Effect of organic cultivation of papaya on yield, economics and soil nutrient status*

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Abstract : An experiment was carried out during 2006-07 to 2007-08 at Horticulture Department, University of Agricultural Sciences, Dharwad to study the influence of organic manures on fruit yield and their effect on nutrient status of the soil after crop harvest in papaya cv. Surya. The study revealed that application of FYM equivalent to 100% recommended dose of nitrogen (RDN) (154.3 t/ha) gave significantly higher fruit yield of 173.9 t/ha as compared to control with RDF and other organic manure treatments except agrigold equivalent to 100% RDN (33.32 t/ha) and vermicompost, sheep manure and bhumilabha in combination with FYM treatments each equivalent to 50% RDN. Higher gross and net returns were recorded with the application of FYM equivalent to 100% RDN and benefit:cost (B:C)ratio was maximum with pressmud equivalent to 100% RDN. Analysis of the soil after harvest of papaya crop did not show any significant difference on organic carbon, DTPA-extractable Cu and Mn content among the treatments. Available major nutrients (NPK) were significantly higher with the application of FYM equivalent to 100% RDN and DTPA extractable Zn and Fe in combination with FYM and vermicompost each equivalent to 50% RDN as compared to control comprising chemical fertilizer as RDF.

Key words: Nutrient status, Organic manures, Papaya, Vermicompost

Introduction

Papaya (Carica papaya L.) which remained as a backyard crop hitherto has become an important commercial fruit crop over the years for its nutritional and pharmaceutical values, besides its quick and continuous yielding habit generating early income to the growers. Successful commercial cultivation of improved, high yielding varieties of papaya crop depends on critical nutrient management practices due to its continuous growth, flowering and fruiting habit. In the present scenario of energy crises, fertilizers have become one of the costliest inputs of Indian Agriculture. As papaya demands nutrients continuously in large amounts and use of large quantity of chemically formulated fertilizers alone is not only feasible but also costly to the poor farmers, as majority of them are small and marginal farmers. Apart from this, use of chemical fertilizers has resulted in progressive rise in multi nutrient deficiencies, nutrient imbalances, deterioration of soil health and productivity with time (Nambiar and Abrol, 1989). Although, the organic manure

contains plant nutrients in small quantities as compared to fertilizers, they influence in building up of organic matter, good soil aggregation, permeability of soil and related physical properties to long lasting supply of several macro and micronutrients, vital plant promoting substances apart from increasing the density of microbes in the soil. This helps in maintenance and possible improvement of soil fertility and health for sustaining crop productivity. Keeping this in view, a field experiment was conducted to study the influence of organic manures on papaya fruit yield and their effect on available major and micronutrient status of soil after harvest of crop.

Material and methods

A field experiment was conducted on the red clay soil (Inceptisol) of Olericulture Unit, Department of Horticulture, University of Agricultural Sciences, Dharwad during 2006-07 to 2007-08. The experimental soil contained 0.46% organic carbon, 233 kg/ha of available N, 31 kg per ha available P,O₅ and 296 kg/

Table 1. Treatment details

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Τ,	-	Farmyard manure equivalent to 50 % RDN (77.15 t/ha) + Vermicompost equivalent to 50 % RDN (30.86 t/ha)
T_2	-	Farmyard manure equivalent to 50 % RDN (77.15 t/ha) + Pressmud equivalent to 50 % RDN (16.05 t/ha)
T,	-	Farmyard manure equivalent to 50 % RDN (77.15 t/ha) + Sheepyard manure equivalent to 50 % RDN (55.09 t/ha)
T ₄	-	Farmyard manure equivalent to 50 % RDN (77.15 t/ha) + Agrigold equivalent to 50 % RDN (16.66 t/ha)
T ₅	-	Farmyard manure equivalent to 50 % RDN (77.15 t/ha) +Bhumilabh equivalent to 50 % RDN (12.34 t/ha)
T ₆	-	Farmyard manure equivalent to 100 % RDN (154.3 t/ha)
T ₇	-	Vermicompost equivalent to 100 % RDN (61.72 t/ha)
T ₈	-	Pressmud equivalent to 100 % RDN (32.10 t/ha)
T ₉	-	Sheepyard manure equivalent to 100 % RDN (110.18 t/ha)
T ₁₀	-	Agrigold equivalent to 100 % RDN (33.32 t/ha)
T ₁₁	-	Bhumilabh equivalent to 100 % RDN (24.68 t/ha)
T ₁₂	-	Control (RDF) - 772: 772: 1544 kg NPK per ha
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RDN = Nitrogen as per RDF (250 g N /plant) RDF= 250: 250: 500 g NPK / plant

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ha of K₂O with pH of 6.7. The experiment was laid out in a randomized complete block design with three replications. There were 12 treatments (Table 1) comprising six organic manures and 5 combinations of these organic manures with FYM and a control with recommended dose of NPK. The composition of major nutrients, their source, cost and quantity applied per plant and per ha of the organic manures was presented in table 2. The seeds of papaya cv. Surva a hybrid released from Indian Institute of Horticultural Research (IIHR), Bangalore was used for the study by following the cultural practices as recommended by IIHR and the treatments were imposed one week after the transplanting (1.8m x 1.8m spacing). Observations on yield were recorded by following standard procedure in five tagged plants of each treatment plots. Composite soil samples were collected and analyzed for organic carbon, available major and DTPAextractable micronutrients before imposing treatments and in each treatment after the harvest of crop. The data were subjected to statistical analysis as per the method outlined by Panse and Sukhatme (1967).

Results and discussion

From the results registered for yield components in the present investigation (Table 3), it is clear that number of fruits were more (84 fruits) in T_6 and were less (76 fruits) in T_{11} (Bhumilabh equivalent to 100% RDN *i.e.*, 24.68 t/ha). Heavier fruits (675g and 674g) with higher fruit volume (640 and 642 ml) were observed in T_4 and T_{10} organic manure treatments. Number of fruits per plant, fruit weight and fruit volume varied significantly among the organic manure treatment. Fruit yield in papaya ranged from 138.1 to 173.9 t/ha among different organic manure treatments with an overall average of 156.82 t/ha. Among the organic manure treatments, application of Farmyard

Table 2. Nutrient composition of organic manures used, their source, cost and quantity applied (per plant and per ha)

Organic manures, their source and cost	Nitrogen	Phosphorus	Potassium		Qu	antity app	plied
-		(Per cent)		50%	100%	50%	100%
			_	RDN	RDN	RDN	RDN
			_	(kg/p	lant)	(t/	'ha)
Farmyard manure (Dairy Unit, UAS, Dharwad) ₹ 500/t	0.5	0.9	1.3	25.0	50.0	77.15	154.30
Vermicompost (Dairy Unit, UAS, Dharwad) ₹ 250/q	1.2	0.8	1.0	10.0	20.0	30.86	61.72
Pressmud (Malaprabha Sugars MK Hubli, Dist. Belgaum)	2.4	1.5	1.3	5.2	10.4	16.05	32.10
₹ 1200/t							
Sheepyard manure (Dairy Unit, UAS, Dharwad) ₹550/t	0.7	0.5	0.8	17.8	35.7	55.09	110.18
Agrigold (Karnataka State Seeds Corporation, Hubli)	2.3	5.5	5.5	5.4	10.8	16.66	33.32
₹ 250/q							
Bhumilabh (Godavari Sugars Ltd., Sameerwadi) ₹ 640/q	3.2	1.7	1.4	4.0	8.0	12.34	24.68

RDN = Nitrogen as per RDF (250 g N /plant)

Table 3. Influence of organic manures and their combinations on yield and yield attributes of papaya

	Treatments	Fruits per plant (No.)	Fruit weight (g)	Fruit volume (ml)	Fruit yield	Fruit yield
					(kg/plant)	(t/ha)
T ₁ -	FYM equivalent to 50 % RDN (77.15 t/ha) + Vermicompost equivalent to 50 % RDN (30.86 t/ha)	81	646	620	52.33	161.5
T ₂ -	FYM equivalent to 50 % RDN (77.15 t/ha) + Pressmud equivalent to 50 % RDN (16.05 t/ha)	78	642	617	50.08	154.5
T ₃ -	FYM equivalent to 50 % RDN (77.15 t/ha) + Sheepyard manure equivalent to 50% RDN (55.09 t/ha)	83	649	628	53.87	166.2
T ₄ -	FYM equivalent to 50 % RDN (77.15 t/ha) + Agrigold equivalentx equivalent to 50% RDN (55.09 t/ha)	83	675	640	56.03	172.9
T ₅ -	FYM equivalent to 50 % RDN (77.15 t/ha) + Bhumilabh equivalent to 50 % RDN (12.34 t/ha)	79	643	613	50.80	156.8
T ₆ -	FYM equivalent to 100 % RDN (154.3 t/ha)	84	671	635	56.36	173.9
T_{7}^{0} -	Vermicompost equivalent to 100 % RDN (61.72 t/ha)	78	606	582	47.27	145.9
T ₈ -	Pressmud equivalent to 100 % RDN (32.10 t/ha)	76	589	567	44.76	138.1
T ₉ -	Sheepyard manure equivalent to 100% RDN (110.18 t/ha)	77	601	575	46.28	142.8
T_{10} -	Agrigold equivalent to 100 % RDN (33.32 t/ha)	82	674	642	55.27	170.6
T ₁₁ -	Bhumilabh equivalent to 100 % RDN (24.68 t/ha)	76	608	563	46.21	142.6
T ₁₂ -	Control (RDF) - 772: 772: 1544 kg NPK per ha	80	632	609	50.56	156.0
S.Em	±	2.26	17.22	17.61	2.28	5.97
C.D.	at 5 %	6.63	50.52	51.64	6.70	17.52

RDN = Nitrogen as per RDF (250 g N /plant)

 $RDF = 250 \text{ N}: 250 \text{ P}_2\text{O}_5: 500 \text{ K}_2\text{O} \text{ (g / plant)}$

manure equivalent to 100% RDN *i.e.*, 154.3 t/ha (T_6) recorded maximum fruit yield of 173.9 t/ha followed by 172.9 t/ha in combination of Farmyard manure equivalent to 50% RDN *i.e.*, 77.15 t/ha + Agrigold equivalent to 50% RDN *i.e.*, 16.66 t/ha (T_4) and 170.6 t/ha in Agrigold equivalent to 100% RDN *i.e.*, 33.32 t/ha (T_{10}) which were significantly superior over 142.6 t/ha in pressmud equivalent to 100% RDN *i.e.*, 32.10 t/ha (T_8). Similarly, the organic manure treatment T_4 followed by T_{10} and T_6 recorded significantly higher fruit yield per plant as compared to T_8 . Higher fruit yield in papaya may be realized due to increase in fruit number and fruit weight per plant and this was attributed to application of organic manures. The results of the present investigation are in conformity with findings of Borges *et al.* (2002), Bhavidoddi Rahulkumar (2003), in banana and Naik and Sriharibabu (2005) in guava.

The economic benefits of use of organic manures either alone or in combination with FYM was assessed by calculating the net and gross returns and benefit:cost ratio (Table 4). Net returns was highest in T_6 (Farmyard manure equivalent to 100% RDN *i.e.*, 154.3 t/ha) and in T_4 (Farmyard manure equivalent to 50% RDN i.e., 77.15 t/ha + Agrigold equivalent to 50% RDN i.e., 16.66 t/ha), while it was lowest in T₁₁ (Bhumilabh equivalent to 100% RDN *i.e.*, 24.68 t/ha) and in T_{τ} (Vermicompost equivalent to 100%) RDN i.e., 61.72 t/ha). Whereas the ratio of benefit to cost was maximum with T_o (Pressmud equivalent to 100% RDN *i.e.*, 32.10 t/ha), T₂ (Farmyard manure equivalent to 50% RDN *i.e.*, 77.15 t/ha + Pressmud equivalent to 50% RDN i.e., 16.05 t/ha) and T₂ (Farmyard manure equivalent to 50% RDN *i.e.*, 77.15 t/ha + Sheepyard manure equivalent to 50% RDN *i.e.*, 55.09 t/ha) while it was lowest in T_{11} and T_7 . The higher and lower net returns and B: C ratio in the above treatments could be either due to fruit yield or due to cost of the manures. Similarly, by

using organic manures Bhavidoddi Rahulkumar (2003) and Kurubar (2007) registered higher net returns and B: C ratio in banana and fig respectively.

Based on the present study it can be concluded that organic manures viz., FYM and Agrigold either alone or their combinations produced higher fruit yield and the B:C ratio can be excelled with the use of organic manures as against application of chemical fertilizers in papaya.

In general, addition of organic amendments had favourable effect on the soil organic matter content. Organic carbon present in the soil is an indication of amount of organic matter in soil. Organic matter has several beneficial effects on soil health. The application of organic manures has constructive upshot on organic carbon. As such, no significant effect was found in present investigation on soil organic carbon after the harvest of crop due to application of different organic manures (Table 5). However, it ranges from 0.46 to 0.55% due to application of different organic carbon with application of FYM was reported by Rajashree *et al.* (2005).

Decomposing organic matter in soil gradually releases nitrogen. The values for available nitrogen were found to vary significantly due to organic manure treatments (Table 5). Significantly higher content of available nitrogen after crop harvest was recorded in the organic manure treatment T_6 (Farmyard manure equivalent to 100% RDN *i.e.*, 154.3 t/ha) as compared to T_{12} (Control (RDF) *i.e.*, 772: 772: 1544 kg NPK/ha) and T_{11} (Bhumilabh equivalent to 100% RDN *i.e.*, 24.68 t/ha). The increase in available nitrogen due to application of organic manures might be attributed to the greater multiplication of soil microbes by application of organic manures. These organic manures during mineralization convert organically bound N to inorganic from resulting in higher available nitrogen of soil.

Table 4. Economics of using organic manures and their combinations in papaya

	Treatments	Gross	Cost of	Total cost	Net	B:C
		returns	manures	of cultivation	returns	
		(₹ ha-1)				
T ₁ -	FYM equivalent to 50 % RDN (77.15 t/ha) + Vermicompost equivalent to 50 % RDN (30.86 t/ha)	4, 84, 500	1, 15, 725	1, 48, 085	3, 36, 415	3.27
T ₂ -	FYM equivalent to 50 % RDN (77.15 t/ha) + Pressmud equivalent to 50 % RDN (16.05 t/ha)	4, 63, 500	57, 835	90, 195	3, 73, 305	5.14
T ₃ -	FYM equivalent to 50 % RDN (77.15 t/ha) + Sheepyard manure equivalent to 50% RDN (55.09 t/ha)	4, 98, 600	68, 875	1, 01, 235	3, 97, 366	4.93
T ₄ -	FYM equivalent to 50 % RDN (77.15 t/ha) + Agrigold equivalent to 50 % RDN (16.66 t/ha)	5, 18, 700	80, 225	1, 12, 585	4, 06, 115	4.61
T ₅ -	FYM equivalent to 50 % RDN (77.15 t/ha) + Bhumilabh equivalent to 50 % RDN (12.34 t/ha)	4, 70, 400	1, 17, 551	1, 49, 911	3, 20, 489	3.14
T ₆ -	FYM equivalent to 100 % RDN (154.3 t/ha)	5, 21, 700	77, 150	109510	4, 12, 190	4.76
$T_{7}^{"}$ -	Vermicompost equivalent to 100 % RDN (61.72 t/ha)	4, 37, 700	1, 54, 300	1, 86, 660	2, 51, 040	2.34
T ₈ -	Pressmud equivalent to 100 % RDN (32.10 t/ha)	4, 14, 300	38, 520	70, 880	3, 43, 420	5.85
T _o -	Sheepyard manure equivalent to 100% RDN (110.18 t/ha)	4, 28, 400	60, 599	92, 959	3, 35, 441	4.61
T ₁₀ -	Agrigold equivalent to 100 % RDN (33.32 t/ha)	5, 11, 800	83, 300	1, 15, 660	3, 96, 140	4.43
T ₁₁ -	Bhumilabh equivalent to 100 % RDN (24.68 t/ha)	4, 27, 800	1, 57, 952	1, 90, 312	2, 37, 488	2.25
T ₁₂ -	Control (RDF) - 772: 772: 1544 kg NPK per ha	3, 12, 000	41, 236	73, 596	2, 38, 404	4.24

RDN = Nitrogen as per RDF (250 g N /plant) & RDF = 250 N: 250 P_2O_5 : 500 K₂O (g / plant)

Papaya fruits grown with chemical fertilizer = ₹ 2/kg (2000 ₹/t) & Organically grown papaya fruits= ₹ 3/kg (3000 ₹/t)

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Table 5 Influence of organic manures at	nd their combinations on organic	carbon and available major nutrient sta	his in soil after cron harvest
Tuble 5. Influence of organie manufes a	ia men comonations on organic	carbon and available major nament sta	as in son and crop harvest

Treatments	Organic	Ν	P_2O_5	K ₂ O
	carbon		(kg ha ⁻¹)	
	(%)			
T_1 - FYM equivalent to 50 % RDN (77.15 t/ha) + Vermicompost equivalent to	0.53	246	33	300
50 % RDN (30.86 t/ha)				
T_2 - FYM equivalent to 50 % RDN (77.15 t/ha) + Pressmud equivalent to	0.50	242	32	297
50 % RDN (16.05 t/ha)				
T_3 - FYM equivalent to 50 % RDN (77.15 t/ha) + Sheepyard manure equivalent to	0.52	245	32	298
50% RDN (55.09 t/ha)				
T_4 - FYM equivalent to 50 % RDN (77.15 t/ha) + Agrigold equivalent to 50 % RDN (16.66 t/ha)	0.51	238	34	303
T ₅ - FYM equivalent to 50 % RDN (77.15 t/ha) + Bhumilabh equivalent to 50 % RDN (12.34 t/ha)	0.50	238	31	296
T_6 - FYM equivalent to 100 % RDN (154.3 t/ha)	0.55	248	35	305
T_{7} - Vermicompost equivalent to 100 % RDN (61.72 t/ha)	0.52	244	30	296
T ₈ - Pressmud equivalent to 100 % RDN (32.10 t/ha)	0.51	240	30	295
T_{q} - Sheepyard manure equivalent to 100% RDN (110.18 t/ha)	0.53	242	30	296
T_{10} - Agrigold equivalent to 100 % RDN (33.32 t/ha)	0.49	237	35	302
T_{11} - Bhumilabh equivalent to 100 % RDN (24.68 t/ha)	0.50	235	30	294
T_{12}^{-1} - Control (RDF) - 772: 772: 1544 kg NPK per ha	0.46	234	30	296
S.Em <u>+</u>	0.03	3.65	1.29	2.58
C.D. at 5 %	NS	10.71	3.79	7.57

RDN = Nitrogen as per RDF (250 g N /plant)

RDF = 250: 250: 500 g NPK per plant

Available phosphorus content was more in the treatments T_6 and T_{10} (Agrigold equivalent to 100% RDN *i.e.*, 33.32 t/ha) which were significantly higher than T_{12} . Higher availability of phosphorus in the organic manures treated plots as compared to RDF treated plots might be due to the release of organic acids during microbial decomposition of organic matter which might have helped in the solubility of native phosphorus. In addition, the organic anions compete with phosphate ions for the binding sites on the soil particles. Similarly, a maximum potassium was observed in T_6 which was significantly higher as compared to T_{11} , T_8 (Pressmud equivalent to 100% RDN *i.e.*, 32.10 t/ha), T_7 (Vermicompost equivalent to 100% RDN *i.e.*, 61.72 t/ha) T_9 (Sheep

yard manure equivalent to 100% RDN *i.e.*, 110.18 t/ha) and also in T_{12} . The lesser values in Bhumi labh, Press mud, Vermicompost and Sheep yard manure treatments might be due to lower contents of K in these manures as against recommended doses for papaya. The higher K content might be because of the organic acids produced during decomposition of organic manures helping the release of minerally bound insoluble potassium and also might had reduced the potassium fixation. Similar results were also reported by several workers. These results are in line with the findings of Blair *et al.* (1996) for nitrogen, Chellamuthu *et al.* (1998) for phosphorus and Shinde and Gowande (1992) for potassium.

Table 6. Influence of organic manures and their combinations on DTPA-extractable micronutrients status in soil after crop harvest

Treatments	Zn	Fe	Cu	Mn
		(mg l	(g ⁻¹)	
$\overline{T_1}$ - FYM equivalent to 50 % RDN (77.15 t/ha) + Vermicompost equivalent to	0.81	5.81	1.42	2.39
50 % RDN (30.86 t/ha)				
T_2 - FYM equivalent to 50 % RDN (77.15 t/ha) + Pressmud equivalent to 50 % RDN (16.05 t/ha)	0.72	5.40	1.27	2.34
T ₃ - FYM equivalent to 50 % RDN (77.15 t/ha) + Sheepyard manure equivalent to	0.80	5.75	1.45	2.40
50% RDN (55.09 t/ha)				
T_4 - FYM equivalent to 50 % RDN (77.15 t/ha) + Agrigold equivalent to 50 % RDN (16.66 t/ha)	0.74	5.50	1.36	2.32
T_5 - FYM equivalent to 50 % RDN (77.15 t/ha) + Bhumilabh equivalent to 50 % RDN (12.34 t/ha)	0.75	5.54	1.30	2.33
T_6 - FYM equivalent to 100 % RDN (154.3 t/ha)	0.78	5.66	1.50	2.37
T_7 - Vermicompost equivalent to 100 % RDN (61.72 t/ha)	0.79	5.70	1.35	2.34
T ₈ - Pressmud equivalent to 100 % RDN (32.10 t/ha)	0.61	4.94	1.17	2.30
T_9 - Sheepyard manure equivalent to 100% RDN (110.18 t/ha)	0.71	5.34	1.48	2.36
T_{10} - Agrigold equivalent to 100 % RDN (33.32 t/ha)	0.69	5.26	1.23	2.32
T_{11} - Bhumilabh equivalent to 100 % RDN (24.68 t/ha)	0.63	5.02	0.98	2.33
T_{12}^{-1} - Control (RDF) - 772: 772: 1544 kg NPK per ha	0.53	4.62	0.88	2.25
S.Em±	0.16	0.26	0.18	0.08
C.D. at 5 %	0.48	0.77	NS	NS

RDN = Nitrogen as per RDF (250 g N /plant)

RDF = 250: 250: 500 g NPK per plant

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In the soil after crop harvest, all the organic manure treatments registered higher concentration of DTPA extractable micronutrients (Table 6) mainly zinc, iron, copper and manganese compared to T_{12} (Control (RDF) *i.e.*, 772: 772: 1544 kg NPK/ha). Generally, the increase in available micronutrients status of soils in organically treated plots might be due to release of chelating agents from organics matter decomposition which might have

prevented micronutrients from precipitation, oxidation and leaching (Sharma *et al.*, 2001). There was a reduction in micronutrients content in the treatments receiving only inorganic fertilizers. It was attributed to non replenishment of micronutrients through chemical fertilizers. The results of the present study are in agreement with the findings of Anand Swarup (1991) and Sriramachandrashekaran *et al.* (1996).

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