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Influence of organic amendments on growth, yield, fruiting and nutritional status of kiwifruit vineyard

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ABSTRACT

The increasing cost of fertilizers and growing ecological concerns have created considerable interest in using organics as a source of plant nutrients and boosting microbial activities. The present study was carried out to elucidate the effects of different organic manures viz; Farmyard manure (FYM), Vermicompost (VC) and Poultry manure on vine growth, yield, fruit quality characteristics and nutrient uptake of kiwifruit. The experiment consisted of eight treatments wherein different organic manures with sole and conjoint applications were applied to the experimental vines. In addition to the abovementioned treatments, common treatments of two liquid manures, namely, Panchgavya (5%) and Jeevamrit and soil application of neem cake @ 1 kg/vine, were also given. The effects of different organic treatments were compared with standard recommended doses of inorganic fertilizers (RDF). The results revealed variable responses of different organic amendments concerning growth yield and fruit quality characteristics at harvest and after 10 days of storage at ambient temperature. The leaf area, chlorophyll content, yield and physical parameters, namely; fruit dimensions and fruit weight, were recorded to be the highest with RDF and FYM. However, improvement in fruit quality parameters, namely, TSS content, ascorbic acid and TSS acid ratio, was noticed with the sole application of vermicompost. The total sugars content and leaf macronutrient uptakes were highest with the combined application of FYM and VC (50:50).

Keywords: *Actinidia deliciosa* Chev., FYM; Poultry manure; Vermicompost

INTRODUCTION

The kiwifruit (*Actinidia deliciosa* Chev.) is native to China, however, its cultivation has been exploited commercially by the new-Zealanders. In India, it gained enormous popularity during the last two decades due to its potential health benefits and rich source of vitamin C coupled with properties like lowering of blood lipids and improved gastrointestinal laxation (Singletary, 17). The area under kiwifruit cultivation in India is 4,000 ha with an annual production of 12,000 metric tonnes (Anonymous, 2). As the apple has revolutionized the economy of farmers in higher hills, it is a boon for the farmer of mid-hills.

The kiwifruit is a nutrients exhaustive crop and outflow of the nutrient is much higher due to higher yields coupled with removal of biomass during summer and winter pruning (Rana and Gitesh, 13). Thus, the nutrient requirement for optimum vegetative growth and quality fruit production is an important consideration. The conventional farming system involves enormous use of chemicals which has resulted into degraded soil health. On the contrary, organic fruit production technology has gained momentum in the recent years both in terms of consumer demand and as a genuine desire of many fruit orchardists to sustain crop production and soil health (Rezaei-Chiyaneh *et al.,* 15). Organic approach in kiwifruit is of paramount importance as there are very few insects, pests and diseases that cause major problems

Organic farming technology solely depends on the use of crop residues, animal manures, green manures and off-farm wastes to maintain soil productivity (Palaniappan and Annadurai, 12). Hence, there is an urgent need to explore the different sources of organic manures like farmyard manure (FYM); vermicompost (VC); Poultry manure (PM); Neem cake and liquid formulations namely; Panchgavya and Jeevamrit. The FYM is most commonly used organic manure which not only supplies nitrogen (N), phosphorus (P) and potassium (K) but also improves the physical, chemical and biological health of soil. Vermicompost is a stable fine granular organic matter, which loosens the soil and provides passage for air, besides the nutrients supplementation. Poultry manure is considered as a store house of nutrients, containing twice as much N and 3-4 times more P as that of FYM. The Neem cake is a by-product of neem seeds after removing the oil, which kills root nematodes and lessens the insect attack. Among liquid organic formulations,

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Panchagavya represents a combination of five products obtained from cow. Panchagavya (3-5%) can be applied as foliar spray, soil application or seedling treatment. Jeevamrit is an another organic liquid manure which is obtained from the mixture of desi cow dung, cow urine, jaggery, green or black gram flour and forest soil. It has been reported to promote growth, flowering and yield of horticultural crops (Chandra and Kadian, 4). Keeping in view the demand of organic kiwifruit, the present study was made to identify the best source of nutrients for the organic production of this berry under Indian conditions.

MATERIALS AND METHODS

The present investigation was carried out in the experimental block of Department of Fruit Science, Dr YSP University of Horticulture and Forestry, Nauni, Solan (HP) during the year 2017-18. The region falls under sub-temperate, mid hills agro-climatic zone of Himachal Pradesh with an average annual precipitation of 1130.30 mm. The top soil (0–20 cm depth) has a pH of 6.75 and contains 0.82 per cent organic carbon. The available N, P, K contents of the experimental orchards were 250.55 kg/ha, 40.00 kg/ha, 260.35 kg/ha, respectively. The experiment was carried out on eight year-old vines of 'Allison' kiwifruit planted at a spacing of 4.0 m × 6.0 m. The experiment comprised of eight treatments with three replications. Straight fertilizers (urea:46% N, SSP:16% P, MOP:60%) were applied as standard recommended dose of fertilizers (RDF) as suggested by (Chadha, 4). On the basis of testing before layout of research trial, the farm yard manure (FYM) contained 0.5% N 0.25%, P and 0.5% K; vermicompost (VC) contained 3.05% N, 2.0% P and 0.5% K and poultry manure (PM) contained 2.05% N, 1.5% P and 1.0% K.

The treatment combination consisted of T_1:sole (100%) N through FYM; T_2:sole (100%) N through VC; T_3:sole (100%) N through PM; T_4:N application through equal proportions of FYM and PM (50:50) ; T_5:N application through equal proportions of FYM and VC (50:50); T_6: N application through equal proportion of PM and VC (50:50); T_7: N application through equal proportion of FYM, PM and VC which were compared with recommended dose of fertilizers (RDF) representing 800 g N, 600 g P_2O_5 and 800 g K_2O coupled with 40 kg FYM (Chadha, 3). In addition to the aforesaid treatments, two common applications of *Jeevamrit* and *Panchgavya* (5%) and one soil application of Neem cake @ 1 kg/vine were also given except T_8. The procedure for preparation of Jeevamrit and Panchgavya were followed according to the methods described by the Chandra and Kadian, (4).

The leaf area of fully expanded leaves from each experimental vine was recorded with Li-COR 3100 leaf area meter. Total leaf chlorophyll content (mg/100g) was estimated as per the method suggested by the Hiscox and Israelstam (9). The fruits were harvested at optimum harvest (>6.2° Brix). Fruit yield was estimated on kg per vine basis. The harvested fruit were classified into three grades *viz*., grade A (>80 g), grade B (50-70 g) and grade C (<50 g). The dimensions of the fruit in terms of fruit length and diameter were measured with the help of Digital Vernier calliper. The average fruit weight was estimated on electronic top pan balance. The total soluble solids (%) and fruit firmness (kg/cm^2) were determined with Erma hand refractometer (0-32º Brix) and Magness-Taylor Pressure Tester, respectively. The titratable acidity was calculated on the basis of 0.1 N NaOH equivalents to 0.0064 g anhydrous citric acid. The total sugars and ascorbic acid contents were determined according to AOAC method (A.O.A.C.,1). The fruit harvested at commercial harvest were subjected to 10 days storage at ambient temperature.

The leaf and soil nitrogen, phosphorus and potassium contents were estimated as per the standard procedure given by Chapman and Pratt (5). The results of the investigation were computed, tabulated and analysed according to Randomized Block Design (Gomez and Gomez, 8)

RESULTS AND DISCUSSION

A perusal of the data pertaining to effect of different organic amendments exhibited the significant effects on the leaf area and chlorophyll content (Table 1). Among different treatments, recommended dose of NPK and FYM (T_8) showed the highest leaf area (118.33 cm^2) and total chlorophyll content (3.56 mg/100 g), however, it was found statistically similar with T_1 (sole application of vermicompost) in respect of leaf area. The treatments T_8 and T_5 showed similarity statistically in relation to chlorophyll content. The lowest leaf area (111.67 cm^2) and chlorophyll content (2.79 mg/100 g) were recorded with the sole application of PM. The better efficiency of organic manures in combination with inorganic fertilizers might be due to availability of the nutrients at optimum level (Schnitzer, 16). He reported that organic manures like vermicompost besides supplying nutrients, also alters various enzymatic activities in plants which promote cell elongation, root/shoot growth and carbohydrate metabolism.

Table 1. Influence of organic manures on the morpho-physiological, yield and physical characteristics of kiwifruit

Code	Treatment	Leaf area (cm^2)	Total chlorophyll content (mg/100g)	Total yield (kg/ vine)	Graded yield (Kg/vine)			Fruit size		L:D ratio	Fruit weight (g)
					A	B	C	Length (mm)	Diameter (mm)		
T_1	FYM (sole)	116.33	3.14	16.62	9.28	4.36	2.98	65.05	43.47	1.50	77.54
T_2	VC (sole)	117.00	3.24	17.23	9.40	5.08	2.74	66.44	43.41	1.53	80.37
T_3	PM (sole)	111.67	2.79	12.23	5.13	2.81	4.29	61.18	41.29	1.48	54.51
T_4	FYM & PM (50: 50)	112.4	2.94	13.52	6.38	3.20	3.94	62.60	42.19	1.48	57.50
T_5	FYM & VC (50: 50)	116.35	3.40	18.17	9.82	5.36	2.99	67.24	45.21	1.48	81.32
T_6	PM + VC (50: 50)	116.00	3.15	15.23	7.98	3.87	3.38	63.35	43.10	1.46	66.21
T_7	FYM, PM& VC (equal proportions)	115.67	2.96	13.68	6.90	3.41	3.36	62.87	41.78	1.50	61.38
T_8	RDF+ 40kg FYM	118.33	3.56	24.86	15.34	7.30	2.22	74.58	49.23	1.51	97.93
$CD_{0.05}$		2.58	0.26	2.43	1.05	0.86	0.26	2.15	1.19	NS	6.17

FYM: Farmyard manure; VC: Vermicompost; PM: Poultry manure; Sole: 100% N equivalence; RDF: Recommended doses of fertilizers

The total fruit yield per vine and the graded yield and fruit size were also significantly influenced by the application of the organic amendments in kiwifruit vines (Table 1). Among treatments, the highest kiwifruit yield (24.86 kg/vine) was recorded with T_8 (RDF coupled with FYM) statistically, while it was lowest (12.23 kg/vine), supplied with T_3 (sole application of PM) and was statistically at par with T_4 and T_7. The treatment T_8 also excelled for the highest proportions of 'A' (15.34 kg/vine) and 'B' (7.30 kg/vine) grade fruits over others. The T_8 also yielded the heaviest fruit (97.93 g) statistically, while lightest fruit (54.51 g) in T3 with no significant difference with T_4. This may be due to the fact that the combined application of inorganic fertilizers and organic manures supply adequate food material at optimum levels. Furthermore, the organic manures release the nutrients slowly into the soil in comparison to inorganic fertilizers (Deshpande and Senapathy, 7).

The fruit dimensions in terms of length and diameter were also recorded to be the highest in kiwifruit vines supplemented with T_8 (RDF and FYM). The lowest fruit size was observed with T_3 (sole application of PM). However, the observation with respect to L/D ratio were not significantly affected by any of the treatment under study. The relative increase in availability of nutrients and better solute uptake by plants might have resulted into increased fruit size and weight of kiwifruit (Korwar *et al.*, 10).

The fruit firmness was recorded highest (6.39 kg/cm^2) with T_5 (FYM and VC in 50:50) and the lowest fruit firmness (5.72 kg/cm^2) was observed with T_8 (RDF and FYM). After 10 days of storage, the highest fruit firmness (3.53 kg/cm^2) was recorded with T1 (sole application of FYM) without having significant difference with T_2, T_5 and T_6 treatments. The improved fruit quality by plant nutrients through organic manures might be attributed to the balanced availability of nutrients which lead to enhanced metabolic activities (Table 2). The positive effect of organic manures on fruit firmness is in agreement with Rekha (14) in Papaya who reported the important role of organic manures in plant cell structure, thus helping in catalysing metabolic reactions. This might also be due to changes in the amount of pectin materials cementing the cell walls and the hydrolysis of starch in the fruit.

The applications of different organic manures exerted a significant influence on the physico-chemical characteristics of fruits (Table 2). The highest TSS (7.64°/16.33°B), TSS acid ratio (6.21/27.68) and ascorbic acid (89.90 mg/ 68.66 mg/100g) were recorded with T_2 (sole application

Table 2. Influence of organic manures on chemical characteristics of kiwifruit at harvest and after 10 days storage at ambient temperature

Code	Treatments	Fruit firmness (kg/cm^2)		TSS (°B)		Total sugars (%)		Titratable acidity (%)		TSS-Acid Ratio		Ascorbic acid mg/100g	
		At harvest	After storage	At harvest	After storage	At harvest	After storage	At harvest	After storage	At harvest	After storage	At harvest	After storage
T_1	FYM (sole)	6.13	3.53	7.12	15.92	4.06	9.23	1.38	0.79	5.16	20.15	86.62	66.12
T_2	VC (sole)	6.03	3.34	7.64	16.33	3.93	9.37	1.23	0.59	6.21	27.68	89.90	68.60
T_3	PM (sole)	5.86	3.11	6.63	14.66	3.43	8.55	1.48	0.94	4.48	15.60	82.66	62.23
T_4	FYM & PM (50: 50)	5.95	3.07	6.64	15.10	3.53	8.85	1.50	0.95	4.43	15.89	83.7	63.50
T_5	FYM & VC (50: 50)	6.39	3.48	7.46	16.18	4.13	9.63	1.36	0.75	5.49	22.57	88.15	67.53
T_6	PM + VC (50: 50)	5.94	3.31	6.86	15.82	3.91	9.15	1.36	0.79	5.04	20.03	85.42	65.02
T_7	FYM, PM& VC (equal proportions)	6.00	3.18	6.79	15.36	3.64	8.97	1.40	0.82	4.85	18.73	84.62	64.26
T_8	RDF+ 40kg FYM	5.72	2.57	6.33	13.43	3.30	8.44	1.49	1.01	4.25	13.30	80.43	61.56
	$CD_{0.05}$	0.34	0.24	0.41	0.30	0.25	0.35	NS	0.20	0.46	3.44	1.52	1.48

FYM: Farmyard manure; VC: Vermicompost; PM: Poultry manure; Sole: 100% N equivalence; RDF: Recommended doses of fertilizers

of vermicompost) at harvest/after 10 days storage, respectively. The lowest content of acid at harvest (1.53%) and after storage (0.59%) was noticed in T_2 treatments. However, the total sugars were found to be highest with T_5 (FYM and VC in 50:50). On the contrary, the application of T_8 (RDF coupled with FYM) resulted in high titratable acid content. The addition of organic manures for nutrients, moisture and growth promoting substances enhance the metabolic and hormonal activities. This promotes production of more photosynthates to be stored in fruits in the form of starch. It is an established fact that the transformation of mature fruit into ripe form *i.e.* during the process of ripening in storage, the fruit undergoes physical, physiological and bio-chemical changes. The increase in total soluble solids (TSS) and total sugars may be attributed to the conversion of reserved starch and other insoluble carbohydrates into soluble sugars (Korwar *et al.*, 10). In the present study, the ascorbic acid content was found higher with the application of organic supplements than the inorganic fertilizers. A negative relationship between nitrogen and vitamin C content has also been noticed by Citak and Sonmez (6). This might be due to the reason that higher nitrogen results into increased protein synthesis and reduced carbohydrate production.

The data presented in Table 3 revealed a significant variation in the uptake of leaf nutrients *viz.*, N, P and K. The highest nutrient uptake in the leaves of kiwifruit was found with combined application of T_5 (VC and FYM in 50:50). The higher uptake of macronutrients with the addition of VC and FYM may be due to enhanced microbial N-fixation, improved soil physical condition and better moisture retention which might have increased the absorption of water and nutrients (Rezaei-Chiyaneh *et al.,* 15). The increase in phosphorus content with the application of T_5 (FYM and VC) may be attributed to better availability of P in the rhizosphere. The complex organic chelates of Al^{+3}, Fe^{+3} and Ca^{+2} decrease the phosphate precipitating power of theses cations and thereby increase the phosphorus and Potassium availability. Furthermore, addition of organic manures increase the macronutrient uptake as reported in Guava (Trivedi *et al.,* 18). The observations on influence of different organic amendments on the available soil macronutrient status revealed higher contents with application of T8 (RDF and FYM). This may be attributed to the residual effect of inorganic fertilizers. Marimuthu *et al.* (11) also reported increase in the soil NPK content with variable rates of inorganic fertilizers.

The results obtained from the study concluded that the application of RDF coupled with FYM

Table 3. Influence of organic manures on leaf and available soil nutrients status of kiwifruit vineyard

Code	Treatments	Leaf nutrient status (%)			Available Soil Nutrients (Kg/ha)		
		N	P	K	N	P	K
T_1	FYM (sole)	2.47	0.24	1.69	254.33	36.10	247.44
T_2	VC (sole)	2.50	0.32	1.75	264.33	48.25	262.67
T_3	PM (sole)	1.90	0.18	1.34	292.00	52.13	245.59
T_4	FYM & PM (50: 50)	2.07	0.21	1.45	260.93	37.66	248.06
T_5	FYM & VC (50: 50)	2.57	0.38	1.81	260.10	41.16	260.07
T_6	PM + VC (50: 50)	2.20	0.19	1.48	277.10	39.70	256.40
T_7	FYM, PM& VC (equal proportions)	2.27	0.23	1.64	267.33	38.03	252.00
T_8	RDF+ 40kg FYM	1.57	0.16	1.31	299.03	52.63	276.29
	$CD_{0.05}$	0.17	0.02	0.09	8.25	1.29	15.42

FYM: Farmyard manure; VC: Vermicompost; PM: Poultry manure; Sole: 100% N equivalence; RDF: Recommended doses of fertilizers

resulted in higher leaf area, chlorophyll content, fruit size, yield, titratable acidity and available soil nutrients. However, other fruit quality parameters namely; TSS content, ascorbic acid, and TSS acid ratio were found better with sole application of VC. Whereas, total sugars content and nutrient uptake of macronutrients were found higher with combined application FYM and VC (50:50).

AUTHORS' CONTRIBUTION

Conceptualization of research (Sharma, S. and Rana, V.S.); Designing of the experiments (Rana V.S. and Rana, N.); Contribution of experimental materials (Rana, N and Bhardwaj, V. and Pawar, R.); Execution of field/lab experiments and data collection (Sharma S. and Rana V.S.); Analysis of data and interpretation (Sharma S. and Rana V.S.); Preparation of the manuscript (Sharma S. and Rana V.S.)

DECLARATION

The authors declare no conflict of interest

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