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Plant Growth, Fruit Yield and Quality of Strawberry (*Fragaria × ananassa* Duch.) as Affected by Bioorganic Nutrient Sources

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HIGHLIGHTS

- The study is primarily focused on the recycling of biomass inside the farm by using formulations made on the farm from cow dung and urine.
- Lowering reliance on purchased inputs and relieving the burden of debt on smallholder farmers.
- Crop performance of strawberries in comparison to the currently used recommended growing techniques.
- Investigation on the viability of supplementing the crop with bioorganic nutrient sources.
- Bioorganic nutrient sources considerably improved strawberry plant growth, flowering, fruit yield and quality.

Abstract: India in today's scenario is implementing an agroecologically based, diversified agricultural system that includes functional biodiversity along with crops, trees and livestock. Therefore, advocating natural farming, an agroecologically based diverse farming system that includes crops, trees and animals as well as functional biodiversity. It is primarily focused on the recycling of biomass inside the farm, with a focus on the use of formulations made on the farm from cow dung and urine (Jeevamrit & Ghanjeevamrit) and the elimination of all synthetic chemical inputs. It aims to lessen smallholder farmers' reliance on inputs that must be purchased as well as their credit load. With all of these facts in mind, this study investigated how the application of bioorganic nutrient sources like Jeevamrit and Ghanjeevamrit used in natural farming system affected the crop performance in strawberry grown under mid hill conditions of Himachal Pradesh, India. Farmyard manure, freshly prepared Jeevamrit and Ghanjeevamrit was used for manuring in twelve different

treatment combinations replicated thrice planned on the basis of recommended dose of nitrogen. The nitrogen content in bioorganic nutrient sources like Jeevamrit (1.71%) and Ghanjeevamrit (1.68%) was analyzed before application. Jeevamrit and Ghanjeevamrit treatments significantly increased plant growth, flowering, fruit yield and fruit quality. The findings indicated that application of treatment combination T4 (100% RDN through Jeevamrit + Ghanjeevamrit in the ratio of 1:1) resulted in better effects on strawberry plant growth, fruit quality and yield (17.50 tonnes/ha) as compared to the recommended practices.

Keywords: Bioorganic nutrient sources; crop performance; Ghanjeevamrit; Jeevamrit; strawberry.

INTRODUCTION

Fragaria ananassa Duch., the strawberry variety now grown, is a recent hybrid crop created by mating *Fragaria chiloensis* with *Fragaria virginiana*. Due to its high value and potential for sizable profit, this crop might be a viable choice for many small-scale and part-time agricultural businesses. Nutrition is a crucial component of crop production and is one of the many elements that affect strawberry development and yield [8].

Integrated nutrient management, which includes inorganic, organic and microbial sources of nutrients, ensures balanced nutrient proportion through improved nutrient response efficiency and maximizes crop yield. Additionally, it aids in closing the gap between the supply of nutrients from slow-release fertilizers and the elimination of nutrients caused by continual usage of chemical fertilizers. It is now well-established that frequent use of chemical fertilizers has a negative impact on the health of the soil and lowers crop quality and output [4]. Modern intensive crop farming uses a lot of chemical fertilizers, which are expensive, in short supply and harmful to the soil, water and environment.

Natural farming is an agroecological method of agriculture that promotes crop cultivation and animal husbandry in a synergistic manner, utilizing locally available resources. Formulations for crop production and maintaining soil fertility in harmony with nature require readily available constituents [9, 21]. Bijamrita (microbial coating for seed), Jeevamrit (microbial culture for soil), Acchadana (mulching) and Whapahasa (soil aeration) are the four main components of natural farming. Jeevamrit is a fermented microorganism's culture which is utilized to sustain soil microbial populations and earthworm activity. Increased populations of bacteria, P-Solubilizing microorganisms, promote the mineralisation of soil nutrients. The jeevamrit contains Azotobactor and Rhizobium [16]. Ghanjeevamrit is jeevamrit in its desiccated form. These amendments have the potential to enhance soil health and contribute to crop production by increasing the efficiency with which nutrients and water is used [19].

As a result, the focus of the current study was on investigating the viability of supplementing the crop with bioorganic nutrient sources (Jeevamrit & Ghanjeevamrit), with the objective of lowering reliance on purchased inputs and relieving the burden of debt on smallholder farmers.

MATERIAL AND METHODS

Experimental site:

The 2018–19 and 2019–20 academic years of this experiment were conducted at a height of 1250 m above mean sea level at the experimental field of the Department of Fruit Science, Dr. YS Parmar University of Horticulture and Forestry, Himachal Pradesh (India) (latitude 30°51'46.8"N, longitude 77°09'19.6"E). The region falls under the zone-II (sub humid-mid hills) of the agro-ecological zone of Himachal Pradesh. In both years, the plants were planted in October with 30 cm × 60 cm spacing. Grass mulch (10 cm thick) was added in January of each of the two research years.

Experimental design and treatment details:

With 12 treatments, each replicated three times, and twenty-one plants in each replicate plot of size about 3.78 m^2, the experiment was set up using a randomized block design (RBD). Over the two years of the experiment, the distribution of the plots remained the same. The different treatment combinations are detailed in Table 2. According to the recommended package of practices in the state, the recommended dose of fertilizer (RDF) applied was 50 tonnes of farmyard manures, 80 kg of nitrogen, 40 kg of phosphorus and 40 kg of potassium per hectare [3]. Recommended Dose of Nitrogen is referred to as RDN in this experiment. No additional inputs, such as chemical fertilizers or pesticides, were used during the research.

Collection and preparations of bioorganic formulations:

The sources of farmyard manure and cow urine were local. The farmyard manure was composed of cattle manure, bedding material (straw), and leftover fodder from the cow stable. The preparation of Ghanjeevamrit and jeevamrit followed the method outlined by Palekar [14]. Ghanjeevamrit was prepared with 200 kg of fresh cow dung, 4 kg of jaggery (sugarcane juice concentrate), 4 kg of gram flour (*Cicer arietinum* L.), 1–1.5 L of cow urine, and 500 g of unaltered, chemical-free soil. These components were combined, and the resulting mixture was allowed to air-dry in the shade for two days before being stored until use. Jeevamrit is a liquid formulation consisting of 10 kilograms of fresh cow dung, 10 liters of cow urine, 2 kilograms of jaggery, 2 kilograms of gram flour (*Cicer arietinum* L.), and 500 grams to one kilogram of undisturbed orchard soil blended with 200 liters of water. After 7–10 days of stirring in a clockwise direction three times per day, the mixture was ready for application.

Method of application:

As per the advised procedures, FYM and N, P and K fertilizers were applied during field preparation and after transplantation. In contrast to Ghanjeevamrit, which was applied in two equal split doses at transplanting and at the onset of flowering, Jeevamrit was applied in the field in five equal split doses at monthly intervals beginning at 15 days after transplanting as a soil treatment. The chemical characteristics of Jeevamrit and Ghanjeevamrit were examined using the established methods advised by Nyang'au and coauthors [13] (Table 1).

Plant growth:

Plant height was measured in centimeters from the crown level to the tips of the main leaves using a measuring scale (cm). East-West (E-W) and North-South (N-S) measurements of plant spread were made and the mean value was used to determine the actual plant spread. At the conclusion of harvest, the number of leaves was counted on fifteen plants from each replication, and the average result was represented as the number of leaves per plant. Using a leaf area meter, the leaf area was measured using 10 leaf samples from each replication (LI-COR 3000). Before removing the plant to prepare for new planting, the quantity of runners it had generated was tallied. It was virtually recorded how many runners each plant generated. At the conclusion of the growth season, the average number of crowns per plant was noted.

Chlorophyll content:

In the third week of June, fully developed leaves from the current season's growth were harvested in the morning, immediately put in an ice box and transported to the lab. In order to prevent the pigment in the chlorophyll from deteriorating, the samples were then maintained in the freezer at 0 ^{o}C. DMSO was used for chlorophyll extraction and quantification [6], and absorbance measurements were made on a UV-VIS spectrophotometer at wavelengths of 645 nm and 663 nm in comparison to a DMSO blank for chlorophyll a and b, respectively. Using a formula, the total chlorophyll content was calculated and represented as (mg/g of fresh weight).

Flowering and fruiting:

Ten marked plants were used to record the total numbers of flowers at blossoming, with the findings reported as the number of flowers per plant. At the time of fruit maturity, the number of primary, secondary and tertiary fruits was counted per pedicel and the result was represented as the number of fruits per plant. Ten plants' total blooms per plant and the amount of berries produced by these plants were counted at intervals of five days. The formula Fruit set (%) = (Number of berry set / Number of flowers) × 100 was used to calculate the percentage of berries set per plant. At the end of fruiting, the total berries from 10 randomly chosen plants were counted flush by flush, pooled and their average was calculated and represented as grams/plant. Based on the yield, which was measured in kg per plot and represented in t/ha, the yield per hectare was computed.

Fruit quality:

With the use of digital Vernier Calipers, fruit length was measured on ten randomly selected berries from each treatment and the results were represented in centimeters (cm). Vernier Calipers were used to measure the fruit's diameter (cm). On a top pan electronic scale, five randomly chosen fruits were weighed and the average weight was calculated. Using an Erma hand refractometer (0-32 ^{o}B), the total soluble solids content

of fruits was calculated. Fruits were biochemically analyzed to determine their quality in accordance with the AOAC (1980)'s recommended standard operating procedure [1].

Statistical Analysis:

The data were analyzed statistically by analysis of variance (ANOVA) at $p \leq 0.05$ probability level. For the parameters that were assessed in both years, the results from the different years were analyzed separately.

RESULTS

Plant growth:

The incorporation of bioorganic nutrient sources was discovered to be a significant factor ($p < 0.05$) in terms of the effects on plant growth parameters. Its application in strawberries was also discovered to have a substantial impact on the aggregated results throughout time. The recommended cultivation practices (T_1), recorded significantly higher plant height (cm), spread (cm) and number of leaves per plant among different treatment combinations during both the years of the study (Table 3). Leaf area (cm^2) values did not vary significantly between the treatments during 2019 and ranged between 40.81-43.48. In 2020 and pooled data over the years recorded maximum Leaf area (cm^2) with application of 100 per cent RDN through Jeevamrit (T_2) as indicated in Table 3. Number of runners and crowns per plant were also significantly improved by application of Jeevamrit and Ghanjeevamrit (Table 4).

Chlorophyll content:

The chlorophyll content of the leaves was determined by laboratory analysis (DMSO), producing significant findings. Application of 100 per cent RDN through Jeevamrit recorded the highest leaf chlorophyll concentration during both the years of study, followed by application of 100 per cent RDN through Jeevamrit and Ghanjeevamrit in equal proportion (Table 4).

Flowering and fruiting:

Bioorganic nutrient sources had significant influence on flowering, fruit set and yield parameters (Table 5). Number of flowers per plant and number of fruits per plant were recorded significantly higher in plants supplied with 100 per cent RDN through Jeevamrit during 2019 and in pooled data of both the years (Table 5). In both years, fruit set and yield parameters were also significantly improved by the application of bioorganic formulations. The treatment combination comprising of 100 per cent RDN through Jeevamrit and Ghanjeevamrit in equal proportion recorded the higher values for fruit set and yield parameters (Table 5).

Fruit quality:

Pooled data over the years revealed that application of bioorganic nutrient sources significantly improved the physical parameters of the fruits (Table 6). Fruit length and fruit weight recorded its maximum values in treatments supplied with 100 per cent RDN through Jeevamrit and Ghanjeevamrit in equal ratio. Fruit breadth was recorded maximum in treatment combination of 75 per cent RDN through FYM and 25 per cent RDN through Jeevamrit (Table 6).

Significant improvement in physico-chemical parameters of the fruits was also observed in different treatment combinations of bioorganic formulations. Pooled data over the years revealed that TSS/acid ratio, total sugars and reducing sugars were significantly higher in treatment of 100 per cent RDN through Ghanjeevamrit (Table 7). However, Non-reducing sugars were recorded maximum in treatment combination of 75 per cent RDN through FYM and 25 per cent RDN through Ghanjeevamrit, followed by 75 per cent RDN through FYM and 25 per cent RDN through Jeevamrit (Table 8). Anthocyanin content, ascorbic acid and total phenols were also significantly improved with the application of bioorganic nutrient sources (Table 8). The pooled data over the years showed that application of 100 per cent RDN through Jeevamrit and Ghanjeevamrit in equal ratio recorded higher values for anthocyanin content, ascorbic acid and total phenols.

Tables

Table 1. Chemical properties of Jeevamrit and Ghanjeevamrit

Chemical properties	Jeevamrit	Ghanjeevamrit
pH	4.99	6.73
EC (dSm^{-1})	3.08	1.63
N (%)	1.71	1.68
P (%)	0.19	0.25
K (%)	0.32	0.63

Table 2. Treatment details

Treatment	Detail
$T_{1(Control)}$	100% RDF through inorganic fertilizers (50 tonnes FYM, 80 kg N, 40 kg P, and 40 kg of K per hectare)
T_2	100% RDN through Jeevamrit
T_3	100% RDN through Ghanjeevamrit
T_4	100% RDN through Jeevamrit + Ghanjeevamrit in the ratio 1:1
T_5	75% RDN through FYM + 25% RDN through Jeevamrit
T_6	75% RDN through FYM + 25% RDN through Ghanjeevamrit
T_7	75% RDN through FYM + 25% RDN through Jeevamrit + Ghanjeevamrit in the ratio 1:1
T_8	50% RDN through FYM + 50% RDN through Jeevamrit
T_9	50% RDN through FYM + 50% RDN through Ghanjeevamrit
T_{10}	50% RDN through FYM + 50% RDN through Jeevamrit + Ghanjeevamrit in the ratio 1:1
T_{11}	Jeevamrit (500 litre/ ha)
T_{12}	Ghanjeevamrit (250 kg/ha)

Table 3. Plant growth parameters of strawberry as influenced by organic formulations-I

Treatment	Plant height (cm)			Plant spread (cm)			Number of leaves per plant			Leaf area (cm^2)		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T1	20.33	21.50	20.92	26.54	26.77	26.66	17.3	20.7	19.0	43.34	42.62	42.98
T2	19.33	21.33	20.33	24.64	25.95	25.30	13.7	20.3	17.0	43.48	45.03	44.26
T3	16.50	19.33	17.92	23.11	25.11	24.11	14.0	20.3	17.2	42.64	43.32	42.98
T4	17.50	21.33	19.42	23.82	25.52	24.67	14.3	20.0	17.2	42.82	44.17	43.50
T5	15.33	18.83	17.08	20.54	21.84	21.19	13.7	19.0	16.4	43.20	43.22	43.21
T6	16.33	18.67	17.50	19.91	20.81	20.36	13.7	19.3	16.5	43.18	43.87	43.53
T7	13.67	18.83	16.25	19.38	20.38	19.88	13.7	17.3	15.5	40.41	43.29	41.85
T8	14.33	16.50	15.42	21.63	20.61	21.12	13.7	18.0	15.9	41.88	39.89	40.88
T9	14.17	16.50	15.33	21.83	20.48	21.16	14.0	14.0	14.0	41.72	41.74	41.73
T10	13.17	15.83	14.50	20.50	19.97	20.24	15.0	16.7	15.9	41.57	42.26	41.91
T11	11.17	15.33	13.25	18.83	19.19	19.01	12.7	14.3	13.5	41.58	41.60	41.59
T12	13.17	15.17	14.17	17.67	18.41	18.04	12.7	14.0	13.4	40.81	40.83	40.82
$CD_{(0.05)}$	**2.60**	**2.58**	**2.52**	**0.75**	**1.38**	**1.09**	**2.97**	**3.03**	**2.93**	**NS**	**3.32**	**3.40**

$T_{1\ (Control)}$: 100% RDF through inorganic fertilizers (50 tonnes FYM, 80 kg N, 40 kg P, and 40 kg of K per hectare), **T_2**: 100% RDN through Jeevamrit, **T_3**: 100% RDN through Ghanjeevamrit, **T_4**: 100% RDN through Jeevamrit + Ghanjeevamrit in the ratio 1:1, **T_5**: 75% RDN through FYM + 25% RDN through Jeevamrit, **T_6**: 75% RDN through FYM + 25% RDN through Ghanjeevamrit, **T_7**: 75% RDN through FYM + 25% RDN through Jeevamrit + Ghanjeevamrit in the ratio 1:1, **T_8**: 50% RDN through FYM + 50% RDN through Jeevamrit, **T_9**: 50% RDN through FYM + 50% RDN through Ghanjeevamrit, **T_{10}**: 50% RDN through FYM + 50% RDN through Jeevamrit + Ghanjeevamrit in the ratio 1:1, **T_{11}**: Jeevamrit (500 litre/ ha) and **T_{12}**: Ghanjeevamrit (250 kg/ha)

Table 4. Number of runners, number of crowns and total chlorophyll content of strawberry as influenced by organic formulations

Treatment	Number of runners per plant			Number of crowns per plant			Total chlorophyll content (mg/g)		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T1	4.7	5.7	5.2	2.3	2.6	2.5	0.67	0.75	0.71
T2	4.7	5.7	5.2	2.0	2.3	2.2	0.70	0.78	0.74
T3	5.7	5.3	5.5	2.6	2.3	2.5	0.67	0.75	0.71
T4	4.3	5.3	4.8	2.7	2.4	2.5	0.69	0.77	0.73
T5	3.3	4.3	3.8	2.7	2.3	2.5	0.68	0.76	0.72
T6	3.7	5.0	4.3	2.6	2.3	2.5	0.62	0.71	0.66
T7	3.3	4.0	3.7	2.3	2.3	2.3	0.66	0.75	0.70
T8	4.3	4.7	4.5	2.0	2.0	2.0	0.63	0.71	0.67
T9	4.0	4.3	4.2	2.6	2.3	2.5	0.65	0.73	0.69
T10	3.3	4.0	3.7	2.3	2.0	2.2	0.66	0.75	0.70
T11	2.3	2.7	2.5	2.3	2.0	2.2	0.64	0.72	0.68
T12	2.3	2.7	2.5	2.3	2.0	2.2	0.62	0.71	0.66
$CD_{(0.05)}$	**1.26**	**1.44**	**1.39**	**0.88**	**0.79**	**0.82**	**0.06**	**0.06**	**0.05**

$T_{1\ (Control)}$: 100% RDF through inorganic fertilizers (50 tonnes FYM, 80 kg N, 40 kg P, and 40 kg of K per hectare), **T_2**: 100% RDN through Jeevamrit, **T_3**: 100% RDN through Ghanjeevamrit, **T_4**: 100% RDN through Jeevamrit + Ghanjeevamrit in the ratio 1:1, **T_5**: 75% RDN through FYM + 25% RDN through Jeevamrit, **T_6**: 75% RDN through FYM + 25% RDN through Ghanjeevamrit, **T_7**: 75% RDN through FYM + 25% RDN through Jeevamrit + Ghanjeevamrit in the ratio 1:1, **T_8**: 50% RDN through FYM + 50% RDN through Jeevamrit, **T_9**: 50% RDN through FYM + 50% RDN through Ghanjeevamrit, **T_{10}**: 50% RDN through FYM + 50% RDN through Jeevamrit + Ghanjeevamrit in the ratio 1:1, **T_{11}**: Jeevamrit (500 litre/ ha) and **T_{12}**: Ghanjeevamrit (250 kg/ha)

Table 5. Flowering, fruit set and yield parameters of strawberry as influenced by organic formulations

Treatment	Number of flowers per plant			Number of fruits per plant			Fruit set (%)			Yield per plant (g)			Yield per hectare (tonnes)		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T1	24.33	26.00	25.17	20.67	22.33	21.50	85.24	85.85	85.54	272.81	294.73	283.77	15.16	16.37	15.76
T2	25.67	25.67	25.67	22.00	22.00	22.00	85.64	85.74	85.69	295.31	318.51	306.91	16.41	17.69	17.05
T3	22.67	25.67	24.17	20.00	22.67	21.33	88.13	88.44	88.28	257.01	311.13	284.07	14.28	17.28	15.78
T4	23.00	25.67	24.33	20.67	23.00	21.83	89.90	89.87	89.89	299.97	329.86	314.92	16.66	18.33	17.50
T5	22.00	26.67	24.33	16.67	20.67	18.67	75.76	77.54	76.65	185.35	264.24	224.80	10.30	14.68	12.49
T6	21.00	20.33	20.67	16.33	16.00	16.17	77.97	78.89	78.43	186.66	190.17	188.42	10.37	10.56	10.47
T7	18.33	21.00	19.67	14.00	16.67	15.33	76.22	78.89	77.55	154.18	201.31	177.74	8.57	11.18	9.87
T8	21.33	23.00	22.17	15.00	17.00	16.00	70.30	73.78	72.04	148.18	162.10	155.14	8.23	9.01	8.62
T9	19.67	21.67	20.67	14.33	16.67	15.50	72.42	76.33	74.38	133.69	158.14	145.92	7.43	8.79	8.11
T10	19.00	22.00	20.50	13.33	16.33	14.83	70.22	73.81	72.02	123.52	152.50	138.01	6.86	8.47	7.67
T11	16.00	17.33	16.67	11.00	12.00	11.50	68.41	69.28	68.84	95.27	102.61	98.94	5.29	5.70	5.50
T12	13.67	18.00	15.83	9.33	12.33	10.83	68.57	68.35	68.46	83.75	108.98	96.37	4.65	6.05	5.35
$CD_{(0.05)}$	**2.65**	**3.90**	**3.18**	**3.09**	**4.13**	**3.48**	**12.53**	**10.13**	**10.94**	**84.42**	**77.19**	**80.56**	**4.69**	**4.29**	**4.48**

$T_{1\ (Control)}$: 100% RDF through inorganic fertilizers (50 tonnes FYM, 80 kg N, 40 kg P, and 40 kg of K per hectare), **T_2**: 100% RDN through Jeevamrit, **T_3**: 100% RDN through Ghanjeevamrit, **T_4**: 100% RDN through Jeevamrit + Ghanjeevamrit in the ratio 1:1, **T_5**: 75% RDN through FYM + 25% RDN through Jeevamrit, **T_6**: 75% RDN through FYM + 25% RDN through Ghanjeevamrit, **T_7**: 75% RDN through FYM + 25% RDN through Jeevamrit + Ghanjeevamrit in the ratio 1:1, **T_8**: 50% RDN through FYM + 50% RDN through Jeevamrit, **T_9**: 50% RDN through FYM + 50% RDN through Ghanjeevamrit, **T_{10}**: 50% RDN through FYM + 50% RDN through Jeevamrit + Ghanjeevamrit in the ratio 1:1, **T_{11}**: Jeevamrit (500 litre/ ha) and **T_{12}**: Ghanjeevamrit (250 kg/ha)

Table 6. Fruit size, weight and TSS of strawberry as influenced by organic formulations

Treatment	Fruit length (cm)			Fruit breadth (cm)			Fruit weight (g)			TSS (˚Brix)		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T1	3.50	3.51	3.51	2.51	2.79	2.65	13.20	13.50	13.35	9.5	10	9.75
T2	3.48	3.50	3.49	2.21	2.69	2.45	13.75	14.55	14.15	10.2	9.5	9.83
T3	3.48	3.48	3.48	2.64	2.19	2.42	12.80	13.70	13.25	9.8	11	10.42
T4	3.51	3.53	3.52	2.36	2.69	2.53	14.54	14.32	14.43	9.0	9	9.00
T5	3.36	3.36	3.36	3.33	2.72	3.02	11.20	12.66	11.93	8.5	8.5	8.50
T6	3.35	3.35	3.35	3.42	2.59	3.00	11.39	11.94	11.66	7.8	7.5	7.67
T7	3.30	3.35	3.32	2.40	2.73	2.56	11.07	11.55	11.31	8.0	8.5	8.25
T8	3.18	3.17	3.18	2.59	2.52	2.55	10.00	9.63	9.81	8.0	9	8.50
T9	3.13	3.18	3.16	2.23	2.78	2.51	9.37	9.61	9.49	7.2	7.5	7.33
T10	3.08	3.16	3.12	2.57	2.54	2.55	9.20	9.47	9.34	8.2	8	8.08
T11	2.71	2.93	2.82	2.49	2.27	2.38	8.74	8.68	8.71	6.5	7.5	7.00
T12	2.96	2.98	2.97	2.58	2.16	2.37	8.99	8.87	8.93	6.2	7.5	6.83
$CD_{(0.05)}$	**NS**	**0.31**	**0.68**	**0.63**	**0.53**	**0.44**	**4.79**	**3.68**	**4.30**	**1.12**	**1.05**	**0.99**

$T_{1\ (Control)}$: 100% RDF through inorganic fertilizers (50 tonnes FYM, 80 kg N, 40 kg P, and 40 kg of K per hectare), **T_2**: 100% RDN through Jeevamrit, **T_3**: 100% RDN through Ghanjeevamrit, **T_4**: 100% RDN through Jeevamrit + Ghanjeevamrit in the ratio 1:1, **T_5**: 75% RDN through FYM + 25% RDN through Jeevamrit, **T_6**: 75% RDN through FYM + 25% RDN through Ghanjeevamrit, **T_7**: 75% RDN through FYM + 25% RDN through Jeevamrit + Ghanjeevamrit in the ratio 1:1, **T_8**: 50% RDN through FYM + 50% RDN through Jeevamrit, **T_9**: 50% RDN through FYM + 50% RDN through Ghanjeevamrit, **T_{10}**: 50% RDN through FYM + 50% RDN through Jeevamrit + Ghanjeevamrit in the ratio 1:1, **T_{11}**: Jeevamrit (500 litre/ ha) and **T_{12}**: Ghanjeevamrit (250 kg/ha)

Table 7. Titratable acidity and sugar content of strawberry as influenced by organic formulations

Treatment	Titratable acidity (%)			TSS/acid ratio			Total sugars (%)			Reducing sugars (%)		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1	0.43	0.32	0.38	22.52	31.05	26.78	5.96	5.87	5.91	3.66	3.53	3.59
T_2	0.37	0.36	0.36	28.82	27.36	28.09	6.01	5.73	5.87	3.71	3.52	3.62
T_3	0.35	0.38	0.37	28.92	29.55	29.24	6.11	6.17	6.03	3.77	3.76	3.77
T_4	0.40	0.32	0.36	22.47	28.59	25.53	6.00	5.86	5.93	3.73	3.55	3.64
T_5	0.37	0.38	0.37	24.15	23.84	23.99	6.07	5.98	6.03	3.74	3.61	3.68
T_6	0.42	0.37	0.39	19.01	20.99	20.00	6.02	5.93	5.97	3.74	3.46	3.60
T_7	0.42	0.36	0.39	19.25	23.76	21.51	5.87	6.05	5.96	3.77	3.66	3.72
T_8	0.35	0.32	0.33	22.86	28.80	25.83	6.07	5.79	5.93	3.64	3.69	3.66
T_9	0.37	0.33	0.35	19.66	23.00	21.33	5.89	5.72	5.92	3.72	3.46	3.59
T_{10}	0.29	0.37	0.33	28.16	21.83	24.99	6.01	5.56	5.78	3.72	3.51	3.61
T_{11}	0.22	0.38	0.30	29.30	20.03	24.66	6.00	5.59	5.80	3.56	3.41	3.49
T_{12}	0.22	0.41	0.32	27.85	18.70	23.28	5.80	5.93	5.86	3.57	3.95	3.76
$CD_{(0.05)}$	**0.04**	**0.05**	**0.04**	**6.81**	**6.76**	**6.75**	**0.21**	**0.01**	**0.17**	**0.09**	**0.20**	**0.16**

$T_{1\ (Control)}$: 100% RDF through inorganic fertilizers (50 tonnes FYM, 80 kg N, 40 kg P, and 40 kg of K per hectare), **T_2**: 100% RDN through Jeevamrit, **T_3**: 100% RDN through Ghanjeevamrit, **T_4**: 100% RDN through Jeevamrit + Ghanjeevamrit in the ratio 1:1, **T_5**: 75% RDN through FYM + 25% RDN through Jeevamrit, **T_6**: 75% RDN through FYM + 25% RDN through Ghanjeevamrit, **T_7**: 75% RDN through FYM + 25% RDN through Jeevamrit + Ghanjeevamrit in the ratio 1:1, **T_8**: 50% RDN through FYM + 50% RDN through Jeevamrit, **T_9**: 50% RDN through FYM + 50% RDN through Ghanjeevamrit, **T_{10}**: 50% RDN through FYM + 50% RDN through Jeevamrit + Ghanjeevamrit in the ratio 1:1, **T_{11}**: Jeevamrit (500 litre/ ha) and **T_{12}**: Ghanjeevamrit (250 kg/ha)

Table 8. Fruit quality parameters (physico-chemical) of strawberry as influenced by organic formulations

Treatment	Non-reducing sugars (%)			Anthocyanin content (mg/100g)			Ascorbic acid (mg/100g)			Total phenols (%)		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1	2.19	2.22	2.21	28.00	36.00	32.00	65.10	65.10	65.10	45.68	45.13	45.40
T_2	2.19	2.10	2.14	32.00	32.00	32.00	66.03	65.18	65.57	54.65	55.60	55.13
T_3	2.01	2.29	2.15	32.00	34.00	33.00	63.24	66.03	64.64	55.83	54.97	55.40
T_4	2.15	2.19	2.17	34.00	38.00	36.00	70.68	64.17	67.43	55.84	55.71	55.78
T_5	2.21	2.25	2.23	32.00	32.00	32.00	63.24	63.24	63.24	48.12	47.31	47.72
T_6	2.17	2.34	2.26	34.00	30.80	32.40	66.03	66.03	66.03	46.74	44.21	45.48
T_7	1.99	2.27	2.13	34.00	31.60	32.80	61.38	67.89	64.64	48.09	47.31	47.70
T_8	2.31	2.00	2.15	32.00	36.40	34.20	63.24	69.75	66.50	42.19	42.68	42.43
T_9	2.28	2.15	2.21	24.00	36.80	30.40	65.10	68.82	66.96	42.75	41.87	42.31
T_{10}	2.17	1.95	2.06	34.00	36.00	35.00	62.31	66.96	64.64	41.28	42.27	41.77
T_{11}	2.31	2.07	2.19	32.00	29.60	30.80	65.10	64.17	64.64	36.35	34.04	35.19
T_{12}	2.11	1.88	2.00	28.00	33.60	30.80	66.96	63.24	65.10	34.98	34.03	34.51
$CD_{(0.05)}$	**0.23**	**0.20**	**0.22**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**12.08**	**11.27**	**11.20**

$T_{1\ (Control)}$: 100% RDF through inorganic fertilizers (50 tonnes FYM, 80 kg N, 40 kg P, and 40 kg of K per hectare), T_2: 100% RDN through Jeevamrit, T_3: 100% RDN through Ghanjeevamrit, T_4: 100% RDN through Jeevamrit + Ghanjeevamrit in the ratio 1:1, T_5: 75% RDN through FYM + 25% RDN through Jeevamrit, T_6: 75% RDN through FYM + 25% RDN through Ghanjeevamrit, T_7: 75% RDN through FYM + 25% RDN through Jeevamrit + Ghanjeevamrit in the ratio 1:1, T_8: 50% RDN through FYM + 50% RDN through Jeevamrit, T_9: 50% RDN through FYM + 50% RDN through Ghanjeevamrit, T_{10}: 50% RDN through FYM + 50% RDN through Jeevamrit + Ghanjeevamrit in the ratio 1:1, T_{11}: Jeevamrit (500 litre/ ha) and T_{12}: Ghanjeevamrit (250 kg/ha)

DISCUSSION

Plant growth and chlorophyll content:

Various researchers showed increases in plant height, plant spread, number of leaves per plant, leaf size, leaf area, fresh weight of leaves and dry weight of leaves with the application of fertilizers and organic manure in strawberry plants [12, 24]. Increased nitrogen availability caused by nitrogen content in bioorganic nutrition sources may be the cause of the increase in leaf area. The inoculation of plant-beneficial bacteria through bioorganic nutrient sources in the root zone and the nitrogen content present in these sources may be the cause of the increase in vegetative growth and other metrics. The rhizosphere's microorganisms' synthesis of plant growth regulators may also have contributed to the rise in vegetative growth. The higher biological nitrogen fixation is what is responsible for the increased vegetative growth. Better growth metrics may have been caused by better root development caused by the production of plant growth hormones such IAA, GA and cytokinins [10, 14, 22]. Increased plant height and leaf count, which gathered more photosynthates, may be the cause of the increase in runners and leaf area per plant.

Flowering and fruiting:

During the course of the investigation, it was discovered that applying bioorganic nutrient sources had significantly increased the strawberry fruit yield. These results support various researchers who found that a combination of inorganic and organic sources of nutrients increased strawberry output [2, 11, 15]. Utilizing integrated nutrients speeds up the growth of the inflorescence and the number of leaves, which benefits the plants by increasing the number of flowers and fruits. The number of crowns per plant may have also been a factor in the increased quantity of blooms. Increased fruit set per plant and fruit weight may be to account for the increase in harvest.

Fruit quality:

During the course of the experiment, it was shown that various treatment combinations of bioorganic nutrition sources greatly boosted the physico-chemical parameters of strawberries. The rapid metabolic conversion of starch and pectin into soluble molecules and the rapid transport of sugars from leaves to growing fruits may be responsible for the increase in the physico-chemical characteristics of strawberries with the adoption of bioorganic nutrition management. Several workers have found an improvement in fruit quality metrics when organic sources of nutrients were used [5, 7, 17, 18, 20, 25]. The rise in ascorbic acid concentration could be attributed to the improved ability of microbial inoculants to fix atmospheric nitrogen, the expansion of the phosphorus supply and the release of growth-promoting substances that hastened physiological processes like the synthesis of carbohydrates, among other factors. The findings of Ahmadi and coauthors, Umar and coauthors, Kushwah and coauthors are analogous to those of these results [2, 23, 11].

CONCLUSION

The results of this study suggested that bioorganic formulations may be useful for enhancing crop performance. In this experiment, treatments with combined application 100% RDN through Jeevamrit + Ghanjeevamrit in the ratio 1:1 (T4) proved beneficial for raising the fruit quality indicators as compared to the recommended practices/ control treatment (T1). These treatments increased the quality of the fruit and the growth of the plants. The results showed how crucial bioorganic nutrient sources are, as well as the potential of Jeevamrit and Ghanjeevamrit as manure in the future as these inputs are economic and easily available with the smallholder farmers.

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