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Effect of integrated nutrient management on growth and nutrient status of papaya CV. Taiwan red lady

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Abstract
A filed experiment was conducted during 2012 and 2013 at the Regional Horticultural Research Station and Krishi Vigyan Kendra of Navsari Agricultural University, Navsari, to determine the influence of organic and inorganic fertilizers, fertility levels and different treatment combination. Results revealed that the treatment T_6: 25 % RDN through bio compost + 25 % RDN through castor cake + 50 % RDN through inorganic fertilizer gave higher values of growth characters viz., plant height, stem girth and number of leaves. And this treatment also influenced the higher major and micro nutrient content in leaf of papaya and higher available N, P_2O_5, K_2O, Fe and Zn content in soil after harvest of papaya crop.

Keywords: Integrated nutrient management, growth, nutrient content, papaya

Introduction
Papaya (*Carica papaya* L.) is an evergreen herbaceous commercial fruit crop of tropical and subtropical regions and it belongs to the family Caricaceae and according to Purseglove (1968), In India, it is successfully grown all over country and is available round the year. It occupies a cultivated area of 133.36 thousand hectares (1.87 % of total fruit area) and 5639.30 thousand M.T. of production (6.64 % of total fruit production) with average productivity is 42.3 M. T. per hectare. In Gujarat, it is cultivated on an estimated area of 19.59 thousand hectares with 1185.47 thousand M.T. of production and average productivity is 60.5 M.T. per hectare. (Anon., 2016) [2].
Since 50 years, a considerable research work has been done on various aspects such as varieties, spacing, weed management, nutrient management, fertigation, mulching and post-harvest, for increase the yield and quality of papaya.
Nutrient management is one of the key factor and most important cultivation practices to improve the productivity of papaya and account for 30 % of total cost of cultivation. The productivity of papaya is adversely affected if the crop is not feed properly. For want of maximizing yield potential, continuous sole and erratic use of chemical fertilizer in imbalance ratio leads to decline in soil fertility as well as nutrient uptake efficiency of plants resulting in either yield stagnation or decrease. The nutrition of papaya differ from other fruit crops because of its quick growth, continuous flowering and fruiting habit and heavy production as plant would exhibit sensitiveness to low supply of major and minor nutrients.
Hence, keeping all the point in view the attempts were made to find out the suitable combination of organic and inorganic fertilizers/manures for obtaining suitable combination for growth and nutrient uptake of papaya cv. Taiwan Red Lady

Materials and Methods
The experiment was carried out at the Regional Horticultural Research Station and Krishi Vigyan Kendra of Navsari Agricultural University, Navsari during the year 2011-2012 and 2012-2013, respectively. The treatments are T_1: 50 % RDN through bio compost + 50 % RDN through inorganic fertilizer, T_2: 50 % RDN through vermi compost + 50 % RDN through inorganic fertilizer, T_3: 50 % RDN through castor cake + 50 % RDN through inorganic fertilizer, T_4: 25 % RDN through bio compost + 25 % RDN through vermi compost + 50 % RDN through inorganic fertilizer, T_5: 25 % RDN through vermi compost + 25 % RDN through castor cake + 50 % RDN through inorganic fertilizer, T_6: 25 % RDN through bio compost + 25 % RDN through castor cake + 50 % RDN through inorganic fertilizer, T_7: 25 % RDN

through bio compost + 25 % RDN through castor cake + 25 % RDN through vermi compost + 25 % RDN through inorganic fertilizer along with control (T_8) (RDF: 200-200-250 g NPK/plant) were laid out in RBD with three replications. Organic fertilizer was applied in two split (basal and 45 DAP) as per treatments. Inorganic fertilizer was applied at 2nd, 4th, 6th and 8th month after planting. The experimental plot was prepared by deep ploughing and harrowing. The pits of 30 X 30 X 30 cm were dug out at a spacing of 2.4 m X 1.5 m and well decomposed fine textured FYM @ 10 kg pit^{-1} was applied at time of planting. Common application of *Trichoderma viridi* and *Pseudomonas* culture each @ 5 kg/ha were applied at the time of planting and 2 months after planting. Recommended bio-fertilizers *Azotobacter* and PSB were applied at two time @ 5 kg/ha. as common dose. Common application of micronutrient spray @ 1.5 lit/ha (Grade-IV of GNFC) (composition are Zn-6 %, Fe-4 %, Mn- 1 %, Bo- 0.50 % and Cu- 0.50 %) was given at 90 and 120 DAP. For getting the idea of nutrient status of papaya crop, the healthy and matured leaf samples (6th leaf from apex) were taken at 360 days after transplanting.The data recorded on growth and nutrient available and uptake by plant were analyzed statistically (Pense and Sukhatme, 1961) [7].

Results and Discussion

All the growth attributes like plant height, stem girth and numbers of leaves were significantly influenced by biocompost, vermi compost, castor cake and inorganic fertilizer (Table 1).

Effect of INM on Growth

Plant height recorded significantly higher value of (131.50 cm), (178.22 cm), (186.65 cm) was observed in treatment T_6 during 180, 270 and 360 days after planting, respectively. But these values are remained at par to the treatments T_4, T_7, T_5 and T_1 at 180, 270 and 360 DAP.

Similarly the significantly highest values of stem girth (30.49 cm), (44.55 cm), (50.51 cm) and number of leaf (25.20), (34.58) and (44.92) were recorded in treatment T_6 at 180 DAP, 270 DAP and 360 DAP, respectively. This treatment was on at par with T_7 and T_4 during 180 DAP and 360 DAP, T_4, T_7, T_1 and T_5 during 270 DAP for stem girth. While in case of number of leaf treatment T_4 was at with T_7 at 180 DAP, 270 DAP and 360 DAP. The increase in plant height and stem girth may be due to improvement of physical properties of soil, higher nutrient uptake and increased activity of microorganisms which were manifested in the form of enhanced growth and higher carbohydrates production (Yadav *et al*., 2011) [14]. And it could also be because of continuous supply of available nutrient from organic and inorganic form and effect of bio active substance produced by common application of bio fertilizer. Organic manure application, also improved the aeration into the soil, ultimately improve the physiological activities inside the plants. The similar result was reported by Patel (2008) [8] and Hazarika and Ansari (2010) [4] in Banana.

Significantly higher numbers of leaves per plant at 180 DAP, 270 DAP and 360 DAP was recorded with treatment T_6. This might have attributed to more availability of nutrient particularly nitrogen and subsequent uptake by crop. This result in higher biomass production has reflected by production of additional leaves (Kuttimani *et al*., 2013) [6]. Similarly reported by Ray *et al*. (1999) [9], Shiva kumar (2010) [11], Suresh *et al*. (2010) [13] and Yadav *et al*. (2011) [14] in papaya.

Effect of INM on Nutrient status

Nutrient status like, nutrient content in leaf of papaya and available nutrient in soil after harvest of papaya were significantly influenced by biocompost, vermi compost, castor cake and inorganic fertilizer (Table 2 and 3).

There was a significant effect of integrated nutrient management on the major (N, P_2O_5 and K_2O) and micro (Fe, Zn, Mn and Cu) nutrients content in papaya leaf *cv*. Taiwan Red Lady. The higher value of major nutrient N (3.71 %), P_2O_5 (0.54%), K_2O (5.64 %) and micro nutrients Fe (225.49 ppm), Zn (24.94 ppm), Mn (35.86 ppm) and Cu (5.06 ppm) content in leaf of papaya were noted with plant treated with 25 % RDN through bio compost + 25 % RDN through castor cake + 50 % RDN through inorganic fertilizer (T_6). All the nutreint content was at par with T_7 and T_4.The increase in available nitrogen due to application of organic manure might be attributed to greater multiplication of soil microbes. These organics during mineralization convert organically bound N to inorganic form resulting in higher available nitrogen to soil. It also enhanced phosphorus activities that mobilizes sparingly the available nutrient sources and ectozymes resulting in improve phosphorous uptake. The mechanism involved in solubilizing phosphorus was due to acid production and enzyme activities viz., dehydrogenase, phosphate and urenase activities. Thus, due to transport of solubilized phosphorus through hyphae to roots led to an efficient increase in phosphorus. Increased microbial activities have resulted in greater uptake of potassium in plant due to the solubilization action of certain organic acids produced during decomposition of organic manure and its greater capacity to hold K in available form in soil (Kuttimani *et al*., 2013) [6]. These results are in agreement with those reported by Anjaneyulu (2007) [1] and Khade and Rodrigues (2009) [5] in papaya

The available nutrient viz., N, P_2O_5, K_2O, Fe and Zn in soil were significantly influenced by various INM treatments. Significantly higher value of N (307.0 kg/ha), P (68.37 kg/ha) and K (415.67 kg/ha) were recorded in treatment T_6.Which was at par with treatment T_7. While Fe (17.95ppm) and Zn (0.78 ppm) were recorded in the treatment T_7 and it was on par with treatment T_6. However, Mn and Cu nutrient content in soil were not affected significantly due to different nutrient management treatments.

The increase in available nitrogen due to application of organic manures along with chemical fertilizers might be attributed to the greater multiplication of soil microbes by application of nitrogen through nitrogenous fertilizers along with organic manures. These organic manures during mineralization convert organically bound N to inorganic from resulting in higher available nitrogen of soil (Bhalerao *et al*., 2009) [3].

Higher availability of phosphorus in the organic manures treated plot 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 and thereby increase the phosphorus availability (Patel, 2008) [8]. The higher K_2O content might be the organic and inorganic acids produced due to during decomposition of organic manures helping the release of minerally bound insoluble potassium and also might had reduced the potassium fixation. The buildup of available potassium in soil was due to the beneficial effect of organic manures in releasing potassium due to the interaction of organic matter with clay and direct addition of potassium to the available pool of soil (Shiva kumar, 2010) [11].

Increased Zn status of soil may be due to the presence of zinc in the organic manure and solubilizing effect of organic acids produced during decomposition of organic manures on Zn complexes like $ZnCO_3$, Zn $(OH)_2$ and $Zn_3(PO_4)_2$. Organic matter binds with zinc ions and avoids formation of insoluble zinc complexes due to precipitation reaction. DTPA-extractable iron content of the soil after crop harvest has increased in the plots receiving organic manure with a blend of fertilizers. This may be due to the action of chelating agents that increased the availability of Fe and also due to the release of Fe from the added organic manures as a result of decomposition. (Selvamani *et al.*, 2011) [10]. the results obtained in the present study are in line with the findings of Shivaputra *et al.* (2004) [12], Anjaneyulu (2007) [1], Khade and Rodrigues (2009) [5], Suresh *et al.* (2010) [13] and Yadav *et al.* (2011) [14] in papaya.

Table 1: Effect of integrated nutrient management on growth characters of papaya cv. Taiwan Red Lady

Treatments	Plant height (cm)			Stem girth (cm)			Number of leaves per plant		
	180 DAP	270 DAP	360 DAP	180 DAP	270 DAP	360 DAP	180 DAP	270 DAP	360 DAP
T_1- 50 % RDN through bio compost + 50 % RDN through inorganic fertilizer	122.15	168.64	179.17	27.56	42.92	45.90	22.15	31.43	41.43
T_2- 50 % RDN through vermi compost + 50 % RDN through inorganic fertilizer	116.99	165.80	174.73	26.83	39.49	43.81	21.88	31.20	40.87
T_3- 50 % RDN through castor cake + 50 % RDN through inorganic fertilizer	106.13	157.67	169.74	24.44	37.38	43.24	20.55	30.95	40.95
T_4- 25 % RDN through bio compost + 25 % RDN through vermi compost + 50 % RDN through inorganic fertilizer	125.76	173.33	184.82	29.88	43.72	47.27	23.40	32.78	42.78
T_5- 25 % RDN through vermi compost + 25 % RDN through castor cake + 50 % RDN through inorganic fertilizer	122.33	173.80	181.07	23.45	41.82	44.31	21.82	31.83	41.83
T_6- 25 % RDN through bio compost + 25 % RDN through castor cake + 50 % RDN through inorganic fertilizer	131.50	178.22	185.39	30.49	44.55	50.51	25.20	34.58	44.92
T_7- 25 % RDN through bio compost + 25 % RDN through vermi compost + 25 % RDN through castor cake + 25 % RDN through inorganic fertilizer	125.00	171.00	182.43	29.05	42.22	48.53	25.05	34.32	44.32
T_8- Control (RDF)	112.14	150.59	158.31	22.88	36.06	40.18	19.02	28.33	38.67
S. Em.±	3.192	3.762	3.710	0.931	1.080	1.310	0.464	0.579	0.845
C. D. at 5 %	9.219	10.865	10.715	2.689	3.119	3.783	1.340	1.674	2.442
C. V.%	6.50	5.51	5.14	8.50	6.45	7.06	517	4.57	4.80

Table 2: Effect of INM on major and micro nutrient content in leaf of papaya cv. Taiwan Red Lady

Treatments	Nutrient content in leaf (%)			Micronutrient content in leaf (ppm)			
	N	P_2O_5	K_2O	Fe	Zn	Cu	Mn
T_1- 50 % RDN through bio compost + 50 % RDN through inorganic fertilizer	3.27	0.48	5.276	199.46	22.16	31.07	4.08
T_2- 50 % RDN through vermi compost + 50 % RDN through inorganic fertilizer	3.26	0.47	5.187	196.08	21.79	30.26	3.96
T_3- 50 % RDN through castor cake + 50 % RDN through inorganic fertilizer	3.20	0.46	4.976	190.83	21.66	30.10	3.95
T_4- 25 % RDN through bio compost + 25 % RDN through vermi compost + 50 % RDN through inorganic fertilizer	3.49	0.51	5.408	214.36	22.98	33.97	4.20
T_5- 25 % RDN through vermi compost + 25 % RDN through castor cake + 50 % RDN through inorganic fertilizer	3.30	0.48	5.228	190.42	21.85	30.74	4.15
T_6- 25 % RDN through bio compost + 25 % RDN through castor cake + 50 % RDN through inorganic fertilizer	3.71	0.54	5.644	225.49	24.94	35.86	5.06
T_7- 25 % RDN through bio compost + 25 % RDN through vermi compost + 25 % RDN through castor cake + 25 % RDN through inorganic fertilizer	3.62	0.52	5.513	215.31	23.74	34.73	4.85
T_8- Control (RDF)	2.98	0.43	4.895	189.26	20.42	29.82	3.82
S. Em.±	0.081	0.0123	0.11	3.884	0.499	0.81	0.159
C. D. at 5 %	0.235	0.035	0.314	11.21	1.443	2.337	0.461
C. V.%	6.17	6.32	4.40	4.68	5.52	6.36	9.05

Table 3: Effect of INM on available major and micro nutrient in soil after harvest of papaya cv. Taiwan Red Lady

Treatments	Nutrient content in soil			Micronutrient content in soil			
	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)	Fe (ppm)	Zn (ppm)	Mn (ppm)	Cu (ppm)
T_1- 50 % RDN through bio compost + 50 % RDN through inorganic fertilizer	283.67	61.24	400.50	16.62	0.64	22.27	3.77
T_2- 50 % RDN through vermi compost + 50 % RDN through inorganic fertilizer	269.67	54.58	393.33	15.47	0.61	21.12	3.79
T_3- 50 % RDN through castor cake + 50 % RDN through inorganic fertilizer	264.67	50.59	387.33	15.31	0.60	20.96	3.69
T_4- 25 % RDN through bio compost + 25 % RDN through vermi compost + 50 % RDN through inorganic fertilizer	289.17	62.90	411.00	16.00	0.68	21.65	3.75
T_5- 25 % RDN through vermi compost + 25 % RDN through castor cake + 50 % RDN through inorganic fertilizer	275.00	59.34	404.50	15.52	0.64	21.17	3.86
T_6- 25 % RDN through bio compost + 25 % RDN through castor cake + 50 % RDN through inorganic fertilizer	307.00	68.37	415.67	17.81	0.74	23.60	4.03
T_7- 25 % RDN through bio compost + 25 % RDN through vermi compost + 25 % RDN through castor cake + 25 % RDN through inorganic fertilizer	295.67	66.79	411.67	17.95	0.78	23.31	4.07
T_8- Control (RDF)	249.83	43.75	354.83	15.17	0.55	20.82	3.69
S. Em.±	6.919	1.444	7.868	0.311	0.0215	0.505	0.118
C. D. at 5 %	19.981	4.172	22.722	0.898	0.0622	NS	NS
C. V.%	6.25	6.10	4.98	4.42	8.82	5.41	7.65

Conclusion

Organic manures like bio compost, vermi compost, caster cake with 50 per cent of inorganic fertilizer are more efficient in maintaining a better photosynthetic efficiency, which is responsible to maintain a better growth and nutrient status of the plant. Thus, it was inferred that application of T_6 : 25 % RDN through bio compost + 25 % RDN through castor cake + 50 % RDN through inorganic fertilizer should be adopted by the papaya growers to achieve the growth and nutrient status in soil and leaf of papaya.

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