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Variation in nutrients during the fruit development of Daisy tangerine

Jaspreet Singh*, Tanjeet Singh Chahal and Parmpal Singh Gill**

Department of Fruit Science, Punjab Agricultural University, Ludhiana 141 004, Punjab

ABSTRACT

Seasonal progression in the nutritional concentration of fruit peel, pulp and leaves of Daisy tangerine cultivar were evaluated during fruit development period. Marked variations in nutritional content during specific fruit developmental stages were observed. Overall, leaves were the main sight of nutrient accumulation than fruit parts and their concentration was increased with the advancement in fruit maturity. The general order of abundance of macro and micronutrients in leaves was calcium (Ca)>nitrogen (N)>potassium (K)>magnesium (Mg)>phosphorus (P) and iron (Fe)>manganese (Mn)>zinc (Zn)>copper (Cu) respectively. Overall, P and K were higher in the pulp, while most of the micronutrients registered greater accumulation in the peel. However, in case of N, almost equal distribution was observed in peel and pulp of Daisy fruits. Leaf nutrient showed a strong association with peel, pulp and dry matter accumulation.

Keywords: Nutrient elements, seasonal changes, leaves, peel, pulp.

INTRODUCTION

Citrus is one of the most widely cultivated fruit crop in the world, recognized for its distinct fruit size, colour, flavour, phyto-chemicals, therapeutic and nutraceutical properties.The Punjab province of India is contributing to citriculture sector with cultivation of mandarin, sweet oranges, grapefruits, lime and lemon varieties over an area of 60980 ha. Recently, an early maturing variety Daisy tangerine has been released for commercial cultivation. This variety bears attractive deep orange colour fruit, sweet taste, low seed number and ripens in the month of November. Owing to this, area under Daisy tangerine has been rising since the last few years as it holds the potential of large scale cultivation. In citrus mineral nutrition plays a pivotal role in plant growth, fruit yield and its quality. Imbalance among the essential mineral nutrients in plant parts not just effect the vegetative growth and productive life span of citrus orchards, but also influences the finances of production cost. Malnutrition has been diagnosed as a typical feature of Asian citrus orchards which can be a reason for fruit size reduction resulting into a syndrome commonly termed as citrus decline (Srivastava and Singh, 14). The knowledge regarding periodic accretion of mineral nutrients in plants to establish criteria for interpreting their correct status for both fruit quality and yield of citrus orchards is a major concern. Leaf nutrient examination was established as an appliance to analyze the concentration of nutrients in trees. Information regarding the budget of uptake of nutrients by an established citrus tree can be determined by knowing the amount of nutrients extracted through harvested fruits; fallen leaves, flowers & fruit lets and vegetative parts removed through pruning and training. Xiao *et al.*(16) while working on Newhall and Skagg's Bonanza navel orange fruits investigated the alterations in mineral nutrition during fruit development and registered much lower Mg in old leaves of 'Newhall' than from 'Skagg's Bonanza'. However, to best of our knowledge no information pertaining to seasonal accumulation of nutrients is one of the most commercial mandarin variety Daisy tangerine is available under Indian conditions.

Keeping in view the importance of Daisy tangerine and significance of mineral nutrient distributions, the present investigations were carried out with objective to study the seasonal nutrient densities of macronutrient and micronutrient contents in this commercial mandarin cultivar and their correlation between leaf and fruit parts. The results obtained were used to describe general trends and variability in the mineral concentration during the vegetative cycles of this Tangerine. The information about proper nutrition density of fruits might be helpful to explore more research areas in biofortification of fruits to overcome the deficiency of particular nutrients.

MATERIALS AND METHODS

For research work regarding analysis of mineral nutrition variations, fruits and leaves of Daisy Tangerine were collected during the year 2019 from Punjab Agricultural University (PAU), Fruit Research

*Corresponding author's Email: jaspreet-fs@pau.edu
**PAU Fruit Research Station, Jallowal-Lesriwal, Jalandhar 144 303.

Station, Jallowal, Jalandhar (Lattitude, 31° 29' 38" N and Longitude, 75° 37' 40" E, altitude 228 m) located in Punjab, India. Five-year-old plants spaced at 6×3 m on Carrizo citrange (*Citrus sinensis* Osb. ×*Poncirus trifoliate* L. Raf.) rootstock were used for the study. Experimental plants were maintained through uniform cultural and plant protection practices recommended by Punjab Agricultural University. The samples were collected during the morning hours at a monthly interval from 15th May to15th November (optimum fruit maturity). Forty homogenous fruits having uniform colour and size were picked up randomly with clipper from different sides of the plants having uniform growth. The collected samples were taken to the laboratory of the Department of Fruit Science, PAU, Ludhiana under low temperature conditions. Each treatment comprised of four replications. Care was taken that each selected fruit had no signs of infection or injury and after selection fruits were lightly scrubbed with a soft brush in tap water to remove surface contaminants, cleaned with double distilled water and wiped dry at room temperature. The fruitlets of the first three harvests were not separated, and were taken as whole fruit samples. By the fourth harvest, peel and pulp (consists of juice sacs and segment epidermis) portion were separated manually. Then oven-dried at 65°C until constant weight was attained, grounded through 0.5 mm stainless steel. Thus collected powder was stored in airtight and labelled glass vessels until used for further analysis.

Average dry fruit weight was measured with an electronic balance having 0.01 g accuracy. Total nitrogen content in plant samples was estimated by Kjeldahl method as described by Isaac and Johnson (6) using KelPlus Nitrogen Estimation System (Pelican Equipments, India).For determination of P, K, Ca, Mg and micronutrients (Fe, Mn, Zn and Cu), plant samples were digested by the addition of triple acid mixture consisting of nitric acid (HNO_3), perchloric acid ($HClO_4$) and sulphuric acid (H_2SO_4). Phosphorus content was estimated by Vanado-molybdo phosphoric yellow color protocol as outlined by Chapman and Pratt (2). Determination of potassium content (K) was done by flame photometer (Jackson, 7). Ca, Mg, Fe, Mn, Zn and Cu were determined by Atomic Absorption Spectrophotometer (AAnalyst 200, Perkin Elmer, Shelten, CT, USA) using standards of these elements. All the nutrient contents were expressed on a dry matter basis.

The data were analyzed in quadruplicate and expressed in term of their means ± standard deviations. The statistical difference among time intervals expressed by letters obtained from one-way analysis of variance (ANOVA) and means were compared using LSD ($p \leq 0.05$). The correlation coefficients between these evaluations was obtained through Pearson`s correlation coefficients ($p \leq 0.05$) by using SAS 9.3 (The SAS system for Windows, Version 9.3, SAS Institute, Cary, NC).

RESULTS AND DISCUSSION

Fruit growth was measured in terms of dry matter accumulation at monthly interval throughout the period of fruit development. Dry matter accumulation expressed a significant variation ($p < 0.05$) with fruit development stage and varied from 0.52±0.08 to 22.29±3.88 g (Table 1), however, it remained statistically significantly from June to August, and increased thereafter. It was lowest initially (0.52±0.08 g), and registered to be the highest in November (22.29±3.88 g). Liu *et al.,* (8) also reported similar findings regarding dry matter accumulation in the fruit of Navel orange plants grafted on trifoliate orange and citrange rootstocks.

Total nitrogen content in different plant parts of Daisy variety during seasonal changes varied from 0.72±0.08 to 2.46±0.16 % (Table 1). N concentration was higher in leaves as compared to pulp and peel during the course of study. In leaves, N content ranged from 1.66±0.08 to 2.46±0.16 %, and increased with significant variation up to August, and declined thereafter. Irrespective of maturity stage, higher accumulation of N was observed in pulp (0.78±0.10 to 1.27±0.08 %) followed by peel (0.72±0.08 to 1.27±0.12 %) of Daisy fruits. The trend of N was similar both in peel and pulp, which was highest on first date of sampling, and declined thereafter. The N fluctuation in the present study was in agreement with the findings of Singh *et al.,* (13) in 'Star Ruby' cultivar of grapefruit. Manivannan and Chadha (9) also recorded 2.91 to 2.95% N in 'Kinnow' leaves from July to September. Reduction in N concentration of plant parts with seasonal variations might be due to the transformation and accumulation of carbohydrates in the plant system.

The content of phosphorus in peel was lower than the pulp or the leaves in Daisy tangerine (Table 1). Throughout the period of study, fruit pulp accumulated more P content as compared to leaves and peel. P content in leaves varied from 0.118±0.009 to 0.169±0.014 % exhibiting the increasing trend statistically till the final date of harvesting. The P concentration in peel declined continuously from first sampling date (May) to end of sampling (November) varying from 0.091±0.010 to 0.042±0.010 %, whereas it followed the pattern similar to leaves. Our results are in concurrence with the findings of Sau *et al.* (11) in Nagpur mandarins.

Table 1. Changes in dry matter content and N, P, K of peel, pulp, and leaves of Daisy tangerine during fruit development.

Month	Dry matter content (g)	N (%)			P (%)			K (%)		
		Peel	Pulp/WF	Leaves	Peel	Pulp/WF	Leaves	Peel	Pulp/WF	Leaves
May	0.52 ± 0.08^{e}	1.27 ± 0.12^{a}	1.27 ± 0.08^{a}	2.14 ± 0.24^{bc}	0.091 ± 0.010^{a}	0.156 ± 0.009^{c}	0.118 ± 0.009^{e}	1.73 ± 0.05^{a}	1.87 ± 0.14^{a}	1.93 ± 0.07^{ab}
June	2.54 ± 0.20^{de}	1.05 ± 0.13^{b}	1.07 ± 0.07^{b}	2.26 ± 0.16^{ab}	0.086 ± 0.009^{a}	0.167 ± 0.008^{bc}	0.121 ± 0.015^{de}	1.63 ± 0.06^{ab}	1.57 ± 0.12^{bc}	2.08 ± 0.20^{a}
July	3.83 ± 0.27^{d}	0.97 ± 0.09^{bc}	1.06 ± 0.11^{b}	2.38 ± 0.14^{a}	0.078 ± 0.004^{ab}	0.182 ± 0.015^{ab}	0.135 ± 0.011^{cd}	1.53 ± 0.10^{bc}	1.47 ± 0.11^{cd}	1.95 ± 0.13^{bab}
Aug.	5.05 ± 0.25^{d}	0.88 ± 0.06^{cd}	1.03 ± 0.08^{b}	2.46 ± 0.16^{a}	0.071 ± 0.009^{b}	0.173 ± 0.014^{abc}	0.139 ± 0.010^{bc}	1.43 ± 0.11^{cd}	1.23 ± 0.13^{e}	1.86 ± 0.15^{bc}
Sept.	10.72 ± 1.19^{c}	0.83 ± 0.08^{de}	0.88 ± 0.06^{c}	1.96 ± 0.18^{cd}	0.064 ± 0.012^{bc}	0.159 ± 0.010^{c}	0.143 ± 0.011^{bc}	1.30 ± 0.10^{d}	1.39 ± 0.11^{de}	1.70 ± 0.11^{c}
Oct.	16.47 ± 2.24^{b}	0.78 ± 0.07^{e}	0.85 ± 0.07^{c}	1.78 ± 0.11^{de}	0.050 ± 0.010^{c}	0.165 ± 0.011^{bc}	0.152 ± 0.011^{b}	1.17 ± 0.07^{e}	1.52 ± 0.09^{bcd}	1.47 ± 0.16^{d}
Nov.	22.29 ± 3.88^{a}	0.72 ± 0.08^{de}	0.78 ± 0.10^{c}	1.66 ± 0.08^{e}	0.042 ± 0.010^{d}	0.187 ± 0.013^{a}	0.169 ± 0.014^{a}	1.03 ± 0.12^{f}	1.69 ± 0.12^{b}	1.30 ± 0.12^{d}

Data are expressed as means ± standard deviation (n=4); Different superscripts between rows represent significant differences between fruit developmental stages ($p \leq 0.05$); WF for whole fruit which replaced the pulp from May to July.

Potassium content varied from 1.03±0.12 to 2.08±0.20 % in different tissues of Daisy tangerine (Table 1). In leaves, a maximum K concentration was recorded in the month of June (2.08±0.20 %) afterwards, it declined significantly, being lowest (1.30±0.12 %) on the last date of sampling. During the initial stages of fruit development, K accumulation was higher in pulp than peel with exception in the month of May. However, in September onwards, it was higher in pulp than peel. In case of pulp, K concentration decreased from May to August (May-1.87±0.14 %; August-1.23±0.13 %), and increased continuously. The similar outcomes regarding the accumulation of K in peel and pulp were also observed by Storey and Treeby (15) in Navel oranges.

The content of calcium during fruit development varied from 0.96±0.09 to 1.66±0.08 % in the peel, 0.55±0.09 to 1.29±0.11 % in pulp and 2.24±0.18 to 3.97±0.28 % in leaves of Daisy tangerine (Table 2). Irrespective of sampling stages, Ca was found highest in leaves as compared to other fruit parts (peel followed by pulp). Lowest Ca content in leaves was recorded in the month of May, then rose significantly till the final date of sampling. Storey and Treeby (15) also suggested the similar trend in the peel and pulp of Bellamy Navel orange fruits. Ca content in peel was increased up to July, then exhibited a declining trend, and further increased at full maturity stage non-significantly. Similar pattern of Ca was observed in the fruit pulp up to July, and declined steadily with considerable variations till the last date of sampling.

Magnesium content was higher in leaves as compared to peel and pulp during later stages of sampling (Table 2), being lowest on the first date of sampling (0.137±0.011 %), afterwards increased statistically till fruit maturity stage (0.504±0.039 %), which displayed consonance with the Mg pattern in 'Kinnow' leaves as described by Manivannan and Chadha (9). Mg content in peel increased up to third sampling date significantly, afterwards started declining till September, and increased with the approach of fruit maturity, non-significantly. In case of pulp, Mg content oscillated between 0.251±0.022 to 0.473±0.032 %, with the progression of the season from May to September, and further increased gradually till fruit maturity stage.

Higher seasonal distribution of N, P and K in pulp than peel was observed during fruit developmental period which is characterized as with their relatively higher phloem mobility. While, the higher concentration of Ca in the peel as compared to the pulp, would be associated with the least mobility of Ca in the phloem (Marschner, 10).

Table 2. Changes in Ca, Mg and Fe content of peel, pulp, and leaves of Daisy tangerine during fruit development.

Month	Ca (%)			Mg (%)			Fe (ppm)		
	Peel	Pulp/WF	Leaves	Peel	Pulp/WF	Leaves	Peel	Pulp/WF	Leaves
May	1.15 ± 0.09^{cd}	0.98 ± 0.07^{c}	2.24 ± 0.18^{e}	0.285 ± 0.015^{d}	0.338 ± 0.026^{b}	0.137 ± 0.011^{e}	92.47 ± 15.20^{a}	38.40 ± 8.21^{bc}	101.73 ± 5.81^{d}
June	1.29 ± 0.07^{b}	1.16 ± 0.09^{ab}	2.76 ± 0.15^{d}	0.372 ± 0.017^{c}	0.450 ± 0.033^{a}	0.198 ± 0.010^{d}	85.19 ± 9.94^{ab}	47.19 ± 8.55^{b}	103.54 ± 6.63^{d}
July	1.66 ± 0.08^{a}	1.29 ± 0.11^{a}	3.19 ± 0.29^{c}	0.508 ± 0.039^{a}	0.473 ± 0.032^{a}	0.226 ± 0.019^{cd}	72.39 ± 11.94^{bc}	59.64 ± 8.20^{a}	136.73 ± 8.19^{c}
Aug.	1.22 ± 0.09^{bc}	1.12 ± 0.10^{b}	3.52 ± 0.23^{bc}	0.474 ± 0.031^{ab}	0.328 ± 0.042^{b}	0.248 ± 0.017^{c}	65.47 ± 9.48^{cd}	35.11 ± 8.31^{cd}	148.92 ± 9.53^{bc}
Sept.	0.96 ± 0.09^{e}	0.83 ± 0.12^{d}	3.69 ± 0.21^{ab}	0.317 ± 0.017^{d}	0.251 ± 0.022^{c}	0.395 ± 0.023^{b}	53.19 ± 10.53^{de}	24.36 ± 5.69^{de}	155.13 ± 8.07^{b}
Oct.	1.08 ± 0.07^{de}	0.64 ± 0.09^{e}	3.85 ± 0.29^{ab}	0.395 ± 0.023^{c}	0.299 ± 0.016^{bc}	0.472 ± 0.020^{a}	39.27 ± 10.75^{ef}	19.39 ± 5.57^{e}	168.49 ± 11.37^{a}
Nov.	1.32 ± 0.09^{b}	0.55 ± 0.09^{e}	3.97 ± 0.28^{a}	0.462 ± 0.033^{b}	0.336 ± 0.039^{b}	0.504 ± 0.042^{a}	31.57 ± 10.01^{f}	16.27 ± 5.68^{e}	178.18 ± 10.66^{a}

Data are expressed as means ± standard deviation (n=4); Different superscripts between rows represent significant differences between fruit developmental stages ($p \leq 0.05$); WF for whole fruit which replaced the pulp from May to July.

Iron content in different plant parts of Daisy cultivar varied from 16.27±5.68 to 178.18±10.66 ppm during the study period (Table 2). Irrespective of fruit developmental stages, Fe concentration was found maximum in leaves succeeded by peel and pulp. Fe concentration was altered from 31.57±10.01 to 92.47±15.20 ppm in peel, 16.27±5.68 to 59.64±8.20 ppm in pulp and 101.73±5.81to 178.18±10.66 ppm in leaves during the different sampling stages. The Fe content in peel exhibited reducing trend with the advancement in fruit maturity period, whereas, it increased significantly in leaves. In the case of pulp, Fe content exhibited an increasing trend until July and later declined rapidly with the onset of fruit maturity. Fe acts as stimulator of sucrose phosphate synthase, which plays a key role in the synthesis of soluble sugars during fruit expansion stage (higher Fe content at this stage) and then demonstrated a decline in activity (Marschner, 10). Hence, we contemplated that the higher concentration of Fe in the pulp at fruit expansion stage (July) might have played a crucial role in the gathering of soluble sugars in Daisy fruits. Sharma *et al.,* (12) also recorded the Fe content ranging from 142.58 to 211.25 ppm in Marsh Seedless and 151.21 to 254.45 ppm range in Red Blush grapefruit varieties using different rootstocks.

The level of Mn content differed significantly in different parts of tree ranging from 1.94±0.13 to 38.47±1.96 ppm during the fruit development period (Table 3). The leaves proved rich in Mn having lower amount in May (16.18±1.63 ppm), afterwards increased statistically with the approach of final fruit harvesting stage. Mn content was significantly higher in the peel as compared to pulp throughout the study period. In case of peel, it was highest in August (28.43±10.18 ppm), then followed by a declining pattern with significant variation till the last date of sampling. Whereas in case of pulp, Mn concentration was highest at the fourth sampling stage, and declined thereafter. Similar outcomes regarding the trend of Mn in Bellamy Navel orange fruits were also reported by Storey and Treeby (15).

Zinc content in different plant parts demonstrated significant variation (5.53±1.33 to 39.68±2.23 ppm) during the course of study (Table 3). The Zn concentration was higher in leaves (15.47±1.05 to 39.68±2.23 ppm), followed by peel (10.67±0.94 to 29.27±2.01 ppm), and pulp (5.53±1.33 to 20.27±7.65 ppm). The foliar Zn concentration was highest in the month of May (39.68±2.23 ppm) and decreased thereafter. In peel, it decreased till August, and increased towards the approach of maturity. On the contrary, it was higher in young fruits (up to June)

Table 3. Changes in Mn, Zn and Cu content of peel, pulp, and leaves of Daisy tangerine during fruit development.

Month	Mn (ppm)			Zn (ppm)			Cu (ppm)		
	Peel	Pulp/WF	Leaves	Peel	Pulp/WF	Leaves	Peel	Pulp/WF	Leaves
May	12.38 ± 3.12^{c}	1.94 ± 0.13^{d}	16.18 ± 1.63^{f}	29.27 ± 2.01^{a}	18.47 ± 6.06^{ab}	39.68 ± 2.23^{a}	3.39 ± 0.91^{d}	2.49 ± 0.35^{d}	11.89 ± 2.00^{a}
June	17.59 ± 5.12^{abc}	2.59 ± 0.17^{c}	19.27 ± 1.22^{e}	21.33 ± 1.60^{b}	20.27 ± 7.65^{a}	35.27 ± 2.15^{b}	5.64 ± 0.71^{a}	3.86 ± 0.52^{c}	9.78 ± 1.52^{ab}
July	25.94 ± 8.05^{ab}	3.48 ± 0.33^{b}	23.60 ± 1.54^{d}	16.73 ± 0.88^{c}	15.40 ± 5.61^{abc}	25.94 ± 1.73^{c}	4.98 ± 0.74^{abc}	5.37 ± 1.16^{ab}	8.24 ± 1.80^{bc}
Aug.	28.43 ± 10.18^{a}	4.36 ± 0.28^{a}	26.93 ± 1.49^{c}	10.67 ± 0.94^{d}	12.68 ± 3.14^{bcd}	20.73 ± 1.81^{d}	4.54 ± 0.39^{bc}	6.18 ± 1.27^{a}	7.95 ± 1.54^{bc}
Sept.	22.74 ± 7.76^{abc}	3.74 ± 0.23^{b}	27.86 ± 1.65^{c}	12.40 ± 1.07^{d}	9.97 ± 2.56^{cde}	19.40 ± 1.14^{de}	4.25 ± 0.68^{cd}	5.05 ± 0.95^{abc}	7.60 ± 1.41^{bc}
Oct.	17.38 ± 11.51^{abc}	3.57 ± 0.27^{b}	32.92 ± 2.40^{b}	15.47 ± 1.02^{c}	6.84 ± 0.86^{de}	18.07 ± 1.63^{e}	5.43 ± 0.75^{ab}	4.62 ± 0.89^{bc}	6.82 ± 0.94^{c}
Nov.	14.96 ± 3.09^{bc}	3.52 ± 0.23^{b}	38.47 ± 1.96^{a}	16.20 ± 1.00^{c}	5.53 ± 1.33^{e}	15.47 ± 1.05^{f}	5.69 ± 0.75^{a}	3.89 ± 0.66^{c}	6.05 ± 0.98^{c}

Data are expressed as means ± standard deviation (n=4); Different superscripts between rows represent significant differences between fruit developmental stages ($p \leq 0.05$); WF for whole fruit which replaced the pulp from May to July.

in case of pulp, and then reduced significantly till the last sampling date. A declining pattern of Zn concentration in pulp and leaves of Newhall' and 'Skagg's Bonanza' Navel Oranges has also been reported by Xiao *et al.,* (16).

During the course of fruit developmental, Cu concentration showed the huge variation in peel (3.39±0.91 to 5.69±0.75 ppm), pulp (2.49±0.35 to 6.18±1.27ppm) and leaves (6.05±0.98 to 11.89±2.00 ppm) in of Daisy tangerine (Table 3). In the beginning, higher accumulation of Cu was noted in leaves, which declined continuously till fruit maturity. In peel, it was highest in the month of June (5.64±0.71 ppm), whereas lowest Cu was noticed in September (4.25±0.68 ppm). On the contrary, Cu concentration in pulp tended to increase up to August (6.18±1.27 ppm), and declined thereafter. A similar trend of Cu in peel and pulp of 'Star Ruby' cultivar in grapefruits was observed by Singh *et al.,* (13).

Overall, the declining seasonal pattern in the concentration of Mn, Zn and Cu are typical of fruits other than oranges (Clark *et al.,* 3). The higher content of Mn in the peel than pulp during most of the fruit developmental stages can be associated to the least mobility of these nutrients through the phloem, which can justify many times decline in pulp concentration as compared to peel. During fruit maturity, Fe content was remained relatively constant, while Zn and Cu content declined substantially over the same period, yet all three micronutrients are considered to have intermediate phloem mobility (Marschner, 10).

The correlation of leaf nutrition status with nutrition accumulation of peel, pulp and dry matter content of Daisy tangerine during the fruit development period was studied (Table 4). Of these, leaf N exhibited a positive and strong association with pulp (r= 0.663) than peel and strong negative correlation ($p < 0.01$) with dry matter accumulation (r= -0.861) indicating the competition for the nutrients between the vegetative growth and fruit growth (Dris *et al.,* 4). Other elements like P, Ca and Mg in leaves showed a positive correlation ($p < 0.01$) with dry matter accumulation in fruits. The leaf P exhibited significant negative correlation (r= -0.992) at 99% confidence level with peel nutrition, while, no relationship with fruit, and strong positive contribution (r= 0.959) to dry matter accumulation, during fruit maturity period. On the contrary, Atkinson (1) observed a strong correlation between leaf and pulp phosphorus in many fruit trees. K content in leaf displayed a strong negative association with dry matter accumulation (r= -0.973), and highly positive contribution with peel nutrition

Table 4. Pearson`s correlation matrix for the mineral nutrition concentration of leaves with nutrient accumulation of peel & pulp, and drymatter content of Daisy tangerine during fruit development.

Part	Leaves								
	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu
Peel	0.497	-0.992**	0.938**	-0.144	0.179	-0.973**	0.033	0.858*	-0.636
Pulp/WF[a]	0.663	0.577	-0.100	-0.590	-0.533	-0.965**	0.655	0.927**	-0.565
Dry matter	-0.861*	0.959**	-0.973**	0.846*	0.976**	0.892**	0.960**	-0.822*	-0.849*

*Correlation is significant at the 0.05 level (2-tailed)
**Correlation is significant at the 0.01 level (2-tailed)
[a]WF for whole fruit which replaced the pulp from May to July.

(r= 0.938). A negative association was observed between Ca and Mg of leaves and pulp of fruits (r= -0.590 and -0.533, respectively) with the onset of fruit maturity stage. This negative correlation of Ca between pulp and leaves might be associated to the restricted transport and immobility of Ca deposited in leaves (Faust, 5). In context to micronutrients, leaf Fe and Mn contents showed a positive correlation, while Zn and Cu had negative association with dry matter accumulation in fruits with relation to maturity stages.

A considerable variation ($p < 0.05$) was observed in macro and micronutrient concentrations during the whole study period. The general order of abundance of macro and micronutrients in leaves were Ca>N>K>Mg>P and Fe>Mn>Zn>Cu, respectively, during the fruit maturity period. However, macronutrient content for peel and pulp were distributed in range as K>Ca>N>Mg>P and K>N>Ca>Mg>P, respectively, at final stage of fruit harvesting. The order of micronutrients at full fruit maturity stage existed as Fe>Zn>Mn>Cu and Fe>Zn>Cu>Mn, for peel and pulp, respectively. Leaf N exhibited a positive association with peel (r= 0.497) than pulp and strong negative correlation with dry matter accumulation (r= -0.861) during the fruit development study period. Other elements like P, Ca and Mg in leaves showed a positive correlation with dry matter accumulation in fruits. This research will give sufficient information regarding accretion of mineral nutrition in plant parts of Daisy tangerine at different growth stages. Knowledge regarding nutrient removal pattern will be useful in determining the fertilizer requirement rates and timings to maintain sufficient supply of those particular nutrients through the soil. Further critical study about the mechanism underlying the genotypic variation in Daisy cultivar is needed.

DECLARATION

The authors declare no conflict of interest.

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