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Sustainable yield index and soil properties in mango under different nutrient management strategies

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ABSTRACT

A field experiment was conducted during 2012-15 to estimate the sustainable yield index and variations in soil properties in mango under different nutrient management modules in subtropical climatic condition of Lucknow. Inorganic (NPK and micronutrients) and organic sources (FYM, *Azotobacter* and PSM) were tried for improving the mango productivity. The frequency, distribution and quantity of rainfall received were observed to be varied during the mango growing seasons. The pan evaporation was varied between 5.6 to 11.4 mm day^{-1} during fruit developmental stages. A range of 1.29 to 1.44 g cm^{-3} bulk density was recorded in top soil layer (0-10 cm) and it increased down the depths (20-30 cm) to 1.36 to 1.51 g cm^{-3}. An impact of different treatments on WHC was recorded with highest and lowest value as 23.70 and 19.97%, respectively. A range of 39.89 to 48.17% porosity across treatments was revealed. Significant effect of various treatments on soil organic carbon and available N content in soil was revealed. The highest fruit yield of 13.96 and 9.10 t ha^{-1} was recorded in the treatment NPK + Zn, Cu, Mn, B (50% soil + 50% foliar application) over control (6.44 and 3.97 t ha^{-1}), respectively. The highest sustainable yield index (SYI) was in the same treatment (0.90 and 0.87) indicating the fact that for maintaining a sustainable yield level, application of micronutrients both in soil and as foliar spray @ 50% are essentially required in mango growing soils.

Key words: *Mangifera indica*, agroclimatic analysis, biofertilizers, quality.

INTRODUCTION

Sustainability of any agroecosystem is an important challenging task under the deteriorating soil fertility status and changing climate situations. It is more pertinent in fruit orchards from view point of maintaining a satisfactory level of yield/ productivity. Therefore, fruit yield stability is an important aspect to look into as it directly related to the orchard sustainability and livelihood security as well as profitability of growers/stakeholders/ farmers. Productivity under a given set of climatic conditions is a function of nutrient management strategy adopted, crop cultivar, response to the tree and biogeochemical changes occurring within the soil. In this context, integrated nutrient management technology was considered as the best one as neither the inorganic nor the organic alone can sustain the production system. Inclusion of micronutrients in the fruit nutrition/production system has immense potential for quality fruit production. Yang *et al.* (16) recommends K to N ratio as an important factor for Litchi nutrition and production areas in China. Similarly, Gasparatos *et al.* (7) recorded the changes in soil properties, plant nutrient level in apple orchard under different nutrient management system in the Mediterranean climatic condition. Holb and Nagy (8) observed the differential availability of micronutrients in soil-plant system under integrated and organic production system in apple orchards. Similar studies on the role of different nutrients on the quality fruit production system was studied across different agroecology, such as in mango (Raghupathi *et al.*, 12) and grape (Singh *et al.*, 15). The sustainability of any orchard ecosystem depends on the different nutrient management system applied for maintaining an optimum level of fruit production. Higher sustainable yield index (SYI) indicated the best treatment from among different treatment combinations applied (Adak *et al.*, 2). Such treatment combination may be recommended at farmers' field for adoption of fertilizer management. The present study was thus aims to indentify the required nutrition modules for better quality fruit production from view point of sustaining soil fertility as well as productivity.

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MATERIALS AND METHODS

Field experiments were conducted during 2012-15 in the experimental research farm of Central Institute for Sub-tropical Horticulture, Rehmankhera, Lucknow (26.54°N Latitude, 80.45°E Longitude and 127 m above mean sea level), Uttar Pradesh, Lucknow, India. The area falls under subtropical zone. The experiment was carried out with ten treatments in a randomized block design with four replications. The mango cultivar used was Dashehari, planted at a spacing of 10×10 m. The treatments details are presented in Table 1. The recommended doses of NPK were applied as 1000 g N + 500 g P_2O_5 + 1000 g K_2O / tree each year in the form of urea, single super phosphate (SSP) and muriate of potash (MOP) respectively. FYM @ 50 kg / tree was applied each year within the tree basin. Micronutrients Zn, Cu, Mn and B were applied in the form of Zinc sulphate, copper sulphate, Manganese sulphate and Borax respectively. Zn @ 200 g Zinc sulphate / tree, Cu @ 150 g Copper sulphate / tree, Mn @ 150 g Manganese sulphate / tree and B @ 50 g Borax / tree/year was applied. The Biosources in the form of *Azotobacter* + PSM was also applied. Full dose of NPK was applied in soil after harvesting the crop during the month of 1st week of September. Soil application of micronutrients was done during last week of September. Two foliar applications of micronutrients were given at peanut and marble stages of fruit. Irrigation was done on crop phenology basis except on rainy days during fruit growth and development and the irrigation was stopped 15 days before the harvesting of the mango fruit. Real time based crop protection measures for pest and diseases controls were applied throughout the crop period.

Soil samples were collected prior to layout of the experiment and after harvesting of fruit for three consecutive years from 0-30 cm depth within the tree basin using a soil augur before fertilization each year. The soil samples were air dried at room temperature and ground by wooden pestle and mortar. Soils were sieved through 2 mm mesh size sieve and were used for analytical purpose. Soil pH was determined using double distilled water suspension in the ratio of 1:2.5 (w/v), prepared by agitating mechanically for 30 min and filtered through Whatman no. 42 filter paper. Soil organic carbon content was estimated by the standard wet digestion method. Available nitrogen was estimated by alkaline distillation with 0.32% potassium permanganate, Available P was estimated by the Olsen method using spectrophotometer and available K was estimated by extraction with ammonium acetate at pH 7.0 by 'Chemito' AA203D model of atomic absorption spectrophotometer. Composite leaf samples (35 to 40 recently matured leaves) from each treatment replication wise were collected after harvesting and before application of treatments and analyzed for macronutrients as per standard procedures. Soil physical parameters *viz.*, Bulk density (BD), particle density (PD), water holding capacity (WHC) and porosity were determined using undisturbed core samples collected from 0-10, 10-20 and 20-30 cm soil depth from tree basin. Weather conditions (daily weather data of maximum and minimum temperatures, morning and evening relative humidity, rainfall, wind speed, bright sunshine hours and evaporation rates during the experimentation were recorded from the agro-meteorological observatory. Mango fruits were harvested during 3rd week of June, fruit yield was recorded per tree basis and presented per ha basis. For fruit quality analysis ten fruits were randomly collected from each treatment replication wise and acidity, vitamin C and TSS were estimated as per the standard procedures of Ranganna (13). Plant growth parameters like plant height, canopy spread and stem girth were also measured. Mango fruit production stability as a function of different nutrient management modules was measured using sustainable yield index.

Table 1. Treatment details.

T-1	Control
T-2	NPK
T-3	NPK + FYM
T-4	NPK + FYM + Bio.
T-5	NPK + Zn, B (Soil application)
T-6	NPK + Zn, Cu, B (Soil application)
T-7	NPK + Zn, Cu, Mn, B (Soil application)
T-8	NPK + Zn, Cu, Mn, B (Foliar application)
T-9	NPK + Zn, Cu, Mn, B (50% Soil application + 50% Foliar application)
T-10	NPK + Zn, Cu, Mn, B + FYM (Soil application)

The sustainable yield index (SYI) was calculated on the basis of following formula (Singh *et al.*, 14):

$$SYI = (Y - \sigma_{n-1})/Y_m$$

Where Y: average annual fruit yield and Y_m: maximum yield recorded in a given set of treatments from all years; σ_{n-1}: standard deviation. All are used in same units. Higher the SYI value higher is the stability of fruit yields.

The data was analyzed by standard analysis of variance (ANOVA). Univariate statistical analysis and significance was concluded using SAS and Microsoft-Excel software.

RESULTS AND DISCUSSION

The agroclimatic analysis during the periods of experimentation (2012-15) revealed wide spread variations in terms of rainfall received. The frequency, distribution and quantity were also varied during the three consecutive mango growing seasons (Table 2). During the fruit developmental stages (Apr and May) no rainfall received, however unseasonal rainfall of 3.17, 114.70 and 87.20 mm was received during flowering stages (Jan-Feb). The pan evaporation during flowering to fruit setting was ranged between 3.0 to 4.5 mm day-1 whereas a range of 5.6 to 11.4 mm day^{-1} during fruit developmental stages was recorded.

The soil properties across treatments and seasons are presented in the Table 3a and 3b. Significant effect of various treatments on organic carbon and available N content in soil was recorded during 2013-14 mango fruiting season. Organic carbon and available N content in the soil under various treatments varied in the range of 0.38 - 0.57% and 78.84-105.80 mg kg^{-1} respectively. Organic carbon and available N increased in the soil significantly by the treatments comprising N along with FYM. Maximum organic carbon and available N

Table 2. Total rainfall and monthly average pan evaporation during the study periods.

	Total Rainfall (mm)			Pan Evaporation (mm)		
	2012-13	2013-14	2014-15	2012-13	2013-14	2014-15
Sep	247.80	243.20	36.80	3.80	3.40	4.90
Oct	0.00	2.20	30.40	2.90	3.10	3.40
Nov	0.00	0.00	0.00	1.70	2.10	2.60
Dec	0.00	0.00	0.00	1.20	1.80	2.50
Jan	2.01	7.50	60.80	1.50	1.70	2.30
Feb	1.16	107.20	26.40	3.40	3.00	3.20
Mar	4.20	0.00	9.80	4.10	3.70	4.50
Apr	0.00	0.00	0.00	6.30	7.40	8.50
May	0.00	0.00	0.00	7.50	9.00	11.00
Jun	14.20	280.70	24.00	9.20	5.60	11.40

Table 3a. Soil properties as influenced by different nutrient management system in mango.

Treatment	SOC (%)		Avail N (mg/kg)		Avail P (mg/kg)		Avail K (mg/kg)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
T1	0.38	0.44	78.84	68.13	20.92	16.15	118.83	116.88
T2	0.44	0.50	95.20	77.43	20.10	22.40	167.15	152.46
T3	0.55	0.59	102.67	83.30	20.83	21.25	183.43	170.79
T4	0.57	0.54	105.80	85.17	19.08	22.22	166.65	149.99
T5	0.48	0.54	90.08	75.73	21.13	23.80	187.18	177.48
T6	0.47	0.52	89.13	76.77	22.92	23.67	175.07	161.64
T7	0.49	0.51	91.93	74.20	21.53	22.77	156.87	168.48
T8	0.47	0.48	86.88	80.50	20.75	23.80	175.70	161.78
T9	0.49	0.48	90.73	73.50	20.63	21.92	167.40	159.77
T10	0.55	0.54	99.80	93.33	24.10	21.03	196.60	165.24
LSD (0.05)	0.07	0.07	13.56	12.3	NS	NS	NS	24.83

Table 3b. Micronutrients in soil as influenced by different nutrient management system in mango.

Treatment	Fe (mg/kg)		Mn (mg/kg)		Zn (mg/kg)		Cu (mg/kg)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
T1	7.48	8.63	12.11	12.16	1.04	1.12	4.46	4.30
T2	9.69	9.16	13.95	12.90	1.22	1.27	4.39	3.98
T3	9.71	9.00	12.26	13.21	1.84	1.37	4.88	3.69
T4	7.86	9.01	13.57	13.49	1.32	1.20	4.56	4.75
T5	7.96	8.72	12.34	13.51	1.80	1.58	5.52	4.97
T6	7.90	9.93	12.01	12.73	1.41	1.51	5.82	5.59
T7	8.77	9.56	14.13	14.95	1.41	1.61	6.23	5.67
T8	8.88	9.54	12.99	12.93	1.18	1.31	5.36	3.84
T9	8.22	9.07	14.09	14.34	1.54	1.61	5.83	5.93
T10	8.34	9.82	14.09	14.15	1.61	1.57	7.04	5.94
LSD (0.05)	NS	NS	NS	NS	NS	NS	2.4	NS

was recorded in the treatment NPK + FYM + Bio (T_4). Available P varied in very close range (19.08-24.10 mg kg^{-1}) in different treatments. Available K increased in all the fertilizer treated trees as compared to control, however the effect was non-significant. Highest available K (196.6 mg kg^{-1}) was recorded in the treatment NPK + Zn, Cu, Mn, B + FYM (T_{10}). DTPA extractable Fe, Mn and Zn contents in the surface soil of the tree basins increased due to micronutrient fertilization as compared to control, however the effect of the treatments was non-significant. In the next mango fruiting season (2014-15), the effect of various treatments on soil organic carbon, available N and K content in the orchard soil was observed significantly. Organic carbon and available N content varied in the range of 0.44 - 0.59% and 68.13-93.33 mg kg^{-1}. Maximum organic carbon (0.59%) and available N (93.33 mg kg^{-1}) was recorded in the treatments NPK + FYM (T_3) and NPK + FYM + Zn, Cu, Mn and B (T_{10}) respectively. Available P varied from 16.15 to 23.80 mg kg^{-1} in different treatments. Available K increased significantly in all K treatments as compared to control. The DTPA extractable Fe, Mn, Zn and Cu contents in the soil increased as compared to control, however, the effect of the treatments was non-significant just like previous season. Wide ranges of soil physical parameters were recorded across nutrient management modules (Fig. 2 to 4). A range of 1.29 to 1.44 g cm^{-3} bulk density (BD) was reordered in top soil layer (0-10 cm) and it increased down the depths (20-30 cm) to 1.36 to 1.51 g cm^{-3}. However, 1.33 to 1.47 g cm^{-3} BD was estimated in pooled depth (0-30 cm). A range of 2.43- 2.65 g cm^{-3} particle density was also recorded. Higher WHC was found in surface layer as compared to lower depths across different treatments. An impact of different treatments on WHC was recorded with highest (22.97%) in T_9 and lowest (20.47%) in T_1 respectively. Lower porosity was recorded at lower depths due to compaction. A range of 38.90 to 52.00% porosity across depths and treatments was estimated with pooled value (0-30 cm) of 39.89% (T_1) and 48.01 to 48.17% (T_8 to T_{10}). The leaf tissue analysis showed significant increase in N, P and K contents in all the treatments over control (Table 4a). Iron, Mn, Zn and Cu contents were in optimum range in all the treatments, however, the concentration was higher in the respective treatments applied (Table 4b). Foliar application of Zn and Cu maintained significantly higher concentration of these elements in the leaves (54.50 and 51.33 mg kg^{-1}, respectively) as compared to control (31.17 and 24.17 mg kg^{-1}, respectively). Foliar application or 50% soil + 50% foliar applications was found better than 100% soil application in respect of Zn and Cu. The leaf B concentration was below sufficiency range (critical limit 50 ppm) even in B applied treatments (Fig. 1). There was no significant effect of treatments on Fe and Mn content of leaf. Foliar application of B, Zn and Cu maintained significantly higher concentration of these elements in the leaves as compared to control. Foliar application (T_8) or 50% soil + 50% foliar application (T_9) was found better than 100% soil application (T_7) in respect of Zn, B and Cu.

Differential changes in available soil nutrients (soil organic C, N and K) may be because of applied

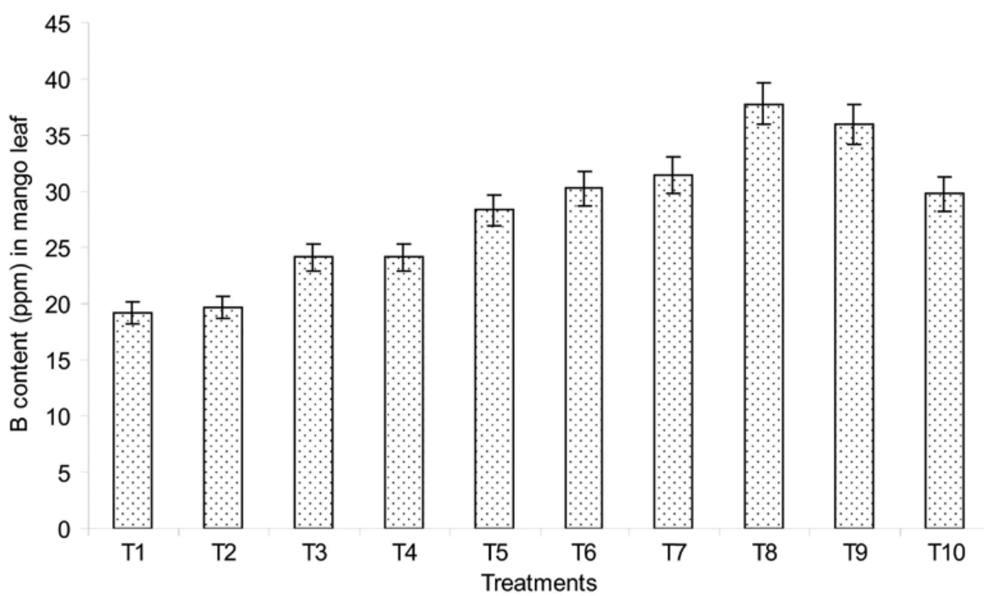

Fig. 1. Foliar B content (mg kg^{-1}) in mango under different nutrient management modules.

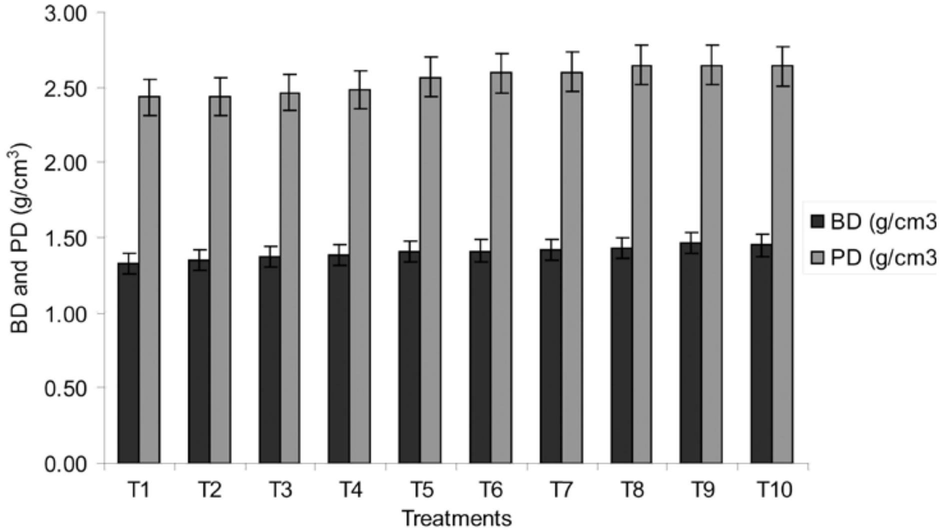

Fig. 2. Bulk density and particle density across different nutrient management modules.

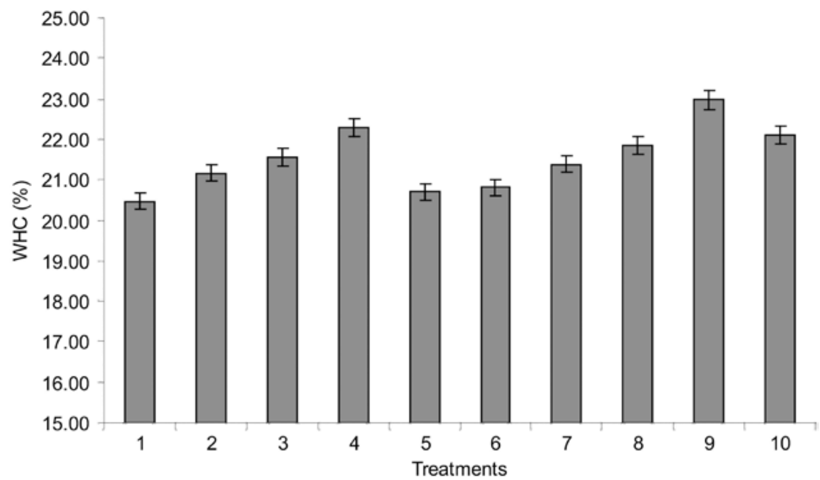

Fig. 3. Variations in water holding capacity (%) under different nutrient management modules.

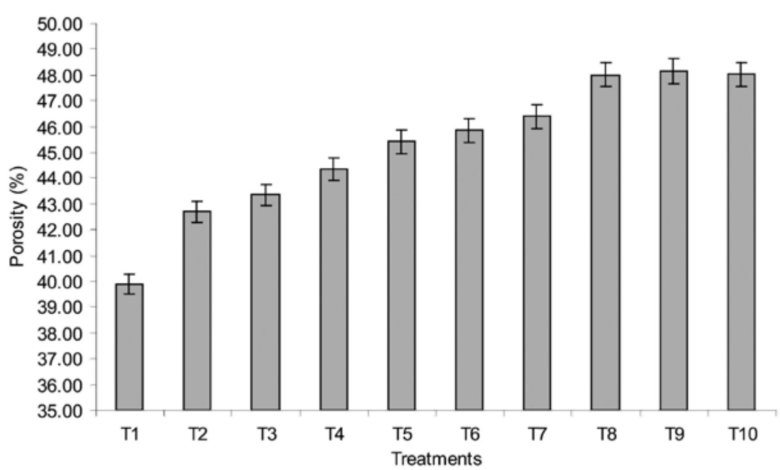

Fig. 4. Variations in porosity (%) under different nutrient management modules.

inputs. Impacts of different treatments over the soil physical parameters was also depicted due to treatment combinations. Adak *et al.* (1) recorded variations in bulk density (BD), porosity and water holding capacity (WHC) across different depths as an impact of fertigation levels in Dashehari grown mango soil. A range of 1.41 to1.50 g cm^{-3} BD, 41.41 to 45.01% porosity and a narrow range of 20.82 to 21.37% WHC was recorded. Similarly, compaction due to different planting density was also observed for Dashehari orchard sustainability. A range of 1.49 to 1.53 g cm^{-3} BD and WHC between 20 to above 22% was recorded with yield potentiality of 15.5 t ha^{-1} (Adak *et al.*, 5). In general, mango growing soils of Malihabad was deficient in one or more number of nutrients. A study based on 250 soil samples of mango orchards indicated deficient in soil organic carbon and N for which standard package of practices for cultivation involving NPK+ micronutrients application may be advocated (Adak *et al.*, 5). Boron content was also reported low in many mango orchards of UP districts along with Zn, Cu and Mn (Kumar *et al.*, 9). Therefore, B nutrition plays an important role in systaining the satisfactory yield level.

During 2013-14 fruiting season, treatments including micronutrients showed significant effect on fruit yield and TSS (Table 5 and 6). The highest fruit yield (13.96 t ha^{-1}) and TSS (19.57°B) was recorded in the treatment NPK + Zn, Cu, Mn, B (50% soil + 50% foliar application) over control (6.44 t ha^{-1} and 18.43°B respectively). Acidity and vitamin C content in the fruits ranged from 0.14 to 0.18 per cent and 30.30 - 37.04 mg / 100g in different treatments. However, there was no significant difference because of various treatments. During 2014-15 fruiting season,

Table 4a. Foliar nutrient content in Dashehari Mango.

Treatment	N (%)		P (%)		K (%)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
T1	1.31	1.32	0.11	0.125	0.78	0.75
T2	1.72	1.65	0.16	0.153	1.08	1.13
T3	1.73	1.73	0.16	0.157	1.10	1.14
T4	1.97	1.48	0.15	0.16	1.03	1.10
T5	1.69	1.58	0.16	0.156	1.03	1.11
T6	1.63	1.63	0.16	0.167	1.01	1.27
T7	1.73	1.66	0.15	0.154	1.03	1.05
T8	1.64	1.66	0.16	0.161	1.06	1.11
T9	1.70	1.53	0.16	0.158	1.03	1.09
T10	1.71	1.60	0.16	0.16	1.01	1.08
LSD(0.05)	NS	0.24	NS	0.014	NS	0.16

Table 4b. Foliar micronutrient content in Dashehari Mango.

Treatment	Fe (ppm)		Mn ppm)		Zn (ppm)		Cu (ppm)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
T1	194.17	247.33	70.67	127.17	31.17	26.50	24.17	23.83
T2	206.17	266.33	70.17	133.00	30.67	25.17	31.00	26.67
T3	217.67	259.33	75.67	116.83	30.33	33.17	29.50	23.33
T4	203.00	250.33	78.83	133.17	31.50	30.67	26.67	26.17
T5	275.00	272.00	73.50	125.67	36.17	34.17	34.67	27.67
T6	209.83	257.50	81.17	106.50	36.33	30.67	38.33	37.33
T7	197.67	243.00	90.50	107.0	35.17	31.00	40.50	34.83
T8	198.50	249.33	92.23	112.17	54.50	39.17	51.33	46.00
T9	200.67	269.50	93.33	115.33	44.33	38.50	42.33	41.67
T10	204.00	273.00	91.17	113.67	34.83	33.33	45.33	42.50
LSD(0.05)	NS	NS	NS	NS	11.32	4.20	11.47	6.58

Table 5. Effect of different INM treatments on yield and sustainable yield index in Dashehari Mango.

Treatments	2013-14			2014-15		
	Yield (t ha^{-1})	sd	SYI	Yield (t ha^{-1})	sd	SYI
T-1	6.44	2.5	0.28	3.97	1.4	0.28
T-2	7.28	3.2	0.29	5.13	0.9	0.46
T-3	7.78	5.3	0.18	5.55	3.1	0.27
T-4	8.34	4.1	0.30	6.91	0.9	0.66
T-5	9.39	0.8	0.62	6.37	0.1	0.68
T-6	11.16	3.0	0.58	6.79	1.5	0.58
T-7	11.31	2.4	0.64	7.28	1.7	0.61
T-8	11.87	0.4	0.69	7.52	0.4	0.78
T-9	13.96	1.4	0.90	9.10	1.2	0.87
T-10	12.32	2.3	0.71	8.83	1.2	0.83
$LSD_{(0.05)}$	4.29	-	-	2.48	-	-

Table 6. Effect of different INM treatments on quality parameters in Dashehari Mango.

Treatments	TSS (ºB)		Acidity (%)		Vitamin C (mg/100 g)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
T-1	18.43	18.60	0.18	0.21	30.30	27.91
T-2	18.57	18.70	0.17	0.18	31.99	31.30
T-3	18.60	18.70	0.18	0.17	29.46	30.45
T-4	18.63	18.70	0.15	0.16	31.95	32.14
T-5	18.6	18.60	0.17	0.16	32.83	32.14
T-6	18.73	18.90	0.16	0.15	35.35	34.68
T-7	18.63	18.80	0.17	0.15	32.83	32.14
T-8	19.53	19.60	0.15	0.14	36.19	37.22
T-9	19.57	19.90	0.14	0.13	37.04	38.07
T-10	19.50	19.80	0.15	0.14	37.04	38.07
$LSD_{(0.05)}$	0.53	0.39	NS	0.039	NS	4.37

the treatments including micronutrients showed significant effect on fruit yield, TSS, acidity and vitamin C content. The highest fruit yield (9.10 t ha^{-1}) and TSS (19.90°B) was recorded in the treatment NPK + Zn, Cu, Mn, B (50% soil + 50% foliar) nutrient application over control (3.97 t ha^{-1} and 18.60°B respectively). The sustainable yield index (SYI) was highest (0.90 and 0.87) in case of T_9 treatment wherein half doses of micronutriments was applied as soil application and remaining half as foliar spray, followed by T_{10} treatment (0.71 and 0.83). The control plot had a SYI value of 0.28. The quality parameters *viz*., acidity and vitamin C content in the fruits ranged from 0.13 to 0.21 per cent and 27.91 - 38.07 mg/100g in different treatments (Table 6). Significantly lowest acidity (0.13%) and highest vitamin C content (38.07 mg/100g) was recorded in the treatment NPK + Zn, Cu, Mn, B (50 % soil + 50% foliar application).

Optimum nutrient management strategy under the subtropical regions is one of the key factor for securing higher orchard sustainability besides maintaining post harvest soil fertility. Recognizing the best nutrition module involving micronutrients is the need of the hour to farmers for obtaining higher yield. In this direction, an effort was made to identify the best treatment combination in mango keeping in view the quality as well as sustainable yield index (SYI). Apart from recommended fertilizer doses, soil and foliar application of micronutrients hastens the nutrient uptake particularly (Zn and Cu) for obtaining higher sustainable yield. In general, soil application of fertiliser fastens the nutrient release and uptake by the root of trees while foliar application intended for direct absorption through its leaf tissues. Higher yield in T_4 (8.34 t ha^{-1}) to T_{10} (12.32 t ha^{-1}) may be outcome of integrated management modules than the farmers practice of either control (T_1), NPK (T_2) or NPK+FYM (T_3). Likewise, INM resulted in higher SYI (0.58 to 0.90). Even, content of B in leaf tissues also contributed towards better yield components. Application of micronutrients either in soil (T_7) or foliar (T_8) restricts the opportunity of proper nutrient dynamics in soil or leaf tissues which resulted in lower SYI as compared to their combinations (T9). Similarly, absence or presence of one or more nutrient (T_1 to T_6) also hampers SYI as well as quality components. Similar study conducted by Kumar *et al.* (10) concluded improvement in SYI in NPK+FYM (0.58) and NPK+ green manuring (0.66) than control (0.43) in a low fertile mango soil. Integrated nutrient approaches improves the soil condition in guava orchard ecosystem as observed by Adak *et al.* (6). Improvement of available K (159.77 to 177.48 mg kg^{-1}) in soil contributed towards better quality of mango fruits. Even, enhancement of foliar K, Zn and Cu as compared to control must also have accelerated better fruit quality and yield. Significant difference in soil organic carbon and nitrogen also helps in formation of niche for soil enzymatic activities which may turn hastens the productivity. Even, nitrogen uptake by trees resulted in lower availability in soil for the next season's crop. In field experimentation for enhancing the farmers income through intervention of nutrient management, it was further inferred yield improvement as well as cost : benefit ratio in 21 mango orchards of small and marginal farmers of village Kitna Khera, Malihabad, Uttar Pradesh (Kumar *et al.*, 11). Thus, micronutrient management is one of the important aspect in nutritional management from farmers' profitability view point (Adak *et al.*, 3).

The present study was conducted with the objective to evaluating the nutrient management modules for best yield sustainability. The response of soil and foliar application of micronutrients in addition to recommended fertilizer doses was found to be fruitful. Yield components were varied across different treatment combinations being lowest in control and highest in NPK + micronutrients. Quality parameters like TSS, acidity and Vitamic C were significantly varied across treatments with higher being the combinations of soil+foliar micronutrients+NPK applications. Optimum nutrient modules must be responsible for such improvements in fruit quality parameters. Soil physical parameters also facilitated towards better fruit growing condition through higher water holding capacity and lower porosity to availability of soil nutrients to trees for greater yield sustainability. The current study thus recommends micronutrient application in the form of soil and foliar spray @50% apart from recommended fertilizer doses in order to maintain post harvest fertility status and best sustainable yield index.

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