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Standardization of Organic Production of Strawberry (*Fragaria × ananassa*) cv. Winter dawn

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation was carried out at Horticultural Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj during the Winter season of 2022. The experiment was laid in Randomized block design with 3 replications and 10 treatments *viz.* Poultry manure (8t/ha), Vermicompost (10t/ha), FYM (25t/ha) each alone, then combined with vermiwash (50 L/ha) and with Cow Pat Pit manure (5 kg/ha) and Control. Results revealed that treatment T5 [Vermicompost (10 t/h) + vermiwash (50 L/ha)] was superior over all other treatments with respect to plant growth (plant height, plant spread and number of leaves), however T7 [Poultry manure (8 t/ha) + Cow Pat Pit manure (5 kg/ha)] was found the best in yield, quality, sensory parameters and benefit: cost ratio. Based on this experiment [Poultry manure (8 t/ha) + Cow Pat Pit manure (5 kg/ha)] can be suggested for increasing the yield and quality of organically grown strawberry cv. Winter dawn.

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1. INTRODUCTION

Strawberry *(Fragaria × ananassa* Duchesne ex Rozier) is one of the most popular soft fruits, which belong to Rosaceae family having chromosome number 2n= (8x) = 56. The strawberry we know today was first bred in Brittany, region of France, in the 1750s using a cross of *Fragaria virginiana* Mill*.* from eastern North America and *Fragaria chiloensis (L.) Mill.,* which was brought from Chile in 1714. The newly breed, *Fragaria × ananassa* has replaced the woodland strawberry (*Fragaria vesca L.*), which was the first strawberry species cultivated in the early 17th century. The fleshy fruit of strawberry is categorized as an aggregate fruit. It is an herbaceous annual plant and fruits are highly perishable and non-climacteric in nature. Strawberries are a great source of vitamins, manganese, potassium, fibre and carbohydrates. This fruit is widely appreciated for its characteristic aroma, bright red color, juicy texture, and sweetness. It is consumed in large quantities, either fresh or in prepared foods such as preserves, fruit juice, pies, ice creams, milkshakes, and other desserts [1].

'Winter dawn' is a short-day strawberry cultivar The upper leaf surface is dark grey green and the lower leaf surface is light grey green. Flowers open below the canopy, and have an average of 6 petals and 24 stamens. The preferred planting date for 'Winter dawn' is September 20 to October 5 in North Indian plain. It is moderately resistant to the two most serious disease problems on strawberry. Botrytis fruit rot (caused by *Botrytis cinerea* Pers.) and anthracnose fruit rot (caused by *Colletotrichum sp.* Simmonds).

Cow Pat Pit Manure is a biodynamic manure which is a strong soil conditioner as it enhances seed germination, promotes rooting in cutting and grafting, improvement in soil texture, provide resistance power to plant against pest and diseases. It mainly contained plant growth hormones such as Indole Acetic Acid (28.6 mg/kg), Kinetin (7.6mg/kg) and Gibberellic acid (23.6mg/kg). Mainly prepared by cow manure mixed with crushed egg shell and basalt dust, then put into a 12-inch-deep pit lined with bricks. The dung is fermented, together with the preps 502-507, for a period of 3 to 4 months. It is applied in the evenings during the cooler months. It also contains a wide range of beneficial fungi and bacteria, which can be very helpful in many areas of agriculture and horticulture [2].

Farm yard manure (FYM) refers to the decomposed mixture of dung and urine of farm animals along with litter and left over material from roughages or fodder fed to the cattle. On an average well decomposed farm yard manure contains 0.5 percent N, 0.2 percent P_20_5 and 0.5 percent K_2O. The art of collecting and using wastes from animal and vegetable sources for improving crop productivity is as old as agriculture. FYM with low nutrient, content per unit quantity have longer residual effect besides improving soil physical properties compared to fertilizer with high nutrient content [3].

Poultry manure is the faeces of chickens used as an organic fertiliser, particularly for nitrogen-deficient soil. It contains the most nitrogen, phosphorus, and potassium of any animal manure. It is occasionally pelletized for use as a fertiliser, and this product may contain additional phosphorus or potassium. Optimal storage conditions for chicken manure include keeping it covered and retaining its liquid. Fresh poultry manure has a potassium content of 0.8 per cent, a phosphorus content of 0.4 per cent to 0.5 per cent, and a nitrogen content of 0.9 per cent to 1.5 per cent. Each chicken produces about 3-4 kg of manure per month (Biradarar et al. 2018).

Vermicompost is an organic manure which has porous structure, provides aeration to the soil, increases the water holding capacity, is rich in plant nutrients, has a low carbon level, and increases the microbial activity on the soil surface by providing a slow release of nutrients to the plants, enabling them to be taken up more effectively by the plants. They contain plant growth regulators and other plant growth influencing materials produced by microorganisms. It contains 0.5%-1.50% nitrogen, 0.1%-0.30% available phosphorus and 0.15%-0.56% potassium [4].

Vermiwash is a liquid manure, extracted in the presence of earthworms that contains several enzymes, plant growth hormones, vitamins, and micro and macronutrients that increase crop resistance to various diseases and improve crop growth and productivity. Vermiwash contain a variety of nutrients, including soluble K, Ca, and Mg, which make their way into vermiwash. Plant growth hormones (auxins and cytokinins) are also present, as are nitrate fixing bacteria and phosphorus solubilizing bacteria. It contains 0.01 per cent nitrogen, 1.69 per cent available phosphorus, 25 ppm potassium [5].

2. MATERIALS AND METHODS

The field experiment was conducted during Rabi season of 2022-23 at Department of Horticulture, Sam Higginbottom University of Agriculture Technology and Sciences, (SHUATS), Prayagraj, Uttar Pradesh, India. The experimental site is situated at $20^{o}15^{'}$ latitude and longitude of 60^{0} 3' East and at an altitude of 98 meters above mean sea level (MSL). Minimum temperature ranged from 6^{0} - 8^{0}C (during Nov - Feb) and maximum temperature ranged from 45^{o} - 48^{o} C (during March - June). The soil was sandy loam in texture having a pH (7.3), EC (0.48), organic carbon (0.46%), available N (207.56 kg/ ha), P (15.36 kg/ ha) and K (219 kg/ ha). Winter dawn cultivar with uniform sized strawberry runners were planted during November 2022, maintaining a spacing of 30 X 30 cm. The recommended package of practices was followed for raising the successful crop, data on plant growth fruit yield and quality of strawberry characters were recorded when the plants were fully grown. Irrigation was scheduled at 10 days interval during vegetative growth and total of 6-8 irrigations were applied at critical stages of the crop. However other normal cultural practices were followed timely.

The experiment was laid out in Randomized Block Design (RBD), with 10 treatments replicated threefold. Treatment was randomly arranged in each replication, with plot size of 2m×1m. Nine treatments combinations, comprising: T_1 [Poultry Manure (8t/ha)], T_2 [Vermicompost (10t/ha)], T_3 [FYM (25t/ha)], T_4 [Poultry Manure (8t/ha) + Vermiwash (50 L/ha)], T_5 [Vermicompost (10t/ha) + Vermiwash (50L/ha)], T_6 [FYM (25t/ha) + Vermiwash(50 L/ha)], T_7 [Poultry Manure (8t/ha) + Cow Pat Pit Manure (5 kg/ha)], T_8 [Vermicompost (10t/ha) + Cow Pat Pit Manure (5 kg/ha)], T_9 [FYM (25t/ha) + Cow Pat Pit Manure (5 kg/ha)], T_{10} Control. Parameters data were recorded at 30, 60, 90 and 120 days after planting (DAP).

3. RESULTS AND DISCUSSION

3.1 Effect of Different Organic Manures on Growth Parameter of Strawberry (*Fragaria x ananassa*) cv. Winter dawn

3.1.1 Plant height

The perusal of the data in Table 1 revealed the significant effect of different organic manure on Plant height of Strawberry (*Fragaria ananassa*) cv. Winter dawn at different days interval (30, 60, 90, 120 days after planting, DAP). Maximum plant height was produced in T_5 [Vermicompost (10t/ha) + Vermiwash (50 L/ha)] at 30, 60, 90 and 120 days after planting, reaching 22,14 cm in 120 days. Which was on par with T_2 [Vermicompost (10t/ha)] with 20.47 cm, and T_1 [Poultry Manure(8t/ha)] with 19.49 cm. Minimum plant height of 12.47 cm was recorded under T_{10} [Control]. Nutrition is one of the most important parts of crop production and accounts for around one third of the total cost of production among the different factors that affect strawberry development. Vermicompost boosted the number of roots which improved nutrient intake and plant growth and development. The altered physiochemical and microbiological features of the soil, as well as the enhanced availability of macro and micronutrient elements, may be the cause of vermicompost's potential to improve plant growth [6]. Here it is clearly visible that the effect of T_5 [Vermicompost (10t/ha) + Vermiwash (50L/ha)] increased the plant height compared to other treatments.

3.1.2 Plant spread

The perusal of the data in Table 2 revealed the significant effect of different organic manure on Plant spread of Strawberry (*Fragaria ananassa*) cv. Winter dawn at different days interval (30, 60, 90, 120 days after planting). Maximum plant spread was as plant height along the different DAP evaluated, reaching the maximum in T_5 [Vermicompost (10t/ha) + Vermiwash (50L/ha)] which was of 26.20 and 26.50 cm at 120 DAP according orientation East-West and North-South respectively. Minimum plant spread was recorded in T_{10} (control) which was 18.26 cm in East- West and 18.30 cm in North- South. Vermiwash plays an important role in the plant growth and development; contribute to initiation of rooting, root growth, plant development, promotion of growth rate and improvement in crop production by increasing the soil organic matter and increasing the nutrient content which are readily available for the plants, resulting in good crop yield. Vermicompost with vermiwash increase the plant spread and the similar result was found in by Esakkiammal et al. [7].

3.1.3 Number of leaves per plant

The perusal of the data in Table 3 revealed that maximum number of leaves was as plant height and plant spread along the different DAP evaluated, reaching the maximum in T_5 [Vermicompost (10t/ha) + Vermiwash (50L/ha)]

and T_3 [FYM (25t/ha)] which was 40.22 at 120 DAP which was on par with T_7 (P.M (8t/ha) + Cow Pat Pit Manure (5 kg/ha)) having 34.95 leaves. Minimum Number of leaves 30.96 was recorded in T_{10} (control) The excellent plant growth in vermicompost was possible due to some plant growth promoters in worm casts. The earthworm casts in vermicompost influence the development of the plants and promote leaf length, root length and number of leaves, which suggest the linkage between biological effects of vermicompost and microbial metabolites that influence the plant growth and development. Similar result was found in a study carried out by Tomati and Galli [8].

3.1.4 Fruit length

From the data given in Table 4, it is clearly evident that maximum fruit length was recorded in T_7 [Poultry Manure (8t/ha) + Cow Pat Pit Manure (5 kg/ha)] which had 5.66 cm and it was on par with T_8 [Vermicompost (10t/ha) + Cow Pat Pit Manure (5 kg/ha)] which had a fruit length (5.26 cm). Minimum fruit length was recorded with T_{10} (control) which was 3.46 cm.

3.1.5 Fruit diameter

Data given in Table 4 clearly revealed that maximum fruit diameter was recorded in T_7 [Poultry Manure (8t/ha) + Cow Pat Pit Manure (5 kg/ha)] (1.60 cm) which was on par with T_8 [Vermicompost (10t/ha) + Cow Pat Pit Manure (5 kg/ha)] which was 1.43 cm. Minimum fruit diameter of 0.50 cm was recorded under treatment T_{10} (control).

3.1.6 Weight of fruit

From the data given in Table 4, maximum fruit weight (28g) was recorded in T_7 [Poultry Manure (8t/ha) + Cow Pat Pit Manure (5 kg/ha)] which was on par with T_8 [Vermicompost (10t/ha) + Cow Pat Pit Manure (5 kg/ha)] which was 25.83 g. Minimum fruit weight was recorded in treatment T_{10} (control) with 10.46 g.

Perumal et al. [9] found in a study that cow pat pit manure contains plant growth hormone such as indole acetic acid IAA (28.6 mg kg^{-1}), kinetin (7.6 $mgkg^{-1}$) and gibberellic acid (23.6 mg kg^{-1}) which might have influenced the fruit parameters in strawberry.

3.2 Effect of Different Organic Manure on Yield Parameters of Strawberry (*Fragaria x ananassa*) cv. Winter dawn

3.2.1 Number of flowers per plant

The corresponding data on number of flowers per plant of different treatment combinations are presented in Table 5. It is evident from the statistical analysis that during investigation, number of flowers per plant was recorded more in plants treated with treatment T_7 [Poultry Manure (8t/ha) + Cow Pat Pit Manure (5 kg/ha)] had maximum number of flowers per plant (14.63) which was on par with T_8 [Vermicompost (10t/ha) + Cow Pat Pit Manure (5 kg/ha)] with 14.13 flower per plant. The minimum number of flowers per plant was recorded in T_{10} (control) which had 6.96 flowers.

3.2.2 Yield of fruits per plant

The relevant data pertaining to yield of fruit per plant are presented in Table 5. It is obvious from the data that the various nutritional treatments given to strawberry plants had significant effect on yield of fruits per plant. The maximum yield of 81.33 g was recorded in treatment T_7 [Poultry Manure (8t/ha) + Cow Pat Pit Manure (5 kg/ha)] which was on par with T_8 [Vermicompost (10t/ha) + Cow Pat Pit Manure (5 kg/ha)] and T_1 [Poultry Manure (8t/h)] with a value of 78.46 g and 78.20 g respectively. Minimum yield per plant was recorded in T_{10} (control) which was 42.63 g.

3.2.3 Yield of fruits per plot

From the data given in the Table 5, the maximum yield per plot of 545 g was recorded in T_7 [Poultry Manure (8t/ha) + Cow Pat Pit Manure (5 kg/ha)] which was at par with T_8 [Vermicompost (10t/ha) + Cow Pat Pit Manure (5 kg/ha)] and T_1 [Poultry Manure (8t/h)] with 509.66 g and 493.33 g respectively. Minimum yield per plant was recorded in T_{10} (control) which had 278.33 g fruit yield per plot.

3.2.4 Yield of fruits per hectare

Data pertaining to yield per hectare of different treatment combinations have been presented in Table 5. Data clearly revealed that maximum yield per hectare of 67.76 q/ha was recorded in T_7 [P.M (8t/ha) + Cow Pat Pit Manure (5 kg/ha)] which was on par with T_8 [Vermicompost (10t/ha) + Cow Pat Pit Manure (5 kg/ha)] with 65.60 q/ha. Minimum yield per plant was recorded in T_{10} (control) which had a yield of 47.33 q/ha.

Perumal et al. [9] found in a study that cow pat pit manure contains plant growth hormone such as indole acetic acid IAA (28.6 mg kg^{-1}), kinetin (7.6 $mgkg^{-1}$) and gibberellic acid (23.6 mg kg^{-1}) which might have influenced the yield parameters in strawberry.

3.3 Effect of Different Organic Manures on Quality Parameters of Strawberry (*Fragaria x ananassa*) cv. Winter dawn

3.3.1 Total soluble solids (T S S) (^{0}Brix)

The relevant data pertaining to TSS are presented in Table 6. Statistical analysis has revealed significant differences among the treatments. Data given in Table clearly revealed that maximum TSS was recorded in T_7 [Poultry Manure (8t/ha) + Cow Pat Pit Manure (5 kg/ha)] with 8.98^0B which was on par with T_8 [Vermicompost (10t/ha) + C.P.P. (5 kg/ha)] with 8.48^0B and T_1 [Poultry Manure (8t/h)] with 8.33^0B. The minimum TSS 4.73^0B was recorded in treatment T_{10} (control)

3.3.2 pH value

The relevant data are presented in Table 6. Statistical analysis has shown significant differences among the treatments. The maximum pH (4.50) was recorded in T_7 [Poultry Manure (8t/ha) + Cow Pat Pit Manure (5 kg/ha)] which was on par with T_8 [Vermicompost (10t/ha) + Cow Pat Pit Manure (5 kg/ha)] with a pH of 4.23 and T_1 [Poultry Manure (8t/ha)] with a pH of (4.10). Minimum pH of 3.66 was recorded in treatment T_{10} (control).

3.3.3 Acidity (%)

The relevant data are presented in Table 6. Statistical analysis has shown significant differences among the treatments. The minimum acidity of 0.43 % was recorded in T_7 [Poultry Manure (8t/ha) + Cow Pat Pit Manure (5 kg/ha)] which was on par with T_8 [Vermicompost (10t/ha) + Cow Pat Pit Manure (5 kg/ha)] with an acidity of 0.44 % and T_1 [Poultry Manure (8t/ha)] with 0.47. Maximum acidity of 0.86% was recorded in treatment T_{10} (control).

3.4 Ascorbic Acid Quantity (mg/100g)

The data given in Table 6 revealed that maximum ascorbic acid 59.30mg/100g was recorded in T_7 [Poultry Manure (8t/ha) + Cow Pat Pit Manure (5 kg/ha)] which was on par with T_8 [Vermicompost (10t/ha) + Cow Pat Pit Manure (5 kg/ha)] with 59.13mg/100g and T_1 [Poultry Manure (8t/ha)] which had 58.83mg/100g. The minimum ascorbic acid of 53.13 mg/100g was recorded in treatment T_{10} (control).

Perumal et al. [9] reported that cow pat pit manure contains plant growth hormone such as indole acetic acid IAA (28.6 mg kg^{-1}), kinetin (7.6 mg kg^{-1}) and gibberellic acid (23.6 mg kg^{-1}) which led to the enhanced quality parameters in strawberry.

3.5 Sensory Evaluation: Effect of Different Organic Manures on Organoleptic Feature of Strawberry (*Fragaria* x *ananassa*) Fruit

3.5.1 Fruit colour

The relevant data are presented in Table 7. Statistical analysis has shown significant differences among the treatments. The data given in table revealed that maximum colour score (8.33) was recorded in T_7 [Poultry Manure (8t/ha) + Cow Pat Pit Manure (5 kg/ha)] which was on par with T_8 [Vermicompost (10t/ha) + Cow Pat Pit Manure (5 kg/ha)] and T_1 [Poultry Manure (8t/ha)] which had a score of 8.06 and 7.83 respectively. The minimum was recorded in treatment T_{10} (control) with a score of 6.20.

3.5.2 Fruit aroma

The data given in Table 7 revealed that maximum aroma score of 8.96 was recorded in T_7 [Poultry Manure (8t/ha) + Cow Pat Pit Manure (5 kg/ha)] which was on par with T_8 [Vermicompost (10t/ha) + Cow Pat Pit Manure (5 kg/ha)] and T_1 [Poultry Manure (8t/ha)] with a aroma score of 8.70 and 8.66. The minimum aroma score of 6.63 was recorded in treatment T_{10} (control).

3.5.3 Fruit taste

The data given in Table 7 revealed that maximum taste score (8.96) was recorded in T_7 [Poultry Manure (8t/ha) + Cow Pat Pit Manure (5 kg/ha)] which was on par with T_8 [Vermicompost (10t/ha) + Cow Pat Pit Manure (5 kg/ha)] and T_1 [Poultry Manure (8t/ha)] which had a score of 8.80 and 8.50. The minimum taste score of 6.50 was recorded in treatment T_{10} (control).

3.5.4 Overall acceptability

The data given in Table 7 revealed that the maximum overall acceptability score of 8.83 was recorded in T_7 [Poultry Manure (8t/ha) + Cow Pat Pit Manure (5 kg/ha)] which was on par with T_8 [Vermicompost (10t/ha) + Cow Pat Pit Manure (5 kg/ha)] and T_1 [Poultry Manure (8t/ha)] which had score 8.63 and 8.60. The minimum score of 6.93 was recorded in treatment T_{10} (control).

Perumal et al. [9] found in a study that cow pat pit manure contains plant growth hormone such as indole acetic acid IAA (28.6 mg kg^{-1}), kinetin (7.6 $mgkg^{-1}$) and gibberellic acid (23.6 mg kg^{-1}) which might have influenced the sensory parameters in strawberry.

4. ECONOMICAL PARAMETERS

B:C Ratio

The B:C ratio recorded under the different treatments was statistically analysed and is being presented in Table 8.

The maximum B:C ratio (3.19) was recorded in T_7 [Poultry Manure (8t/ha) + Cow Pat Pit Manure (5 kg/ha)] minimum B:C ratio (2.42) was recorded in treatment T_{10} (control) [10].

Table 1. Effect of different organic manures on plant height of strawberry (*Fragaria* x *ananassa*) cv. Winter dawn

Treatment	Treatment Combination	Plant height (cm)			
		30 DAP	60 DAP	90 DAP	120 DAP
T1	PM (8t/ha)	6.42	8.48	15.73	19.49
T2	VC (10t/ha)	6.50	8.5	16.76	20.47
T3	FYM (25t/ha)	6.18	7.96	13.45	16.79
T4	P M (8t/ha) + VW (50L/ha)	6.17	8.07	13.35	16.95
T5	VC (10t/ha) + VW (50L/ha)	7.50	9.50	17.81	22.14
T6	FYM (25t/ha) + VW (50L/ha)	5.80	8.12	13.03	16.11
T7	PM (8t/ha) + CPP (5 kg/ha)	5.75	8.31	14.64	18.27
T8	VC (10t/ha) + CPP (5 kg/ha)	5.61	8.31	13.91	18.46
T9	FYM (25t/ha) + CPP (5 kg/ha)	6.33	8.37	14.23	19.18
T10	Control	5.07	6.14	9.83	12.47
F-test		S	S	S	S
CD (5%)		1.46	1.99	2.45	2.79
SE(d)		0.66	0.94	1.15	1.32
C.V.		13.36	14.21	9.94	8.96

Note: Cow Pat Pit manure= CPP; Poultry manure = PM; Vermicompost= VC; Vermiwash= VW; DAP= days after planting

Table 2. Effect of different organic manures on plant spread of strawberry (*Fragaria* x *ananassa*) cv. Winter dawn

Treatment	Treatment Combination	Plant spread (cm)							
		30 DAP		60 DAP		90 DAP		120 DAP	
		E-W	N-S	E-W	N-S	E-W	N-S	E-W	N-S
T1	PM (8t/ha)	15.06	14.06	15.83	16.00	19.60	19.23	22.36	23.06
T2	VC (10t/ha)	15.56	14.33	16.86	16.40	20.40	20.83	25.13	25.23
T3	FYM (25t/ha)	13.33	12.56	14.90	15.73	18.86	19.70	22.20	22.93
T4	PM (8t/ha) + VW (50L/ha)	14.93	14.23	16.06	16.16	19.50	19.70	21.76	20.73
T5	VC (10t/ha) + VW (50L/ha)	15.90	15.00	17.46	17.26	21.90	22.56	26.20	26.50
T6	FYM (25t/ha) + VW (50L/ha)	14.20	13.73	15.50	15.73	17.63	17.93	22.66	22.66
T7	PM (8t/ha) + CPP (5 kg/ha)	12.73	11.96	14.36	14.16	17.30	17.40	22.16	22.56
T8	VC (10t/ha) + CPP (5 kg/ha)	13.66	13.66	15.53	15.20	16.56	16.66	20.86	21.06

		Plant spread (cm)							
Treatment	**Treatment Combination**	**30 DAP**		**60 DAP**		**90 DAP**		**120 DAP**	
		E-W	**N-S**	**E-W**	**N-S**	**E-W**	**N-S**	**E-W**	**N-S**
T9	FYM (25t/ha) + CPP (5 kg/ha)	10.90	10.60	13.36	13.10	16.40	16.56	20.20	20.50
T10	Control	8.96	9.03	11.80	11.30	14.26	14.86	18.26	18.30
F-test		S	S	S	S	S	S	S	S
CD (5%)		2.29	1.33	1.90	1.36	1.38	1.38	2.27	2.05
SE(d)		1.08	0.62	0.90	0.64	0.65	0.65	1.07	0.97
C.V.		9.79	5.96	7.26	5.23	4.39	4.33	5.92	5.32

Note: Cow Pat Pit manure= CPP; Poultry manure = PM; Vermicompost= VC; Vermiwash= VW; DAP= days after planting; E-W= East-West; N-S= North-South

Table 3. Effect of different organic manures on number of leaves per plant of strawberry (*Fragaria* x *ananassa*) cv. Winter dawn

Treatment	**Treatment Combination**	**Number of leaves per plant**			
		30 DAP	**60 DAP**	**90 DAP**	**120 DAP**
T1	PM (8t/ha)	13.55	19.00	26.27	31.72
T2	VC (10t/ha)	14.33	21.44	27.83	33.37
T3	FYM (25t/ha)	12.55	18.05	23.66	40.22
T4	P M (8t/ha) + VW (50L/ha)	13.05	18.77	24.44	33.37
T5	VC (10t/ha) + VW (50L/ha)	15.55	21.83	28.16	40.22
T6	FYM (25t/ha) + VW (50L/ha)	12.11	17.05	25.88	33.27
T7	PM (8t/ha) + CPP (5 kg/ha)	13.17	18.97	25.38	34.95
T8	VC (10t/ha) + CPP (5 kg/ha)	11.55	16.05	23.44	32.05
T9	FYM (25t/ha) + CPP (5 kg/ha)	13.55	18.44	25.33	33.5
T10	Control	11.14	16.18	22.78	30.96
F-test		S	S	S	S
CD (5%)		3.79	4.46	5.63	5.55
SE(d)		1.8	2.12	2.68	2.62
C.V.		16.92	13.98	12.96	9.31

Note: Cow Pat Pit manure= CPP; Poultry manure = PM; Vermicompost= VC; Vermiwash= VW; DAP= days after planting

Table 4. Effect of different organic manures on fruit parameters of strawberry (*Fragaria* x *ananassa*) cv. Winter dawn

Treatment	**Treatment Combination**	**Fruit length (cm)**	**Fruit diameter (cm)**	**Weight of fruit (g)**
T1	PM (8t/ha)	4.86	1.16	21.30
T2	VC (10t/ha)	4.20	1.30	17.53
T3	FYM (25t/ha)	4.73	1.03	16.83
T4	P M (8t/ha) + VW (50L/ha)	3.56	1.26	19.16
T5	VC (10t/ha) + VW (50L/ha)	3.93	0.97	18.66
T6	FYM (25t/ha) + VW (50L/ha)	3.73	1.38	18.60
T7	PM (8t/ha) + CPP (5 kg/ha)	5.66	1.60	28.00
T8	VC (10t/ha) + CPP (5 kg/ha)	5.26	1.43	25.83
T9	FYM (25t/ha) + CPP (5 kg/ha)	4.03	1.03	13.10
T10	Control	3.46	0.50	10.46
F-test		S	S	S
CD (5%)		1.08	0.49	3.89
SE(d)		0.51	0.23	1.83
C.V.		14.48	24.69	11.87

Note: Cow Pat Pit manure= CPP; Poultry manure = PM; Vermicompost= VC; Vermiwash= VW

Table 5. Effect of different organic manure on yield parameters of strawberry (*Fragaria* x *ananassa*) cv. Winter dawn

Treatment	Treatment Combination	Number of flowers per plant	Yield of fruits per plant (g)	Yield of fruits per plot (g)	Yield of fruits per hectare (q/ha)
T1	PM (8t/ha)	11.40	78.20	493.33	63.36
T2	VC (10t/ha)	12.30	69.00	413.66	61.86
T3	FYM (25t/ha)	9.56	75.66	370.33	62.63
T4	P M (8t/ha) + VW (50L/ha)	9.50	58.20	398.33	61.90
T5	VC (10t/ha) + VW (50L/ha)	10.43	65.50	489.33	63.30
T6	FYM (25t/ha) + VW (50L/ha)	11.63	67.00	430.00	61.10
T7	PM (8t/ha) + CPP (5 kg/ha)	14.63	81.33	545.00	67.76
T8	VC (10t/ha) + CPP (5 kg/ha)	14.13	78.46	509.66	65.60
T9	FYM (25t/ha) + CPP (5 kg/ha)	9.00	68.76	310.00	61.43
T10	Control	6.96	42.63	278.33	47.33
F-test		S	S	S	S
CD (5%)		2.25	4.98	78.47	2.66
SE(d)		1.06	2.35	37.82	1.25
C.V.		11.87	4.21	10.93	2.50

Note: Cow Pat Pit manure= CPP; Poultry manure = PM; Vermicompost= VC; Vermiwash= VW

Table 6. Effect of different organic manures on quality parameters of strawberry

Treatment	Treatment Combination	TSS (^{0}Brix)	pH	Acidity (%)	Ascorbic acid(mg/100g)
T1	PM (8t/ha)	8.33	4.10	0.47	58.83
T2	VC (10t/ha)	7.47	3.86	0.69	57.86
T3	FYM (25t/ha)	6.42	3.93	0.59	57.03
T4	P M (8t/ha) + VW (50L/ha)	6.90	3.90	0.50	56.50
T5	VC (10t/ha) + VW (50L/ha)	7.09	3.80	0.51	54.83
T6	FYM (25t/ha) + VW (50L/ha)	7.55	3.93	0.60	55.86
T7	PM (8t/ha) + CPP (5 kg/ha)	8.98	4.50	0.43	59.30
T8	VC (10t/ha) + CPP (5 kg/ha)	8.48	4.23	0.44	59.13
T9	FYM (25t/ha) + CPP (5 kg/ha)	5.72	3.93	0.75	54.00
T10	Control	4.73	3.66	0.86	53.13
F-test		S	S	S	S
CD (5%)		0.92	0.47	0.17	0.88
SE(d)		0.43	0.22	0.08	0.41
C.V.		7.49	6.88	17.34	0.90

Note: Cow Pat Pit manure= CPP; Poultry manure = PM; Vermicompost= VC; Vermiwash= VW

Table 7. Effect of different organic manures on sensory evaluation of strawberry

Treatment	Treatment Combination	Colour	Aroma	Taste	Overall acceptability
T1	PM (8t/ha)	7.83	8.66	8.50	8.60
T2	VC (10t/ha)	7.26	8.60	8.13	8.56
T3	FYM (25t/ha)	6.96	7.26	7.20	7.36
T4	P M (8t/ha) + VW (50L/ha)	6.83	7.30	7.23	7.46

Treatment	Treatment Combination	Colour	Aroma	Taste	Overall acceptability
T5	VC (10t/ha) + VW (50L/ha)	6.93	7.46	7.36	7.53
T6	FYM (25t/ha) + VW (50L/ha)	6.96	7.63	7.50	7.83
T7	PM (8t/ha) + CPP (5 kg/ha)	8.33	8.96	8.96	8.83
T8	VC (10t/ha) + CPP (5 kg/ha)	8.06	8.70	8.80	8.63
T9	FYM (25t/ha) + CPP (5 kg/ha)	6.76	6.86	6.76	6.76
T10	Control	6.20	6.63	6.50	6.93
F-test		S	S	S	S
CD (5%)		1.13	0.84	1.03	0.83
SE(d)		0.53	8.60	0.48	0.39
C.V.		9.10	7.26	7.75	6.13

Note: Cow Pat Pit manure= CPP; Poultry manure = PM; Vermicompost= VC; Vermiwash= VW

Table 8. B: C ratio of different treatments in organic production of strawberry

Treatment	Treatment Combination	B:C Ratio
T1	PM (8t/ha)	3.00
T2	VC (10t/ha)	2.52
T3	FYM (25t/ha)	2.84
T4	P M (8t/ha) + VW (50L/ha)	2.90
T5	VC (10t/ha) + VW (50L/ha)	2.55
T6	FYM (25t/ha) + VW (50L/ha)	2.74
T7	PM (8t/ha) + CPP (5 kg/ha)	3.19
T8	VC (10t/ha) + CPP (5 kg/ha)	2.66
T9	FYM (25t/ha) + CPP (5 kg/ha)	2.77
T10	Control	2.42

Note: Cow Pat Pit manure= CPP; Poultry manure = PM; Vermicompost= VC; Vermiwash= VW

5. CONCLUSION

From the present experiment, it is concluded that treatment T_5 [Vermicompost (10t/ha) + Vermiwash (50L/ha)] performed the best in terms of growth (plant height, plant spread and number of leaves). However, in terms of yield, quality (TSS, pH, acidity, ascorbic acid) and organoleptic parameters, treatment- T_7 [Poultry Manure (8t/ha) + Cow Pat Pit Manure (5 kg/ha)] was superior compared to other treatments.

The highest B:C ratio of 3.19 was also found in treatment T_7 [Poultry Manure (8t/ha) + Cow Pat Pit Manure (5 kg/ha)]. Therefore, based on present study, organic production of strawberry with poultry manure and cow pat pit manure can enhance the production.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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