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Feasibility of papaya-banana relay cropping under organic farming

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Abstract
Quality of manure, pests-diseases, market price fluctuation, possibilities of low yield and in present scenario climate change pattern have a great impact on organic farming. Focusing on these, a field experiment was conducted to study the feasibility of papaya-banana relay cropping under organic farming at Navsari Agricultural University, Navsari (Gujarat) in randomized block design comprising of eight treatments with four replications during *kharif* of 2009-10, 2010-11 and 2011-12. Results were statistically analyzed. Pooled data showed that application of BC:VC:CC (25%N:40%N:15%N) + BPS @ 2.0 l/plant (T_8) significantly increased plant height (139.2 cm), fruit weight (1.06 kg) and fruit yield (64.7 t/ha) of papaya. Though the maximum number of fruits per plant was significantly higher in treatment T_6 (BC:VC:CC-25%N:40%N:15%N) but was at par with treatment T8. Fruit quality of papaya *i.e.* acidity, ascorbic acid, TSS, reducing sugar and self life were also affected significantly due to treatments but the results of quality parameters of fruit were found very conspicuous and no uniform trend was observed. In banana crop, maximum plant height (180.6 cm) was observed with BC:VC:CC (50%N:40%N:00%N) + BPS @ 1.0 l/plant (T_4) which was at par with treatments T_3, T_6, T_7 and T_8. Some yield attributing characters were also significantly affected due to treatment effects and maximum fingers per bunch were noted with the treatment T8 which was at par with treatments T_2, T_4 and T_7 while, maximum bunch weight and yield were found significantly higher with treatment T_2 (BC:VC:CC - 50%N:00%N:50%N) and T_8, respectively. Maximum acidity in banana fruit was found in treatments T_6 and T_7 which were at par with most of the other treatments. Considering net income, treatment T_8 showed economically viable in papaya and banana as a sole crop and also in papaya-banana relay system under organic farming.

Keywords: Papaya, banana, relay cropping, organic farming, growth, yield, quality

Introduction
Relay cropping is the growing of two or more crops on the same field with the planting of the second crop after the first one has completed its development. In this way, both crops share a portion of the growing season, increases solar radiation and heat available to each crop. Besides these relay cropping has certain advantages which include the potential to reduce nitrate leaching, increase carbon sequestration and increase income for producers. Papaya 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 cultivation of papaya crop depends on critical nutrient management practices due to its continuous growth, flowering and fruiting habit. Similarly, banana owing to its large size and rapid growth rate require relatively large amount of nutrients for high yield of quality fruits. It is estimated that 50 tones of banana in one hectare removes 320kg N, 32kg P_2O_5 and 925kg K_2O every year (Lahav and Turner, 1983) [8]. As these crop 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 in India. 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) [9]. 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.

The relay cropping system gave a maximum net return of about 9891 Bhat/ha over the single corn cropping and land use efficiency was also increased by 50% and 60% in intercropping and relay cropping, respectively (Polthanee and Butchareon (2000) [11]. Keeping this in view, a field experiment was conducted to study the feasibility of papaya-banana relay cropping under organic farming.

Materials and Methods

The present experiment was conducted at Organic Farm, Navsari Agricultural University, Navsari (Gujarat) to study the feasibility of papaya-banana relay cropping under organic farming in randomized block design comprising eight treatments with four replications during *kharif* season of 2009-10, 2010-11 and 2011-12. The soil of experimental area was slightly alkaline and non saline in nature, and initially contained 0.75, 0.72 and 0.76 per cent OC and 254, 246 and 251 kg available N/ ha during 2009-10, 2010-11 and 2011-12, respectively. The papaya and banana crop were planted in *kharif* at 1.5m x 2.4m and 1.2 m x 1.5 m x 3.3 m (Paired raw), respectively. The recommended dose of 200 g N/plant and 300 g N/plant to the papaya and banana, respectively was supplied in different proportion through biocompost (BC), vermicompost (VC) and castor cake (CC) with banana pseudostem sap (BPS) indicated treatments as, T_1: BC: VC: CC 50: 00:50, T_2: BC: VC: CC 50: 00:50, T_3: BC: VC: CC 50: 50:00, T_4: BC: VC: CC 50: 40:00 with sap @ 1.0 l/plant, T_5: BC: VC: CC 50: 30:00 with sap @ 2.0 l/plant, T_6: BC: VC: CC 25: 75:00, T_7: BC: VC: CC 25: 50:15 with sap @ 1.0 l/plant and T_8: BC: VC: CC 25: 40:15 with sap @ 2.0 l/plant. Manures were applied on equivalent N basis. Fifty percent of required N was applied as basal and remaining quantity was applied in two equal splits at three and six months after planting. The BPS was applied in five splits at one month interval after planting. Recommended bio-fertilizer and green manuring as a common practice were also followed in both the crop. Observations were recorded on five plants selected at random from each plot. For quality parameter samples were collected from each treatment at peak fruiting stage. Biochemical and chemical analysis were performed as per the standard methods. All the collected data were analyzed by standard statistical method. Economics also worked out in terms of gross and net realization on the basis of prevailing market rate.

Results and Discussion

Papaya

The results pertaining to growth parameters, yield attributes, yield and quality are reported in table 1 to 6. Plant height was not affected significantly during the first year but, it was significantly affected and maximum plant height was recorded in treatment T_8 during 2nd year, 3rd year and even in pooled analysis. However, treatment T8 was at par with treatments T4 and T6 during 2010-11 and, with treatment T_6 during 2011-12 and in pooled analysis. Stem girth affected significantly during 2nd year and in pooled only. In the year 2010-11 maximum stem girth (39.9 cm) was recorded in treatment T_6. In pooled analysis treatment T_8 recorded maximum stem girth but it was at par with treatments T_4, T_5, T_6 and T_7 (Table 1).

With respect to yield attributes, significantly maximum fruits/plant was recorded in treatment T8 during 2010-11 and in pooled analysis, but was at par with treatment T_6 in both the cases. Fruit weight was also affected significantly due to different treatments and maximum fruit weight 1.08 kg, 1.03 kg and 1.06 kg was recorded in treatment T8 during 2009-10, 2010-11 and in pooled analysis, respectively (Table 2). The application of organic manures helped for increasing the available major nutrients as well as other essential nutrients. The higher nutrient content and metabolic levels enhanced the growth parameters, ultimately leading to higher yield (Singh and Varu, 2013) [16]. The results are also in close conformity with the findings of Ravishankar *et al.* (2010) [13] in papaya.

Fruit yield of papaya was not found significant during 1st year but during succeeding year and in pooled analysis, it was found significant (Table 3). In the year 2010-11 significantly highest papaya fruit yield was recorded in treatment T6 followed by treatments T_4, T_5, T_7 and T_8. Similarly, maximum papaya fruit yield in the year 2011-13 and in pooled was recorded in treatment T_8 but it was at par with treatments T_4 and T_6 except during 2011-12. 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 (Shivakumar *et al.,* 2012) [15]. Similar variation in papaya fruit yield due to different sources of organics *viz.*, FYM, urban compost, rural compost, sun hemp green manure and vermicompost had also been reported by Reddy *et al.* (2010) [14].

Fruit quality parameters of papaya *i.e.* acidity, ascorbic acid, TSS, reducing sugar and self life are also affected significantly due to treatment effects (Table 4 to 6). In the year 2011-12 treatments T_1, T_3 and T_5 recorded significantly highest acidity (0.025 %) but in pooled analysis, acidity it was observed maximum (0.028 %) in treatments T_1 and T_3 only. In contrary to acidity, significantly highest ascorbic acid content in pooled was noted in treatment T3 followed by treatment T_8 and T_2 (Table 4). Quality parameters like TSS and reducing sugar were affected significantly in the year 2009-10 only. With respect to TSS, maximum TSS content (7.6 %) was recorded in treatment T_8 followed by treatment T_4 and T_6. While maximum reducing sugar content (6.0 %) was recorded in treatment T_6 which was at par with treatments T_2, T_3, T_4, T_5 and T_8. In the case of self life, it was affected significantly during 2010-11 and 2011-12 only (Table 5). Maximum 7.0 days and 7.9 days of shelf life of papaya fruit was noted in the year 2010-11 and 2011-12, respectively (Table 6). Improvement in fruit quality might be due to increased continuous supply of nutrients, higher concentration of soil enzymes, soil micro organism, rapid mineralization and transformation of plant nutrients in soil and also growth promoting substances produced by microorganism. The results are in agreement with the finding of Kumar *et al.* (2010) [6] and Yadav *et al*. (2011) [17].

Table 1: Effect of different treatments on growth parameters of papaya

Treatments	Plant height (cm)				Stem girth (cm)			
	2009-10	2010-11	2011-12	Pooled	2009-10	2010-11	2011-12	Pooled
T_1	112.3	113.3	110.4	112.0	28.5	28.6	29.5	28.9
T_2	107.6	114.8	111.8	111.4	30.0	24.6	34.3	29.6
T_3	105.4	119.1	115.9	113.5	32.3	26.2	31.1	29.9
T_4	122.1	140.0	135.9	132.7	31.2	30.6	34.0	32.0
T_5	112.4	119.8	121.7	118.0	33.4	32.3	31.2	32.3
T_6	124.5	129.9	141.0	131.8	36.7	39.9	35.8	37.5
T_7	114.7	110.8	120.6	115.4	32.3	31.7	31.8	31.9
T_8	123.8	145.8	147.9	139.2	34.1	33.9	37.5	35.2
S.Em.±	4.9	7.1	3.5	3.1	1.6	1.3	2.0	1.4
C.D. @ 5%	NS	21.4	10.5	8.8	NS	3.9	NS	4.1
C.V. %	7.3	9.8	4.8	7.6	8.44	7.2	10.52	8.9
YxT Int.				NS				NS

Table 2: Effect of different treatments on yield attributes of papaya

Treatments	No. of fruits/plant				Fruit weight (kg)			
	2009-10	2010-11	2011-12	Pooled	2009-10	2010-11	2011-12	Pooled
T_1	22.2	20.7	24.3	22.4	0.84	0.80	0.84	0.82
T_2	23.2	21.8	24.0	23.0	0.87	0.82	0.87	0.85
T_3	23.4	20.8	24.0	22.7	0.87	0.76	0.87	0.81
T_4	24.6	22.4	24.1	23.7	0.87	0.89	0.87	0.90
T_5	22.3	22.3	24.1	22.9	0.89	0.90	0.89	0.88
T_6	26.0	25.1	25.9	25.7	0.97	0.91	0.97	0.93
T_7	22.5	22.5	24.1	23.1	0.88	0.90	0.88	0.90
T_8	24.6	24.9	25.3	24.9	1.08	1.03	0.99	1.06
S.Em.±	0.8	0.5	0.8	0.4	0.03	0.02	0.04	0.02
C.D. @ 5%	NS	1.6	NS	1.2	0.08	0.07	NS	0.07
C.V. %	6.3	4.1	5.75	5.5	5.29	4.69	7.06	5.6
YxT Int.				NS				NS

Table 3: Effect of different treatments on yield of papaya

Treatments	Fruit Yield (t/ha)			
	2009-10	2010-11	2011-12	Pooled
T_1	51.4	50.1	52.6	51.3
T_2	54.1	52.5	59.1	55.2
T_3	55.8	54.5	57.0	55.8
T_4	60.5	59.6	62.6	60.9
T_5	55.3	63.1	57.7	58.7
T_6	59.3	66.1	64.7	63.4
T_7	56.5	61.4	62.0	59.9
T_8	60.8	63.6	69.7	64.7
S.Em.±	2.0	3.5	2.2	1.5
C.D. @ 5%	NS	10.6	6.8	4.3
C.V. %	6.31	10.3	6.4	7.9
YxT Int.				NS

Table 4: Effect of different treatments on acidity and ascorbic acid content in papaya fruit

Treatments	Acidity (%)				Ascorbic acid (mg/100g)			
	2009-10	2010-11	2011-12	Pooled	2009-10	2010-11	2011-12	Pooled
T_1	0.028	0.030	0.025	0.028	21.8	21.5	21.3	21.5
T_2	0.023	0.023	0.016	0.021	21.6	23.3	21.9	22.3
T_3	0.029	0.030	0.025	0.028	22.8	21.0	22.1	21.9
T_4	0.029	0.028	0.023	0.027	20.5	22.3	21.5	21.5
T_5	0.029	0.027	0.025	0.027	22.1	21.1	21.5	21.6
T_6	0.024	0.023	0.018	0.022	22.2	20.5	22.1	21.5
T_7	0.026	0.029	0.020	0.025	25.2	23.6	22.1	23.6
T_8	0.025	0.025	0.017	0.022	23.4	23.8	23.3	23.4
S.Em.±	0.002	0.002	0.001	0.001	1.4	0.5	0.8	0.5
C.D. @ 5%	NS	NS	0.003	0.002	NS	1.4	NS	1.5
C.V. %	10.911	10.989	8.901	10.7	10.5	3.6	6.1	7.4
YxT Int.				NS				NS

Table 5: Effect of different treatments on TSS and reducing sugar in papaya fruit

Treatments	TSS (%)				Reducing sugar (%)			
	2009-10	2010-11	2011-12	Pooled	2009-10	2010-11	2011-12	Pooled
T_1	6.6	6.7	7.2	6.8	4.8	5.8	5.9	5.5
T_2	6.8	6.9	6.8	6.8	5.6	5.5	5.7	5.6
T_3	6.8	6.7	6.9	6.8	5.7	5.7	5.7	5.7
T_4	7.4	6.6	6.5	6.9	5.8	5.6	5.8	5.7
T_5	6.8	6.7	7.0	6.8	5.7	5.8	5.9	5.8
T_6	7.4	6.6	7.1	7.0	6.0	6.1	6.2	6.1
T_7	6.9	6.8	7.0	6.9	5.1	6.0	5.5	5.5
T_8	7.6	7.0	6.9	7.1	5.9	6.0	6.1	6.0
S.Em.±	0.1	0.160	0.2	0.2	0.1	0.1	0.1	0.1
C.D. @ 5%	0.4	NS	NS	NS	0.4	NS	NS	NS
C.V. %	2.9	4.10	5.7	4.4	3.9	4.0	3.8	3.9
YxT Int.				NS				NS

Table 6: Effect of different treatments on self life of papaya

Treatments	Self life (days)			
	2009-10	2010-11	2011-12	Pooled
T_1	6.1	6.8	6.1	6.3
T_2	6.1	7.0	6.2	6.4
T_3	6.2	6.3	6.4	6.3
T_4	6.5	6.4	6.9	6.6
T_5	6.6	6.5	6.6	6.5
T_6	6.2	6.7	7.0	6.6
T_7	6.7	6.8	6.7	6.7
T_8	6.9	6.3	7.9	7.0
S.Em.±	0.2	0.1	0.2	0.2
C.D. @ 5%	NS	0.2	0.5	NS
C.V. %	6.1	2.1	4.6	4.6
YxT Int.				NS

Banana

The results regarding the growth parameters, yield attributes, yield and quality of banana are reported in table 7 to 11. Plant height of banana was affected significantly due to treatments effect. Maximum plant height (179.9 cm) was recorded with treatment T_3 which was at par with treatments T_4, T_6, T_7 and T_8 in the year 2011-12. Whereas in the pooled analysis significantly maximum plant height of 180.6 cm was observed with treatment T_4 followed by treatments T_3, T_6, T_7 and T_8. Pseudostem girth of banana was not affected significantly due to different treatments during individual year but in the pooled analysis it was found significant. Significantly maximum pseudostem girth (52.8 cm) was observed in treatment T_5 followed by treatments T_2, T_3 T_4 and T_6 (Table 7). Increase in yield attributes could be due to the increase in morphological traits such as plant height, girth, number of functional leaves, leaf area index, faster rate of leaf production and also higher nutrient uptake by the plants. Increased number of leaves might have increased the photosynthetic activity resulting in higher accumulation of carbohydrates. Relatively higher carbohydrates could have promoted the growth rate and in turn increased bunch weight. This was also in accordance with the results of Chezhiyen *et al.* (1999) [4] and Baiea and Gioushy (2015) [1] in banana.

Some yield attributing characters are also significantly affected due to different treatments. Number of finger/bunch was found significant during 2010-11 and in pool. Here maximum finger/bunch was noted with the treatment T8 which was at par with treatments T_2, T_4 and T_7 in both the cases (Table 8). In the case of weight of bunch and yield, these parameters were significantly affected during the year 2010-11, 2012-13 and in pooled. Maximum bunch weight was recorded in the treatment T_2 in every year. Similarly, maximum yield (t/ha) was observed in with treatment T8 during the year 2010-11, 2012-13 and in pooled analysis but was at par with treatment T_2 in pooled analysis (Table 9). The increase in finger weight might be due to the increase in production of promoting endogenous and enhancement of nutrient uptake in addition to the role of nitrogen on productivity of banana plants (Nijjar, 1985) [10]. Any factor that stimulates higher finger production and favours better finger development leads to better bunch weight. Higher yield response owing to application of organics ascribed to improved physical, chemical and biological properties of soil resulting in better supply of plant nutrients, which in turn led to good crop growth and yield. Humus substance present in organic product could have mobilized the reserve food materials to the sink through increased activity of hydrolyzing and oxidizing enzymes. These products would help the better availability and utilization of nutrients. All these positive effect might have facilitated quick mobilization and availability of nutrients that would aid in increased plant height, number of leaves, leaf area, leaf area index and photosynthetic rate. This in turn would have assisted for the increased yield of banana. This is in confirmation with the findings of Bharadwaj and Omanwar (1994) [2] and Kuttimani *et al.* (2013) [7] in banana.

Treatments effect were not found significant with respect to quality parameters of banana fruit *i.e.* TSS, acidity and shelf life (Table 10-11). Only acidity in the pooled analysis found significant. The maximum acidity was found in treatments T_6 and T_7 which were at par with most of the treatments. The results are also in accordance with Rajulapudi (2013) [12].

Table 7: Effect of different treatments on growth parameters of banana

Treatments	Plant height (cm)				Pseudostem girth (cm)			
	2010-11	2011-12	2012-13	Pooled	2010-11	2011-12	2012-13	Pooled
T_1	155.0	149.6	167.8	157.5	49.7	46.4	52.3	49.5
T_2	157.1	151.4	185.3	164.6	51.8	48.3	54.0	51.4
T_3	172.2	179.9	176.9	176.3	51.6	48.3	53.3	51.1
T_4	186.7	179.3	175.8	180.6	51.0	47.7	52.9	50.5
T_5	166.1	152.2	183.6	167.3	53.0	49.8	55.7	52.8
T_6	169.7	165.4	184.0	173.0	52.2	49.0	52.8	51.3
T_7	165.8	172.0	174.2	170.7	48.1	44.8	50.3	47.7
T_8	185.2	176.7	179.3	180.4	49.9	46.6	52.8	49.8
S.Em.±	8.1	7.1	6.4	4.4	1.8	1.7	2.0	0.9
C.D. @ 5%	NS	21.7	NS	12.4	NS	NS	NS	2.6
C.V. %	8.24	7.46	6.18	7.3	6.1	6.1	6.6	6.3
YxT Int.				NS				NS

Table 8: Effect of different treatments on yield attributes of banana

Treatments	No. of hand/bunch				No. of finger/bunch			
	2010-11	2011-12	2012-13	Pooled	2010-11	2011-12	2012-13	Pooled
T_1	8.1	8.5	8.0	8.2	110.6	111.3	109.3	110.4
T_2	9.6	9.4	9.3	9.4	136.8	127.3	136.0	133.4
T_3	8.8	9.2	8.7	8.9	105.4	112.8	114.7	110.9
T_4	9.0	9.4	8.7	9.0	138.3	122.3	128.0	129.6
T_5	9.5	10.0	9.3	9.6	129.7	121.5	117.7	122.9
T_6	8.5	8.9	8.3	8.6	105.4	116.5	116.7	112.9
T_7	9.6	9.6	9.3	9.5	127.7	133.2	134.0	131.6
T_8	9.7	9.2	9.3	9.4	145.2	135.3	140.4	140.3
S.Em.±	0.7	0.6	0.7	0.3	5.77	6.22	9.12	3.9
C.D. @ 5%	NS	NS	NS	NS	17.49	NS	NS	11.2
C.V. %	14.06	12.09	13.61	13.3	8.00	8.80	12.68	10.0
YxT Int.				NS				NS

Table 9: Effect of different treatments on yields of banana

Treatments	Weight of bunch (kg)				Yield (t/ha)			
	2010-11	2011-12	2012-13	Pooled	2010-11	2011-12	2012-13	Pooled
T_1	15.1	16.7	15.8	15.9	52.2	55.5	53.3	53.7
T_2	18.7	19.3	18.8	18.9	60.1	61.3	63.0	61.5
T_3	16.8	17.5	16.6	16.4	53.2	56.0	58.3	55.8
T_4	16.2	16.8	18.6	17.2	56.0	58.8	65.4	60.1
T_5	15.2	15.8	15.2	15.4	52.0	54.1	54.3	53.5
T_6	15.2	15.8	17.2	16.1	53.3	55.6	60.5	56.5
T_7	16.8	17.5	17.1	17.1	57.4	56.0	60.0	57.8
T_8	18.1	19.1	18.4	18.5	62.6	63.9	66.6	64.4
S.Em.±	0.6	0.8	0.7	0.4	2.3	2.626	2.9	1.4
C.D. @ 5%	1.9	NS	2.2	1.1	7.1	NS	8.7	4.0
C.V. %	6.7	8.2	7.3	7.4	7.3	7.89	8.3	7.9
YxT Int.				NS				NS

Table 10: Effect of different treatments on TSS and acidity in banana fruit

Treatments	TSS (%)				Acidity (%)			
	2010-11	2011-12	2012-13	Pooled	2010-11	2011-12	2012-13	Pooled
T_1	18.6	18.9	20.5	19.3	0.35	0.34	0.33	0.34
T_2	18.8	18.6	19.6	19.0	0.32	0.31	0.35	0.33
T_3	19.5	19.7	20.0	19.7	0.34	0.33	0.33	0.33
T_4	19.8	20.5	19.6	20.0	0.36	0.35	0.36	0.34
T_5	19.7	19.1	19.6	19.4	0.33	0.32	0.35	0.33
T_6	19.6	19.4	19.7	19.6	0.35	0.34	0.35	0.35
T_7	19.8	20.0	20.3	20.0	0.35	0.33	0.36	0.35
T_8	20.8	21.0	19.4	20.1	0.32	0.33	0.32	0.32
S.Em.±	0.6	0.7	0.8	0.4	0.01	0.01	0.02	0.01
C.D. @ 5%	NS	NS	NS	NS	NS	NS	NS	0.02
C.V. %	5.0	6.4	6.6	6.1	6.90	6.81	7.96	7.3
YxT Int.				NS				NS

Table 11: Effect of different treatments on self life of banana

Treatments	Self-life (days)			
	2010-11	2011-12	2012-13	Pooled
T_1	10.5	10.7	11.3	10.8
T_2	11.0	11.2	10.7	11.0
T_3	10.2	12.0	11.0	11.1
T_4	10.6	10.5	11.3	10.8
T_5	11.5	11.2	10.2	11.0
T_6	11.0	11.4	11.5	11.3
T_7	11.3	11.8	11.0	11.4
T_8	11.4	11.5	10.8	11.2
S.Em.±	0.321	0.409	0.3	0.3
C.D. @ 5%	NS	NS	NS	NS
C.V. %	5.08	6.27	4.3	5.3
YxT Int.				NS

Economics

Considering yield and cost of cultivation, gross as well as net income was computed (Table 12 and 13). Among the different organic treatments, application of 25%N through biocompost + 40%N through vermicompost + 15%N through castor cake along with 2.0 liter banana pseudostem sap per plant (T_8) recorded about 26 per cent more yield and higher net income of Rs. 487115 over T1 as lowest net return of Rs. 370125 was obtained with the application of 50%N through biocompost + 50%N through vermicompost (T_1) in papaya (Table 12). Similarly, treatment T8 also recorded higher net return (Rs. 410036) for banana production by producing about 20 per cent more fruit yield compared to treatment T1. The cumulative effect of treatment T8 was also reflected on papaya-banana relay system which gained higher net return (Rs. 897151), whereas lower net return of Rs. 698917 was obtained with treatment T6 (Table 13 to 14).

The benefit:cost ratio was higher as 4.4 and 3.0 in papaya and banana, respectively with the application of 50%N through biocompost + 30%N through vermicompost along with 2.0 liter banana pseudostem sap per plant (T_5). Efficacy of different fertilizer treatments was worked out by computing the gross and net returns and benefit:cost ratio. Application of 25%N through biocompost + 40%N through vermicompost + 15%N through castor cake along with 2.0 liter banana pseudostem sap per plant resulted in higher yield reflected in terms of fruit and bunch weight yield/ha of papaya and banana resulting in higher net return. Whereas, the higher benefit:cost ratio in individual crop production and in papaya-banana relay system was achieved due to less cost of cultivation and satisfactory yield in treatment T_5. For recommendation of relay system more emphasis is given to benefit:cost ratio, and here in papaya-banana relay system the maximum benefit:cost ratio (3.6) was gained with the treatment T_5 which showed their feasibly under organic farming. Similar to this using organic manures Bhavidoddi (2003) [3] and Italiya (2010) registered higher net returns and B:C ratio in banana and papaya, respectively.

Table 12: Economics of different treatments in papaya

Treatments	Yield (t/ha)	Gross income (Rs/ha)	Cost of cultivation (Rs/ha)	Net income (Rs/ha)	CBR
T_1	51.3	513000	142875	370125	3.6
T_2	55.2	552000	152802	399198	3.6
T_3	55.8	558000	162729	395271	3.4
T_4	60.9	609000	148090	460910	4.1
T_5	58.7	587000	133451	453549	4.4
T_6	63.4	634000	195120	438881	3.2
T_7	60	600000	174524	425476	3.4
T_8	64.7	647000	159885	487115	4.0

Table 13: Economics of different treatments in banana

Treatments	Yield (t/ha)	Gross income (Rs/ha)	Cost of cultivation (Rs/ha)	Net income (Rs/ha)	CBR
T_1	53.7	537000	199438	337562	2.7
T_2	61.5	615000	219497	395503	2.8
T_3	55.8	558000	239553	318447	2.3
T_4	60.1	601000	210071	390929	2.9
T_5	53.5	535000	180589	354411	3.0
T_6	56.5	565000	304963	260037	1.9
T_7	57.8	578000	263446	314553	2.2
T_8	64.4	644000	233964	410036	2.8

Table 14: Economics of relay system (papaya-banana)

Treatments	Gross income (Rs/ha)	Cost of cultivation (Rs/ha)	Net income (Rs/ha)	CBR
T_1	1050000	342313	707687	3.1
T_2	1167000	372299	794701	3.1
T_3	1116000	402282	713718	2.8
T_4	1210000	358161	851839	3.4
T_5	1122000	314040	807960	3.6
T_6	1199000	500083	698917	2.4
T_7	1178000	437970	740030	2.7
T_8	1291000	393849	897151	3.3

Selling price of papaya **&** banana: Rs. 10/kg, Selling price of sugarcane: Rs. 240/t; Price of fertilizer: bio-compost: Rs. 400/t, vermicompost : Rs. 3000/t, castor cake: Rs. 7400/t, Price of BPS: Rs. 5/lit

Conclusions

From the field investigations, it is concluded that papaya responded favorably to the application of 25 per cent N through biocompost, 40 per cent N through vermicompost and 15 per cent N through castor cake and it is responded well with the addition of banana pseudostem sap @ 2 l/ha (T_8). In case of banana, similar trend was observed as observed with papaya yield. But here application of 50 per cent N through biocompost and 50 per cent N through castor cake also gave considerable yield of banana. Taking into consideration of quality parameters of both the crops, it is inferred that application of organic manures significantly affects the quality of the fruits. Even though, treatment T8 gave high yield and monitory return in both the sole crop and papaya-banana relay system, high B:C ratio was observed with the application of 50 per cent N through biocompost and 30 per cent N through vermicompost in addition with banana pseudostem sap @ 2 l/ha. The high B:C ratio in this treatment was observed due to less cost of cultivation and satisfactory yield. Hence, nutrient management practice of 50 per cent N through biocompost and 30 per cent N through vermicompost combined with banana pseudostem sap @ 2 l/ha has been found to be an ideal option to achieve high economic yield under sole papaya or banana crop or papaya-banana relay system under organic farming in South Gujarat region.

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