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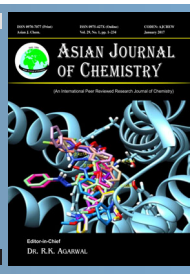

Fractionate Assessment of Elemental Composition in Different Mango Cultivars to Estimate Nutrient Losses through Crop Removal

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To achieve high productivity in mango through judicious nutrient management, cultivar specific fertilization is necessary according to nutrient requirement, nutrient removal and accumulation in the plant tissues. Macro (N, P, K, Ca, Mg) and micro nutrients (Fe, Mn, Zn, Cu) were analyzed in fruit peel, pulp, seed coat and cotyledon in seven cultivars of mango (dashehari, langra, mahmood bahar, menka, sabri, sundar langra and zardalu) at physiological mature stage. It was observed that the nutrients were not uniformly distributed in various parts of fruit but had significant differences in nutrient removal irrespective of the cultivars. With regard to macro nutrients, the order of nutrient removal was: N > K > P > Mg > Ca whereas the micronutrient removal by all the cultivars was: Fe > Cu > Zn > Mn. Thus, based on the findings it could be suggested that fractionate assessment of elemental composition in fruit tissues could help to identify the status of nutrient deficiency, excess or imbalance existence in order to assist in sustainable yield.

Keywords: *Mangifera indica*, Fractionate analysis, Nutrient removal, Nutrient distribution, Fruit tissue.

INTRODUCTION

Analysis of mineral content in fruit parts helps to indentify the nutrient deficiency, excess or imbalance present in a crop. Mango is one of the major fruit crops of India as well as in the world. Low productivity is major problem occurs due to improper and indiscriminate fertilization practices. Generally, a common dose of fertilizer is recommended to every cultivars of mango. In fact, each and every cultivar has specific nutrient requirement as well as removal and accumulation capacity from the soil. So, fertilizer application program should be based on the source to sink relationship.

Leaf nutrient analysis in mango has thoroughly been investigated and suggested but information on fruit nutrient analysis is scarcely available. Leaf nutrient analysis is mostly notified in temperate fruits and some citrus crops. Moreover, leaf analysis information does not explain nutrient accumulated in fruit [1]. In perennial tree fruit production system, harvested fruit is the major component of annual nutrient removal from soil tree system [2]. Presently, chemical analysis of fruits has received special attention, which provides the exact information about the amount of nutrients to be replaced to maintain the proper tree nutritional status and its productivity. It also provides information on fruit quality based on previously known adequate and critical nutrient levels allowing prevention of deficiencies and physiological disturbances in fruits [3-6].

In the current study, different mango cultivars were examined for nutrient distribution in different fractions of fruits to develop a sound nutrient management program.

To determine whether the selected cultivars have any differences in mineral content and amount of nutrient uptake through crop removal in order to successfully complete vegetative and reproductive processes [7].

In spite of the use of single set of standard for similar genotype, it may be necessary to have different standards for some very closely related plants due to requirement at times to use different standards for one or more element. Varietal differences in nutrient content either in leaf or fruit are also been reported by a few researchers [8,9]. Thus, accumulation and removal of mineral nutrient in various cultivars are compared to unique reference value for each nutrient element to indentify the efficient way of fertilization and to increase productivity.

EXPERIMENTAL

Experimental site: The current investigation was laid out at horticulture garden and nutrient estimation was done in

departmental laboratory of Horticulture (Fruit and Fruit Technology), Bihar Agricultural University, Sabour, Bhagalpur, India. Geographically, the experimental site is situated at longitude 87°2'42" East and latitude 25°15'40" North at an altitude of 46 m above mean sea level in the heart of vast Indo-Gangatic plains of North India. The prevailing climate is semiarid, subtropical climate with hot desiccating summer but cold frostless winter with an average annual rainfall of about 1040 mm.

Collection of fruits: Seven cultivars (dashehari, langra, mahmood bahar, menka, sabri, sundar langra and zardalu) were selected for the study. Ten fruits were collected at proper harvesting stage *i.e.* firm ripe stage from each mentioned cultivars.

Preparation of samples: The collected fruit samples were brought to the laboratory immediately after harvesting. Thoroughly washed under running tap water and then dipped into 0.1 N HCl, distilled water and finally under double distilled water and allowed it to dry the surface apparently under fan at an ambient condition. After drying, the samples were cut into small pieces and dried in an oven at 68 °C till constant weight was obtained in three consecutive weighing. Then, dried samples were ground to homogeneous mixture using grinder and kept in refrigerator in butter paper bags for further chemical analyses.

Digestion, distillation and titration of fruit for nitrogen analysis: Sample (0.5 g) was taken into the digestion tube. Then, K_2SO_4 and $CuSO_4$ in the ratio of 10:1 and 10 mL of concentrated H_2SO_4 were added and kept overnight. Then, tubes were allowed to stand in the digestion block 1 h at 390 °C till to obtain a clear digest for proceeding further distillation process. About 10 to 15 mL distilled water along with 40 % NaOH were also added to the cooled digested material present within Kjeldhal digestion tube. During the process of distillation ammonia were liberated which was collected in 250 mL conical flask containing 20 mL of H_3BO_3 and mixed indicator. The distillation process continued for 10-12 min and then distillate was titrated against 0.1 N standard acid and also repeated for blank sample. The total N content was calculated by Kjeldhal method and expressed in percentage (%).

Digestion for P, K, Ca, Mg and micronutrients estimation: Sample (0.5 g) was taken in 100 mL flask and digested under di-acid mixture of nitric acid and perchloric acid in respective ratio of 9:4. The flask were placed on a hot plate at 115-118 °C for digestion until to get a clear digest. The wet digested samples were filtered and diluted with double distilled water to make a volume of 50 mL. This diluted sample further used for the estimation of these mentioned macro and micronutrients.

Analyses for P, K, Ca and Mg present in mango fruit: Phosphorus content was calculated by using ammonium molybdate: ammonium metavandate [10]. The colour intensity was measured at 440 nm in a spectrophotometer (HALO DB-20S UV-Visible double beam spectrophotometer, Australia). Potassium and calcium was determined with flame photometry technique using corning flame photometer, U.K. [11]. Magnesium content was calculated by using atomic absorption spectrophotometer. The absorbance was measured and their values were expressed as %.

Analysis for mango fruit micronutrients (Zn, Cu, Fe and Mn): The micro elements (Zn, Cu, Fe and Mn) were analyzed by using the di-acid digested material with the help of atomic absorption spectrophotometer (AAS) and expressed in ppm [12].

Statistical analysis: The data was subjected to statistical analysis and evaluated by ANOVA. The mean values were compared using experimental design RBD (factorial) with the aid of computer program. Each treatment was comprised of 7 varieties and 4 different parts and each variety was replicated twice. The test of significance was made with 5 % level of significance [13].

RESULTS AND DISCUSSION

Partitioning of macro and micronutrient in mango fruit: Fractionate nutrient analysis of peel, pulp, seed coat and cotyledon (Tables 1-3) supplies more meaningful information than using whole fruit. The results indicated that nutrients are not distributed uniformly in different parts of fruit. The highest nitrogen content was accumulated in peel followed by cotyledons, seed coat and pulp. However, phosphorus content was recorded to be the highest in cotyledon followed by seed coat while pulp and peel did not show significant differences. In contrary to phosphorus and nitrogen, the potassium content was more accumulated in pulp. This difference in the mineral content of fruit parts was pointed toward their selected distribution among cultivars.

There was no significant difference in calcium concentration among the cultivars. However, the mango seed coat contained the highest calcium than pulp, peel and cotyledons. It might be involved in seed coat formation to provide hardiness and to maintain permeability. The highest magnesium content

TABLE-1
PRIMARY NUTRIENT PER CENT ACCUMULATION IN VARIOUS MANGO CULTIVARS

	N				P				K			
	Peel	Pulp	Seed coat	Cotyledon	Peel	Pulp	Seed coat	Cotyledon	Peel	Pulp	Seed coat	Cotyledon
Dashehari	2.15	1.27	1.31	1.99	0.15	0.19	0.18	0.20	0.76	0.63	0.27	0.48
Langra	3.07	1.16	1.04	1.88	0.11	0.13	0.23	0.08	1.06	0.87	0.50	0.69
Mahmood bahar	3.06	1.72	0.91	1.60	0.24	0.17	0.04	0.27	0.69	0.89	0.54	0.47
Menka	3.11	1.08	1.09	1.80	0.20	0.22	0.20	0.20	0.51	0.74	0.35	0.68
Sabri	2.40	1.46	1.44	1.78	0.16	0.19	0.08	0.25	1.04	0.84	0.60	0.74
Sundar langra	2.63	0.54	1.03	1.49	0.16	0.09	0.15	0.16	0.85	1.08	0.45	0.74
Zardalu	2.12	1.58	1.05	1.54	0.05	0.15	0.15	0.17	0.85	0.82	0.56	0.70
S.E	0.195	0.05	0.06	0.12	0.007	0.005	0.009	0.013	0.058	0.04	0.029	0.037
CD	0.67	0.18	0.23	0.42	0.02	0.02	0.03	0.04	0.20	0.14	0.10	0.28

TABLE-2
SECONDARY NUTRIENT PER CENT ACCUMULATION IN VARIOUS MANGO CULTIVARS

Cultivars	Ca				Mg			
	Peel	Pulp	Seed coat	Cotyledon	Peel	Pulp	Seed coat	Cotyledon
Dashehari	0.04	0.05	0.06	0.03	0.16	0.06	0.08	0.10
Langra	0.03	0.05	0.07	0.03	0.23	0.08	0.07	0.10
Mahmood bahar	0.05	0.05	0.06	0.04	0.13	0.14	0.09	0.10
Menka	0.03	0.04	0.05	0.05	0.21	0.09	0.10	0.12
Sabri	0.04	0.04	0.06	0.04	0.16	0.09	0.08	0.10
Sundar langra	0.03	0.05	0.05	0.03	0.17	0.11	0.05	0.10
Zardalu	0.04	0.05	0.05	0.03	0.12	0.07	0.10	0.11
S.E	0.0008	0.001	0.002	0.0009	0.009	0.006	0.006	0.006
CD	0.002	0.005	0.006	0.003	0.03	0.02	0.02	0.02

TABLE-3
MICRONUTRIENT (ppm) ACCUMULATION IN VARIOUS MANGO CULTIVARS

Cultivars	Fe				Mn			
	Peel	Pulp	Seed coat	Cotyledon	Peel	Pulp	Seed coat	Cotyledon
Dashehari	58.75	74.25	141.9	51.05	3.35	16.15	4.15	4.70
Langra	126.40	185.50	55.55	54.45	7.70	4.15	4.75	7.70
Mahmod bahar	109.45	156.30	184.65	39.85	8.90	16.25	5.30	7.15
Menka	118.05	219.45	95.55	250.25	5.90	7.70	6.50	8.90
Sabri	137.50	330.95	70.30	99.30	4.65	8.30	8.20	11.90
Sundar langra	87.35	65.55	110.45	53.50	6.55	12.60	2.40	7.10
Zardalu	73.35	110.40	82.75	110.08	21.62	8.30	10.15	11.30
S.E	6.073	10.37	6.943	5.863	0.587	0.658	0.331	0.428
CD	21.06	35.87	24.02	20.08	2.03	2.27	1.15	1.48
Cultivars	Zn				Cu			
	Peel	Pulp	Seed coat	Cotyledon	Peel	Pulp	Seed coat	Cotyledon
Dashehari	12.85	18.55	20.75	11.50	33.88	19.05	33.45	44.15
Langra	16.20	20.80	16.20	25.40	36.90	29.75	19.45	23.85
Mahmod bahar	15.25	69.10	23.85	21.60	38.60	53.55	12.35	62.50
Menka	15.45	93.80	33.00	24.45	38.10	20.25	54.75	51.25
Sabri	21.30	28.90	27.00	23.84	27.40	13.05	31.90	43.15
Sundar langra	20.50	13.90	12.65	18.60	29.95	15.45	37.60	45.25
Zardalu	17.90	27.35	24.45	24.60	14.45	22.60	53.60	49.75
S.E	0.97	2.059	1.536	1.17	1.527	1.585	1.955	2.804
CD	3.35	7.12	5.31	4.05	5.28	5.48	6.76	9.7

was recorded in peel. It was shown that accumulation of secondary nutrients is in lesser concentration than primary nutriens. It might be due to more mobility of primary nutrients (N, P, K) in comparison to Ca, Mg, it moves more rapidly in phloem and readily translocated to the meristematic tissue and allow meristematic activity and to expand tissues thus required in more amount. This nutrient variation is also noticed [14-16].

As far as micronutrient is concerned, the iron partioning, in general, was observed in pulp. However, the manganese content partitioning does not follow conspicuous trend. The zinc content was accumulated more in pulp followed by seed coat but in some cultivars its concentration was reversed and copper content was accumulated more in cotyledon followed by seed coat, pulp and peel.

The highest content of iron in this study was recorded in the pulp which is not confirmed [17]. Furthermore, they also recorded the least concentration of zinc in pulp; while in the present study the least concentration of zinc was recorded in peel. Thus, the result are self explanatory for mango fruit has different requirement of mineral nutrients, which is co-supported [1], in 'Khao Yai' pummelo fruit and 'Thong Dee' and Khao Nam Phueng' pummelo fruit [18]. The nutrient variation among fruit parts is due to genetic factor [9] and different translocation ability of cultivars [19,20].

These results emphasizing that mango fruit can be a good source of nutrients in fresh as well as processed forms [21-23]. This can be a valuable information for nutritional issues. Apart from this, it is also suggested that in addition to the direct transfer of minerals from cotyledon, the peel, pulp and seed coats also seem to act as a secondary source for nutrient supply to the developing embryo. It seems that peel, pulp and seed coats act as a temporary reservoir in order to maintain continuous supply of nutrients to the developing embryo.

Estimated nutrient removal by different varieties of mango fruit nutrient status at maturity is used to estimate nutrient removal by assuming an estimated average fruit yield of different mango varieties 9462 kg on one hectare of land. It is critically inferred from the Tables 4 and 5 that Cv Langra was at the top in term of yield and nutrient removal than other varieties. It is demonstrated from both tables that each varieties removed each macronutrient from the orchard soil differently. This is suggested that variation in total nutrient removal would be determined by the differences in crop yield. It means age of tree and yield are directly correlated to nutrient removal from soil [1].

TABLE-5
TOTAL NUTRIENT REMOVAL (Kg/ha) BY DIFFERENT VARIETIES OF MANGO BASED ON FRUIT YIELD

Nutrient element	Dashehari	Langra	Mahmood bahar	Menka	Sabri	Sundar langra	Zardalu
Nitrogen	168.0	286.0	64.8	62.8	120.3	113.8	41.5
Phosphorous	16.5	22.0	6.4	12.3	11.5	10.6	69.9
Potassium	53.5	120.8	23.0	35.4	54.7	61.2	19.3
Calcium	4.5	7.2	1.5	2.5	3.0	3.2	1.1
Magnesium	10.0	19.2	4.0	7.8	7.3	9.4	2.6
Iron	8.1	16.8	35.7	10.2	10.8	63.3	24.8
Manganese	7.1	9.7	3.3	4.3	5.6	5.7	3.3
Zinc	15.9	31.4	11.5	25.0	16.8	13.1	0.6
Copper	3.2	4.3	1.4	2.5	1.9	1.7	6.9

TABLE-4
ESTIMATED FRUIT YIELD BY DIFFERENT VARIETIES OF MANGO (Kg/ha)

Varieties	Age of tree (year)	Yield (Kg/ha)
Dashehari	30	12500
Langra	30	20000
Mahmood bahar	20	4432
Menka	15	7500
Sabri	20	8500
Sundar langra	20	10000
Zardalu	30	3300

The result also demonstrates that nitrogen was removed in the largest quantity followed by potassium and phosphorus while calcium and magnesium were removed in small quantity. These results indicate that a variety of factors can affect the nutrient removal from the soil and further accumulation according to nutritional demand for their growth and development. As Cv Langra is a large and prolific bearer tree, so it removes more nutrients from soil due to long spreaded root system. Therefore, the order of nutrient extraction was: N > K > P > Mg > Ca. It was found that N removal was about 3-4 times and K removal was about 10 fold more than P. This suggests that N is the most extensively used for vegetative growth and development of reproductive organs. Regardless of the cultivar, it is pointed out that the cultivars that have high K/Ca ratio removed high amounts of potassium and relatively low amount of calcium, which might induce K-Ca imbalance. It could be suggested that sunder langra is more susceptible to calcium deficiency in the fruits and requires more careful monitoring of calcium nutrition.

With regard to micronutrients, it was observed that iron was removed mostly by each varieties followed by copper, zinc and manganese. Zinc and manganese was removed in small quantity. So, the order of micronutrient removal by all the cultivars was: Fe > Cu > Zn > Mn signifying the enzymatic importance for various oxidation-reduction reactions.

Conclusion

These results explain that it is reasonable to expect significant differences in nutrient removal among mango cultivars. Growers should keep attention to yield potential of cultivar and total nutrient removal of fruits to achieve optimum growth and quality. The cultivar specific balanced fertilization program is necessary for improving fruit yield and quality.

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