J. Hortl. Sci.
Vol. 12(1) : 23-32, 2017

Original Research Paper

Effect of Integrated Nutrient Management on Mango (*Mangifera indica* L.) cv. Himsagar

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ABSTRACT

A field experiment was carried out for two years (2012-13 and 2013-14) to study the effect of integrated nutrient management comprising of biofertilizers (*Azospirillum*, *Azotobacter*, *Trichoderma* and *Pseudomonas*) conjointly with chemical fertilizers and organic manures on growth, yield and quality as well as soil chemical properties of mango cv. Himsagar at Bidhan Chandra Krishi Viswavidyalaya, Regional Research Station, Gayeshpur. Result revealed that treatment with half (1000:500:1000 g NPK/tree) + 50 kg FYM + *Azospirillium* (250 g) + 100 g potassium mobiliser (T_6) recorded maximum plant height (5.79 m), girth (64.91 cm) and plant spread in east-west (5.63 m) and north-south direction (5.46 m) than the other treatments. The treatment T_8 consisting of half (1000:500:1000 g NPK/tree) + 50 kg FYM + 5 kg vermicompost + 100 g potassium mobiliser recorded maximum number of fruits (230.31 / tree), fruit weight (261.48 g), yield (60.22 kg /tree) and also have a significant improvement in terms of TSS (19.66 ^{0}Brix), total sugars (16.48 %), ascorbic acid (33.56 mg/100 g pulp), â-carotene (6935 µg/100g pulp) and shelf life (9 days) at room temperature as compared to other treatments, concomitant with higher values of soil (N-198.22 kg/ha, P-58.44 kg/ha and K-326.93 kg/ha) and leaf nutrient (N-1.77 %, P-0.67 % and K-1.08 %) contents.

Key words: bio-fertilizers, organic mulching, fruit quality, shelf life.

INTRODUCTION

Mango (*Mangifera indica* L.) is an important fruit crops of India because of its wide adaptability, delicious taste and high nutritive value. India is the largest producer of mango in the world with an area of 25.16 lakh ha and production of 184.31 lakh tonnes, share 45.1 % of total mango production in the world with a productivity of 7.3 MT/ha. Chemical fertilizers are mostly in use for supplying nutrient elements for proper growth and yield of mango. Owing to increasing cost of fertilizer, their short supply and sustainability issues, it is felt desirable to reduce the dependence on chemical fertilizers. Therefore, an investigation was carried out to identify the suitable integration of different sources of nutrients viz. chemical fertilizers, organic manures and biofertilizers with respect to plant growth, yield and quality of mango fruits.

MATERIAL AND METHODS

An experiment was conducted during 2012-13 and 2013-14 at Bidhan Chandra Krishi Viswavidyalaya Regional Research Station, Gayeshpur, West Bengal. Twelve years old trees of mango cv. Himsagar of uniform vigor and size, planted at 10x10 m distance and maintained under uniform cultural practices were selected for study. The experiment comprised ten (10) treatments and replicated thrice. The treatments are as follows:

T_1: 1000 : 500 : 1000 g NPK/tree/year (control)

T_2: T_1 + Zn (0.5 %) + B (0.2 %) + Mn (0.1 %) + Ca (0.6 %) as foliar spray twice (August and October)

T_3: T_1 + Organic mulching (10 cm thick)

T_4: T_2 + Organic mulching (10 cm thick)

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T_5: ½ T_1 + 50 kg FYM + *Trichoderma* (250 g) + Potassium mobiliser (100 g)

T_6: ½ T_1 + 50 kg FYM + *Azospirillum* (250 g) + Potassium mobiliser (100 g)

T_7: ½ T_1 + 50 kg FYM + *Azotobacter* (250 g) + Potassium mobiliser (100 g)

T_8: ½ T_1 + 50 kg FYM + 5 kg Vermicompost + Potassium mobiliser (100 g)

T_9: ½ T_1 + 50 kg FYM + *Pseudomonas florescence* (250 g) + Potassium mobiliser (100 g)

T_{10}: ½ T_1 + 50 kg FYM + *Trichoderma* (250 g) + *Pseudomonas florescence* (250 g) + Potassium mobiliser (100 g)

The vegetative growth parameters like plant height (m), plant girth (cm) and canopy spread (east-west and north-south directions in meter) were recorded by standard methods. For yield parameters, average number of fruits per tree, average yield per tree (kg) and average weight of fruit (g) were recorded. The yield was recorded by weighing the fruits at the time of each picking. Fifty uniform mature fruits from each tree were used for recording of various fruit quality parameters. Bio-chemical composition like total sugars, ascorbic acid and β-carotene were estimated using standard procedures as described by Ranganna, 1986. Acidity was analyzed following standard methods (A.O.A.C., 1990). The TSS of fruit pulp was determined with the help of Zeiss hand refractometer. Shelf-life of fruit at room temperature was recorded by keeping ten mature fruits per treatment in three replicates for each treatment at room temperature for ripening without deterioration of fruits. The soil and leaf mineral content (N, P and K) were also estimated using standard procedure viz. soil available nitrogen by alkaline permanganate method (Jackson, 1973), phosphorous (P_2O_5) by Bray and Kurtz No. 1 method (Bray and Kurtz, 1945) and potassium by Flame photometry (Black, 1965) using ammonium acetate as an extractant; leaf nitrogen was determined by Micro-Kjeldahl method as described by Black (1965), phosphorous by Vanadomolybdate phosphoric acid method as described by Jackson (1973) and potassium with the help of photometer (Piper, 1956). The data were analyzed statistically as described by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Effect on plant growth

All the growth parameters, *viz*. plant height, plant girth and canopy spread (east-west and north-south directions) were significantly influenced by the treatments (Table 1). However, T_6 showed maximum plant height (5.79 m), plant girth (64.91 cm) and canopy spread (5.63 m in east-west and 5.46 m in north-south direction) and the minimum was recorded with control. These findings are similar with the findings of Shulka *et al.* (2009). The higher increase in plant height and spread may be due to the build up of colonies of the applied bio-fertilizer inoculates and their growth promoting effects including the synthesis of plant growth promoting substances as mentioned by Tien *et al*. (1979) and Sharma and Bhutani (1998).

Effect on fruit set, fruit weight and yield

Fruiting was significantly influenced by integrated nutrient management. Fig.1 showed that maximum number of fruits (230.31/tree) harvested was in T_8 whereas; the least nos. of fruits (176.71/tree) was recorded in control (T_1). The highest average fruit weight (261.48 g) was in T_8 which was at par with T_7 whereas; the lowest (211.57 g) was in T_3 (Fig.2). T_8 recorded the highest fruit yield (60.22 kg/tree) and T_3 the lowest (39.27 kg/tree) as indicated in Fig.3. These results are in line with the findings of Gautam *et al*. (2012) in mango and Bhutani *et al*. (2012) in banana. The significant improvement in fruiting on account of vermicompost application along with inorganic sources of NPK may be attributed to the translocation of nutrients from soil and enhanced supply of macro and micro-nutrients during entire growing seasons and microbial deposition (Mishra *et al.,* 2011).

Table 1: Effect of integrated nutrients management on growth of mango cv. Himsagar

Treatments	Plant height (m)			Plant girth (cm)			Tree canopy spread (m)					
							East-west			North-south		
	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled
T_1	4.64	4.95	4.80	58.96	63.86	61.41	4.14	4.45	4.30	4.36	4.64	4.50
T_2	4.68	4.98	4.83	56.48	61.58	59.03	4.26	4.55	4.41	4.46	4.75	4.61
T_3	5.14	5.45	5.30	61.35	66.25	63.80	4.90	5.20	5.05	4.95	5.20	5.08
T_4	5.12	5.42	5.27	61.30	66.32	63.81	4.68	4.98	4.83	4.98	5.28	5.13
T_5	5.39	5.72	5.56	58.98	63.88	61.43	5.15	5.32	5.24	5.11	5.42	5.27
T_6	5.63	5.95	5.79	62.46	67.36	64.91	5.48	5.78	5.63	5.30	5.62	5.46
T_7	4.97	5.32	5.15	56.48	61.38	58.93	4.78	5.12	4.95	4.85	5.15	5.00
T_8	4.97	5.30	5.14	59.90	64.70	62.30	4.70	5.10	4.90	4.69	4.98	4.84
T_9	5.51	5.86	5.69	58.28	63.28	60.78	5.16	5.42	5.29	4.70	5.00	4.85
T_{10}	5.26	5.58	5.42	57.36	62.36	59.86	4.98	5.26	5.12	4.86	5.05	4.96
SE±m	0.05	0.08	0.05	0.48	0.75	0.71	0.03	0.05	0.07	0.04	0.07	0.07
CD (p = 0.05)	0.17	0.27	0.16	1.48	2.33	2.19	0.10	0.17	0.24	0.13	0.24	0.23

T_1: 1000 : 500 : 1000 g NPK/tree/year (control); T_2: T_1 + Zn (0.5 %) + B (0.2 %) + Mn (0.1 %) + Ca (0.6 %) as foliar spray twice (August and October); T_3: T_1 + paddy straw mulching (10 cm thick); T_4: T_2 + paddy straw mulching (10 cm thick); T_5: ½ T_1 + 50 kg FYM + *Trichoderma* (250 g) + Potassium mobiliser (100 g); T_6: ½ T_1+ 50 kg FYM + *Azospirillum* (250 g) + Potassium mobiliser (100 g); T_7: ½ T_1+ 50 kg FYM + *Azotobacter* (250 g) + Potassium mobiliser (100 g); T_8: ½ T_1 + 50 kg FYM + 5 kg Vermicompost + Potassium mobiliser (100 g); T_9: ½ T_1+ 50 kg FYM + *Pseudomonas florescence* (250 g) + Potassium mobiliser (100 g); T_{10}: ½ T_1+ 50 kg FYM + *Trichoderma* (250 g) + *Pseudomonas florescence* (250 g) + Potassium mobiliser (100 g)

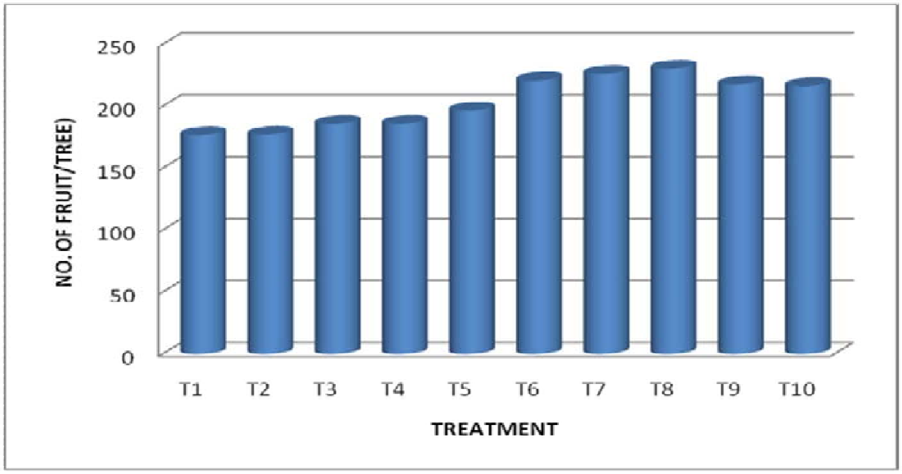

Fig.1: Effect of integrated nutrient management on no. of fruits/tree

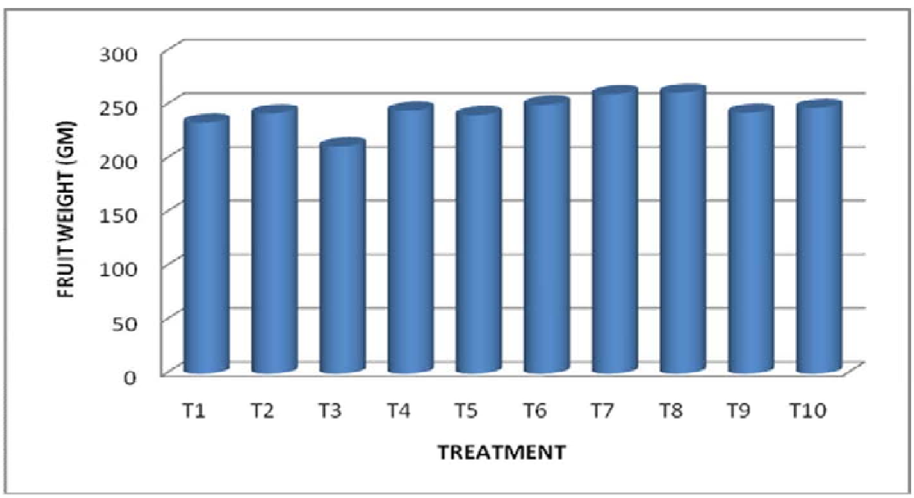

Fig.2: Effect of integrated nutrient management on fruit weight (g)

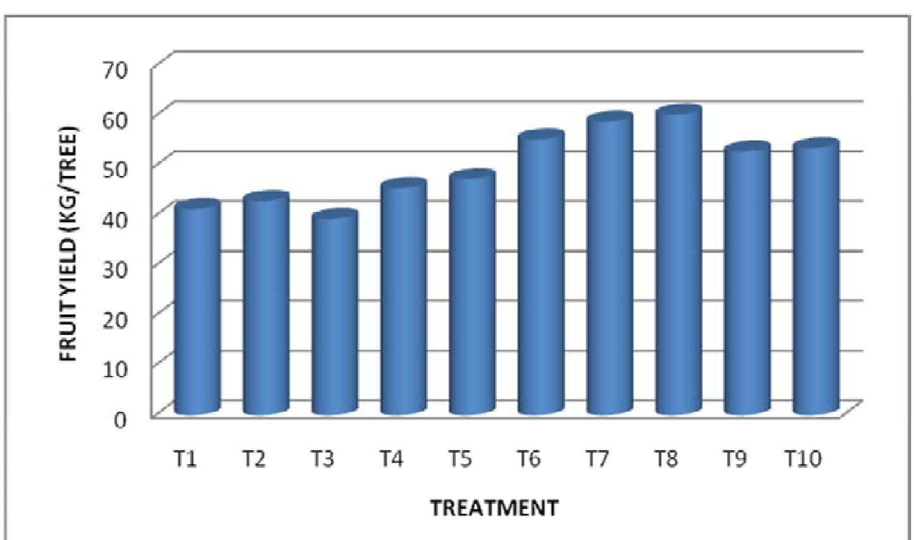

Fig.3: Effect of integrated nutrient management on fruit yield (kg/tree)

Effect on bio-chemical composition of fruits

Variation in TSS, total sugars, acidity, ascorbic acid and β-carotene of mango cv. Himsagar were significant among the treatments. It is clear from Table 2 that lowest acidity content (0.25 %) was recorded in T_8 which was at par with T_2 and T_7 whereas, the highest content (0.34 %) of acidity in the fruit was in T_4 which was statistically at par with T_6 and T_3. T_8 recorded the highest TSS (19.66 °Brix), which was however at par with T_7 (19.27 °Brix) whereas the minimum TSS (17.81 °Brix) was recorded in T_4. Similarly, T_8 recorded the highest total sugars (16.48%), ascorbic acid (33.56 mg/100 g pulp) and beta-carotene (6935 µg/100g pulp) content. This can be attributed to better growth of plants due to vermicompost, which might have favored the accumulation of higher sugars, less acidity and better ascorbic acid content. These findings are in line with the findings of Patel and Naik (2010) in sapota and Singh *et al*. (2010) in papaya.

Effect on shelf life of fruits

It was observed from Fig.3 that T_8 recorded maximum shelf life (9 days) whereas T_2 reduced the shelf life (5 days) at room temperature. These findings are in conformity with Hazarika and Ansari (2010) in banana where they pointed out that treatments with 50 % inorganic fertilizers, vermicompost and biofertilizers improved the shelf life which may be due to beneficial effect of vermicompost. Patel and Naik (2010) also noted that application of vermicompost and chemical fertilizers proved best in respect of extending post harvest shelf-life of sapota.

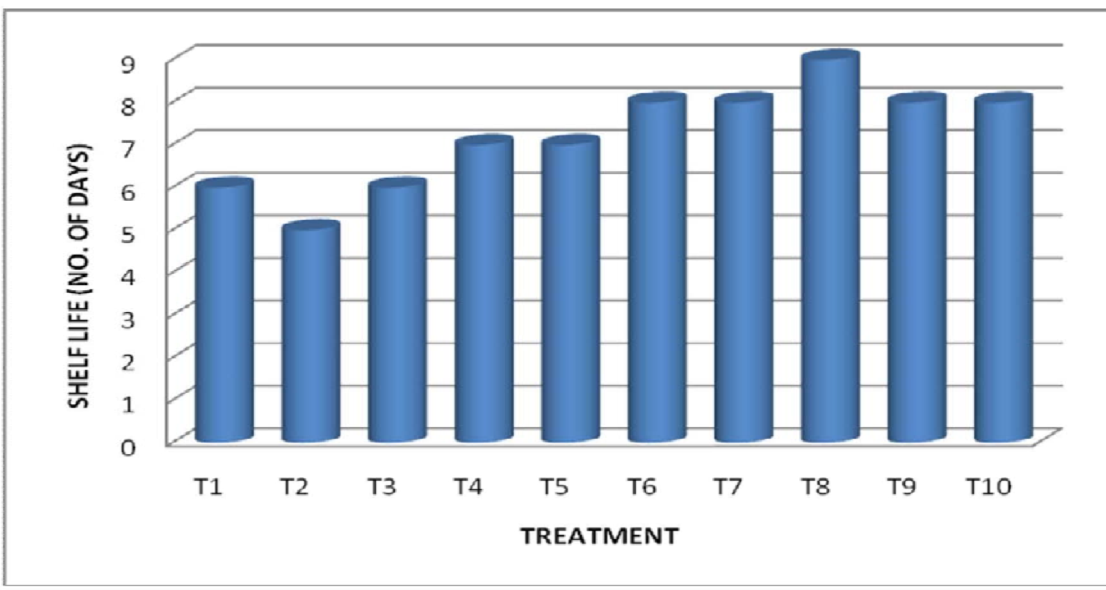

Fig.4: Effect of integrated nutrient management on shelf life of fruits at room temperature (no. of days)

Table 2: Effect of integrated nutrient management on bio-chemical parameters of mango cv. Himsagar

Treatments	Total soluble solids (°Brix)			Titratable acidity (%)			Total sugars (%)			Ascorbic acid (mg/100g)			β-carotene(µg/100g pulp)		
	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled
T_1	18.08	18.89	18.48	0.30	0.28	0.29	14.48	14.52	14.50	30.12	30.12	30.12	4955	4968	4962
T_2	17.69	18.55	18.12	0.28	0.26	0.27	14.45	14.48	14.47	30.72	30.92	30.82	5100	5202	5151
T_3	18.85	19.20	19.02	0.32	0.30	0.31	14.55	14.60	14.58	31.42	30.91	31.17	5214	5298	5256
T_4	17.36	18.25	17.81	0.35	0.32	0.34	14.80	14.84	14.82	31.00	31.12	31.06	4979	5025	5002
T_5	18.15	18.85	18.50	0.31	0.28	0.30	15.32	15.36	15.34	31.51	31.49	31.50	5372	5455	5414
T_6	19.00	19.17	19.08	0.34	0.32	0.33	15.46	15.50	15.48	30.76	30.47	30.62	5712	5796	5754
T_7	19.12	19.42	19.27	0.29	0.26	0.28	16.28	16.24	16.26	30.97	30.91	30.94	5843	5915	5879
T_8	19.52	19.80	19.66	0.26	0.24	0.25	16.42	16.55	16.48	32.33	34.78	33.56	6896	6974	6935
T_9	18.26	19.06	18.66	0.30	0.28	0.29	15.23	15.27	15.25	31.12	30.95	31.04	5742	5897	5819
T_{10}	18.12	18.92	18.52	0.29	0.26	0.28	15.02	15.08	15.05	30.14	30.44	30.29	5792	5852	5822
SE±m	0.20	0.18	0.14	0.01	0.008	0.009	0.10	0.10	0.09	0.45	0.39	0.26	45.02	74.74	35.68
CD ($p = 0.05$)	0.62	0.57	0.45	0.04	0.02	0.03	0.31	0.31	0.28	1.40	1.21	0.81	138.74	230.30	109.94

T_1: 1000 : 500 : 1000 g NPK/tree/year (control); T_2: T_1 + Zn (0.5 %) + B (0.2 %) + Mn (0.1 %) + Ca (0.6 %) as foliar spray twice (August and October); T_3: T_1 + paddy straw mulching (10 cm thick); T_4: T_2 + paddy straw mulching (10 cm thick); T_5: ½ T_1 + 50 kg FYM + *Trichoderma* (250 g) + Potassium mobiliser (100 g); T_6: ½ T_1+ 50 kg FYM + *Azospirillum* (250 g) + Potassium mobiliser (100 g); T_7: ½ T_1+ 50 kg FYM + *Azotobacter* (250 g) + Potassium mobiliser (100 g); T_8: ½ T_1 + 50 kg FYM + 5 kg Vermicompost + Potassium mobiliser (100 g); T_9: ½ T_1+ 50 kg FYM + *Pseudomonas florescence* (250 g) + Potassium mobiliser (100 g); T_{10}: ½ T_1+ 50 kg FYM + *Trichoderma* (250 g) + *Pseudomonas florescence* (250 g) + Potassium mobiliser (100 g)

Table 3: Effect of integrated nutrients management on soil nutrient status in mango cv. Himsagar

Before treatment	N (kg/ha)			P (kg/ha)			K (kg/ha)		
	182.74			43.50			272.99		
After treatment	N (kg/ha)			P (kg/ha)			K (kg/ha)		
	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled
T_1	186.88	186.66	186.77	45.75	44.75	45.25	293.68	293.48	293.51
T_2	189.92	189.72	189.82	47.92	46.90	47.41	299.48	299.28	299.31
T_3	182.45	182.25	182.35	45.31	42.53	43.92	288.95	288.75	288.78
T_4	185.88	185.67	185.78	50.69	49.55	50.12	297.36	297.26	297.27
T_5	186.43	186.24	186.34	50.50	49.50	50.00	296.69	297.16	296.85
T_6	184.54	184.35	184.45	57.62	56.62	57.12	292.88	292.66	292.69
T_7	188.38	188.18	188.28	58.64	57.62	58.13	318.70	318.50	318.53
T_8	198.32	198.12	198.22	58.94	57.94	58.44	327.10	326.90	326.93
T_9	192.20	192.10	192.15	49.72	48.72	49.22	306.25	306.10	306.28
T_{10}	183.81	183.61	183.71	51.60	50.64	51.12	297.10	296.90	296.93
SEm ±	0.36	0.35	0.31	0.24	0.21	0.18	0.69	0.65	0.53
CD (p = 0.05)	1.12	1.10	0.98	0.74	0.65	0.55	2.13	2.01	1.64

T_1: 1000 : 500 : 1000 g NPK/tree/year (control); T_2: T_1 + Zn (0.5 %) + B (0.2 %) + Mn (0.1 %) + Ca (0.6 %) as foliar spray twice (August and October); T_3: T_1 + paddy straw mulching (10 cm thick); T_4: T_2 + paddy straw mulching (10 cm thick); T_5: ½ T_1 + 50 kg FYM + *Trichoderma* (250 g) + Potassium mobiliser (100 g); T_6: ½ T_1+ 50 kg FYM + *Azospirillum* (250 g) + Potassium mobiliser (100 g); T_7: ½ T_1+ 50 kg FYM + *Azotobacter* (250 g) + Potassium mobiliser (100 g); T_8: ½ T_1 + 50 kg FYM + 5 kg Vermicompost + Potassium mobiliser (100 g); T_9: ½ T_1+ 50 kg FYM + *Pseudomonas florescence* (250 g) + Potassium mobiliser (100 g); T_{10}: ½ T_1+ 50 kg FYM + *Trichoderma* (250 g) + *Pseudomonas florescence* (250 g) + Potassium mobiliser (100 g)

Table 4: Effect of integrated nutrients management on leaf nutrient status of mango cv. Himsagar

Before treatment	N (%)			P (%)			K (%)		
	1.73			0.53			0.96		
After treatment	N (%)			P (%)			K (%)		
	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled
T_1	1.73	1.72	1.72	0.58	0.56	0.57	0.93	0.92	0.93
T_2	1.62	1.65	1.64	0.60	0.58	0.59	0.86	0.85	0.86
T_3	1.76	1.75	1.75	0.61	0.61	0.61	0.87	0.86	0.87
T_4	1.72	1.71	1.71	0.60	0.58	0.59	0.86	0.85	0.86
T_5	1.75	1.74	1.74	0.52	0.5	0.51	0.86	0.85	0.86
T_6	1.59	1.59	1.59	0.54	0.52	0.53	0.90	0.89	0.90
T_7	1.68	1.68	1.68	0.61	0.61	0.61	0.91	0.90	0.91
T_8	1.79	1.78	1.77	0.69	0.65	0.67	1.08	1.08	1.08
T_9	1.72	1.71	1.71	0.61	0.61	0.61	0.93	0.92	0.93
T_{10}	1.68	1.68	1.68	0.64	0.62	0.63	0.95	0.94	0.95
SEm ±	0.01	0.008	0.01	0.007	0.006	0.006	0.006	0.009	0.008
CD (p = 0.05)	0.05	0.03	0.03	0.02	0.02	0.02	0.02	0.03	0.02

T_1: 1000 : 500 : 1000 g NPK/tree/year (control); T_2: T_1 + Zn (0.5 %) + B (0.2 %) + Mn (0.1 %) + Ca (0.6 %) as foliar spray twice (August and October); T_3: T_1 + paddy straw mulching (10 cm thick); T_4: T_2 + paddy straw mulching (10 cm thick); T_5: ½ T_1 + 50 kg FYM + *Trichoderma* (250 g) + Potassium mobiliser (100 g); T_6: ½ T_1+ 50 kg FYM + *Azospirillum* (250 g) + Potassium mobiliser (100 g); T_7: ½ T_1+ 50 kg FYM + *Azotobacter* (250 g) + Potassium mobiliser (100 g); T_8: ½ T_1 + 50 kg FYM + 5 kg Vermicompost + Potassium mobiliser (100 g); T_9: ½ T_1+ 50 kg FYM + *Pseudomonas florescence* (250 g) + Potassium mobiliser (100 g); T_{10}: ½ T_1+ 50 kg FYM + *Trichoderma* (250 g) + *Pseudomonas florescence* (250 g) + Potassium mobiliser (100 g)

Effect on soil and leaf nutrient content

The results from two years clearly indicated that the soil and leaf nutrient status were significantly influenced by integrated nutrient management. Table 3 revealed that maximum nitrogen (198.22 kg/ha), phosphorus (58.44 kg/ha) and potassium (326.93 kg/ ha) content in the soil was recorded in T_8 whereas, the lowest nitrogen (182.35 kg/ha), phosphorus (43.92 kg/ha) and potassium (288.78 kg/ha) in the soil was for T_3. The increased soil N,P,K might be due to accelerated decomposition of native soil organic matter by addition of organic material, leading to higher mineralization and release of nutrient elements. This is in line with the finding of Raina *et al.* (2011) who also obtained higher soil N, P and K status with the application of FYM, vermicompost and chemical fertilizers. Similarly, maximum nitrogen (1.77 %), phosphorus (0.67 %) and potassium (1.08 %) content in the leaf was observed in T_8 and minimum in T_3 (Table 4). This may be due to the improvement in the physical conditions of soil, root development and more soil moisture retention by the addition of FYM which resulted in increased absorption of water and nutrients and consequently improved the leaf nutrient status (Morselli *et al.*, 2004).

Effect on benefit:cost ratio

Table 5 indicated that benefit:cost ratio was also influenced by different nutrients combinations. The highest benefit:cost was observed in T_8 while lowest was recorded in control. This may be attributed to the higher yield obtained from vermicompost application.

CONCLUSION

From the above study, it can be concluded that integrated application of half RDF (1000 : 500 : 1000 g NPK/tree/year) + 50 kg FYM + 5 kg Vermicompost + 100 g potassium mobiliser may be a better option than application of chemical fertilizers alone for enhancing growth, yield and fruit quality of mango besides improving the soil and leaf nutrient status.

ACKNOWLEDGEMENT

The first author is thankful to the Department of Science and Technology, Government of India for providing financial assistance.

Table 5: Effect of integrated nutrients management on benefit:cost ratio of mango cv. Himsagar

Treatments	Benefit : cost		
	2012	2013	Pooled
T_1	1.52:1	1.54:1	1.53:1
T_2	1.54:1	1.55:1	1.55:1
T_3	1.78:1	1.79:1	1.79:1
T_4	1.92:1	1.94:1	1.93:1
T_5	1.98:1	2.0:1	1.99:1
T_6	2.10:1	2.15:1	2.13:1
T_7	2.14:1	2.16:1	2.15:1
T_8	2.57:1	2.58:1	2.58:1
T_9	2.02:1	2.05:1	2.04:1
T_{10}	2.0:1	2.2:1	2.10:1
SE±m	-	-	-
CD (p = 0.05)	-	-	-

T_1: 1000 : 500 : 1000 g NPK/tree/year (control); T_2: T_1 + Zn (0.5 %) + B (0.2 %) + Mn (0.1 %) + Ca (0.6 %) as foliar spray twice (August and October); T_3: T_1 + paddy straw mulching (10 cm thick); T_4: T_2 + paddy straw mulching (10 cm thick); T_5: ½ T_1 + 50 kg FYM + *Trichoderma* (250 g) + Potassium mobiliser (100 g); T_6: ½ T_1+ 50 kg FYM + *Azospirillum* (250 g) + Potassium mobiliser (100 g); T_7: ½ T_1+ 50 kg FYM + *Azotobacter* (250 g) + Potassium mobiliser (100 g); T_8: ½ T_1 + 50 kg FYM + 5 kg Vermicompost + Potassium mobiliser (100 g); T_9: ½ T_1+ 50 kg FYM + *Pseudomonas florescence* (250 g) + Potassium mobiliser (100 g); T_{10}: ½ T_1+ 50 kg FYM + *Trichoderma* (250 g) + *Pseudomonas florescence* (250 g) + Potassium mobiliser (100 g)

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(*MS Received 05 March 2016, Revised 01 February 2017, Accepted 28 April 2017*)