mulch under sustainable cultivation. Quality parameters revealed higher TSS and balanced acidity under superior treatments, enhancing fruit taste and acceptability. Fruits with higher sugar content and moderate TSS:TA ratio were found to be of better quality. Thus, integration of organic fertilization with suitable mulching can be recommended for sustainable strawberry production.

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**Table 1: Effect of different treatments on growth and yield parameters of strawberry (cv. Camarosa) during 2024-25 and 2025-26 (pooled values)**

Treatments	Plant height (cm) at 120 DAT	Plant spread (cm) at 120 DAT	Yield per plot (kg)	Yield (qha <sup>-1</sup> )
T <sub>1</sub> Control	11.90	27.95	960.39	97.88
T <sub>2</sub> Vermicompost (21g/plant) + Vermiwash 4% (v/v) at flowering and fruiting stage	16.23	33.22	1271.015	138.67
T <sub>3</sub> Jeevamrut (500mL/plant) at flowering and fruiting stage	15.65	32.50	1189.115	129.63
T <sub>4</sub> Ghanjeevamrut (80g/plant) at flowering and fruiting stage	14.99	31.15	1136.195	118.41
T <sub>5</sub> Silver mulch + Vermicompost (21g/plant) +Vermiwash 4% (v/v) at flowering and fruiting stage	23.13	44.57	2787.1	275.06

T <sub>6</sub> Silver mulch + Jeevamrut (500mL/plant) at flowering and fruiting stage	22.42	43.57	2601.9	260.53
T <sub>7</sub> Silver mulch + Ghanjeevamrut (80g/plant) at flowering and fruiting stage	20.92	40.89	2143.93	228.04
T <sub>8</sub> Silver mulch	13.90	30.17	1079.395	110.00
T <sub>9</sub> Transparent mulch + Vermicompost (21g/plant) + Vermiwash 4% (v/v) at flowering and fruiting stage	21.54	42.07	2350.945	243.71
T <sub>10</sub> Transparent mulch + Jeevamrut (500mL/plant) at flowering and fruiting stage	18.08	35.91	1557.84	168.21
T <sub>11</sub> Transparent mulch+ Ghanjeevamrut (80g/plant) at flowering and fruiting stage	19.63	38.59	1888.075	206.75
T <sub>12</sub> Transparent mulch	17.39	35.42	1467.76	160.08
T <sub>13</sub> Paddy Straw mulch +Vermicompost (21g/plant) + Vermiwash 4% (v/v) at flowering and fruiting stage	19.19	37.99	1775.79	193.94
T <sub>14</sub> Paddy Straw mulch +Jeevamrut (500mL/plant) at flowering and fruiting stage	18.58	36.61	1638.43	181.86
T <sub>15</sub> Paddy Straw mulch + Ghanjeevamrut (80g/plant) at flowering and fruiting stage	20.31	39.52	2024.135	216.16
T <sub>16</sub> Paddy Straw mulch	16.83	34.58	1406.925	152.91
<b>SEm±</b>	0.0529	0.0182	42.3395	2.6127
<b>CD at 5%</b>	0.1528	0.0526	122.2854	7.5460

**Table 2: Effect of different treatments on floral characters and quality parameters of strawberry (cv. Camarosa) during 2024-25 and 2025-26 (pooled values)**

Treatments	Days to 50% flowering (Days)	Number of flowers per plant	TSS (°Brix)	Titratable acidity (g L <sup>-1</sup> )	TSS:TA ratio
T <sub>1</sub> Control	42.49	18.60	6.36	0.76	8.37
T <sub>2</sub> Vermicompost (21g/plant) + Vermiwash 4% (v/v) at flowering and fruiting stage	38.21	20.69	6.81	0.95	7.26
T <sub>3</sub> Jeevamrut (500mL/plant) at flowering and fruiting stage	39.11	19.82	6.67	0.91	7.41
T <sub>4</sub> Ghanjeevamrut (80g/plant) at flowering and fruiting stage	39.56	19.65	6.53	0.86	7.63
T <sub>5</sub> Silver mulch + Vermicompost (21g/plant) +Vermiwash 4% (v/v) at flowering and fruiting stage	32.23	27.10	9.56	1.48	6.48

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T <sub>6</sub> Silver mulch + Jeevamrut (500mL/plant) at flowering and fruiting stage	33.32	26.61	9.26	1.34	6.93
T <sub>7</sub> Silver mulch + Ghanjeevamrut (80g/plant) at flowering and fruiting stage	34.61	25.65	8.83	1.28	6.92
T <sub>8</sub> Silver mulch	38.58	19.17	6.38	0.78	8.18
T <sub>9</sub> Transparent mulch + Vermicompost (21g/plant) + Vermiwash 4% (v/v) at flowering and fruiting stage	34.62	25.97	9.04	1.31	6.92
T <sub>10</sub> Transparent mulch + Jeevamrut (500mL/plant) at flowering and fruiting stage	37.32	22.70	7.55	1.06	7.17
T <sub>11</sub> Transparent mulch+ Ghanjeevamrut (80g/plant) at flowering and fruiting stage	35.62	24.74	8.38	1.18	7.17
T <sub>12</sub> Transparent mulch	37.45	22.11	7.41	1.03	7.24
T <sub>13</sub> Paddy Straw mulch +Vermicompost (21g/plant) + Vermiwash 4% (v/v) at flowering and fruiting stage	35.58	24.08	8.09	1.13	7.23
T <sub>14</sub> Paddy Straw mulch +Jeevamrut (500mL/plant) at flowering and fruiting stage	36.21	23.63	7.76	1.10	7.09
T <sub>15</sub> Paddy Straw mulch + Ghanjeevamrut (80g/plant) at flowering and fruiting stage	35.31	25.33	8.60	1.22	7.09
T <sub>16</sub> Paddy Straw mulch	37.37	21.38	7.26	0.98	7.54
<b>SEm±</b>	0.3550	0.0934	0.0274	0.0036	0.0227
<b>CD at 5%</b>	1.0253	0.2696	0.0792	0.0105	0.0657

