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Elemental Composition of Fresh Strawberry Fruit[1]

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Abstract. **Fruit and calyx of four strawberry clones (*Fragaria x ananassa* Duch.) were analyzed for N, P, K, Ca, Mg, Fe, Zn, Mn, B, and Cu content for 2 seasons. The elemental concn varied because of the year, the clone, and the time of season. The concn of the elements in the fruit decreased in the following order: K, N, P, Ca, Mg, Fe, B, Mn, Zn, and Cu. The elemental concn was greater in the calyx than in the fruit; probably as a result of the much higher dry weight content of the calyx. The total elemental content in kg/ha of the fruit and calyx for a season ranged as follows: K from 40 to 67, N from 33 to 49, P from 6 to 9, Ca from 5.4 to 7.5, Mg from 3.7 to 5.7, Fe from 0.11 to 0.15, Mn from 0.05 to 0.10, B from 0.04 to 0.09, Zn from 0.04 to 0.06, and Cu from 0.012 to 0.016.**

Information on the elemental composition of fresh strawberry fruit during a 3 to 5 month harvest season and on the total elemental content of the strawberry fruit crop for a season is not available. Such information is useful in developing fertilizer programs and determining elemental fruit content differences because of genotype or time of harvest. The elemental composition of fresh strawberry fruit has been reported (1, 4, 5, 6, 7, 8), but some reports concern only one or two elements of a single cultivar (4, 6, 7) while others give the average composition of several cultivars for a season (8). All are for harvest seasons of a month or less. Studies on elemental composition of fruit on a dry wt basis are extensive. However, since variation of the % dry wt of strawberries can be quite large (2), dry wt concn can not be accurately related to fresh wt concn.

This study reports on the elemental composition and concn of fresh strawberry fruit and calyx as related to clone and to the sampling date during a three and one-half month harvest season.

Materials and Methods

The experiment was conducted on a Scranton (adjunct) fine sand in 1974-75 and 1975-76 at the Agricultural Research Center, Dover, FL. The Sept. 1974 soil test values of the saturated paste extract as ppm were: salts 440, K 35, Ca 35, and NO_3 68 (3). The soil had a pH of 6. Plots were fertilized each year with 224, 186, and 49 kg/ha of N, K, P, respectively, derived from NH_4NO_3, KCl, and superphosphate. In Sept. 1974, 40 kg/ha of micronutrients (Frit 503) were applied. Five plots each of the clones 'Tioga', 'Florida Belle', 71-729, and 69-266 were established in a randomized complete block design each Oct. Each year plots were fumigated with methyl bromide and chloropicrin, and beds were mulched with 1 mil polyethylene. Fruit were harvested twice weekly from early Jan. through late April each year, graded as marketable or cull, counted, and weighed. Random samples of the marketable fruit were taken from each plot on Jan. 14, Feb. 4, 28, March 14, 27, and April 10 during 1975 and on Jan. 16, Feb. 12, 26, March 12, 25, and April 9 during 1976. These sampling dates are referred to in this paper as sampling dates 1-6. Fruit samples were rinsed in tap and distilled water and blotted dry. Fruit and calyx were weighed and then dried at 60°C to a constant wt, and ground by mortar and pestle. Samples were wet ashed, and N was determined by the Kjeldahl method, B by the quinalizarin procedure, P was determined colorimetrically, and all other elements by atomic absorption spectrophotometry.

On each sampling date, calyces from each clone were combined for analysis since an insufficient amount of sample was available for analysis from a single plot.

The amount of each element present in the fruit or calyx for the harvest season was determined in the following manner. Fruit yields were determined for each harvest period. The harvest period for a sampling date was one-half the interval between the time of the previous and the time of the following sampling dates. These yields were multiplied by the respective concn to determine the amount of an element in the tissue and in the crop.

Results

Plant growth and foliage color were good both seasons, and fruit yields were average to excellent for central Florida (Table 4). The % dry wt of the fruit varied with the sampling date and the clone (Table 1). These data confirm previous results (2) and indicate that the elemental concn of the fruit on a dry wt basis cannot be directly related to the elemental concn of the fresh fruit. The 'Florida Belle' clone had the highest % dry wt both years. The relative fruit wt of the 4 clones was 1, 1.2, 1.4, and 1.9 for 'Tioga', 71-129, 'Florida Belle', and 69-266, respectively. Thus, there appears to be little relationship between the fruit wt of a clone and the % dry wt of the fruit. The % dry wt of the fruit was highest in the early part of the fruiting season, lowest at mid-season, and increased again towards the end of the season.

Except for N in 1975 and Zn and B in 1976, the concn of the elements in the fruit varied because of clone each year (Table 2). Although the elemental concn of the fruit varied somewhat with the year, the relative elemental concn of the

Table 1. Effect of sampling date and clone on percent dry wt of fruit for two seasons.[z]

Clone	Year		Sampling date[y]	Year	
	1975	1976		1975	1976
Tioga	6.30c	6.69b	1	7.57b	7.42b
69-266	6.65b	6.72b	2	7.87a	7.64a
71-729	6.57b	6.63b	3	5.70d	5.98e
Florida Belle	6.93a	6.98a	4	5.15e	5.36f
			5	5.97d	6.58d
			6	7.06c	6.93c

[z]Mean separation for cultivar or sampling date avg by Duncan's multiple range test, 5% level.

[y]Each sampling date is an avg of all 4 clones.

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Table 2. Effect of season and clone on elemental concn in fresh strawberry fruit.

Clone	Element concn[z] (ppm x 10^2) N	P	K	Ca	Mg	(ppm) Fe	Zn	B	Mn	Cu
					1975					
Tioga	10.3a	2.1b	15.7b	1.5a	1.3a	3.1ab	1.4a	1.8b	2.1a	0.4a
69-266	9.6a	1.9c	15.1b	1.3b	1.1c	2.9b	1.1c	2.0a	1.5b	0.3b
71-729	9.9a	2.0c	13.7c	1.4b	1.3a	3.3a	1.2b	2.0a	1.8ab	0.4a
Florida Belle	11.8a	2.4a	16.4a	1.2c	1.2b	3.3a	1.2b	1.9a	1.5b	0.4a
					1976					
Tioga	13.4a	2.5a	16.6a	1.7a	1.1b	3.0b	1.2a	1.6a		
69-266	11.1b	2.0b	15.2b	1.4b	1.0c	2.9b	1.3a	1.8a		
71-729	11.4b	2.1b	14.0c	1.6a	1.2a	3.4a	1.3a	1.5a		
Florida Belle	13.2a	2.5a	15.8ab	1.4b	1.1b	3.1b	1.3a	1.6a		

[z]Mean separation for clone avg (6 dates x 5 replicates) within each year by Duncan's multiple range test, 5% level.

Table 3. Elemental concn of strawberry calyx (average of the two seasons).

Clone	Element concn (ppm x 10^2) N	P	K	Ca	Mg	(ppm) Fe	Zn	B	Mn	Cu
Tioga	45.2	9.3	30.5	24.7	7.0	37.5	6.1	11.4	12.1	2.1
69-266	53.5	9.7	32.3	32.2	8.8	43.4	6.0	10.6	14.6	1.2
71-729	56.1	8.6	34.2	32.3	10.0	54.4	7.1	12.2	15.1	1.5
Florida Belle	52.5	9.2	30.0	24.5	8.0	48.8	7.2	12.1	12.2	1.4

Table 4. Total elemental content in marketable strawberry fruit and calyx (average of two seasons).

Clone[z]	Tissue[y]	Elemental content (kg/ha) N	P	K	Ca	Mg	(g/ha) Fe	Zn	B	Mn	Cu	Seasonal fruit yield (kg/ha)
Tioga	F	37.72	6.84	50.35	5.07	3.80	90.7	41.9	52.6	76.3	13.3	31621
	C	1.50	0.31	1.02	0.81	0.24	11.9	2.1	3.8	4.8	0.8	343
69-266	F	33.37	6.10	47.05	4.32	3.45	86.9	39.5	56.7	37.5	10.1	32340
	C	2.12	0.39	1.28	1.27	0.35	17.0	2.4	4.3	6.0	0.5	397
71-729	F	28.76	5.45	38.05	3.92	3.48	102.5	37.3	49.3	62.4	12.4	28425
	C	1.94	0.30	1.19	1.14	0.36	18.5	2.5	4.4	6.1	0.6	352
Florida Belle	F	37.32	7.16	48.00	3.88	3.46	96.4	37.7	49.8	44.7	11.4	29647
	C	2.18	0.39	1.27	1.02	0.34	20.1	3.0	5.1	5.6	0.7	421

[z]Cultivar or breeding line.

[y]F = marketable fruit without calyx, C = calyx from marketable fruit.

fruit for a given clone was similar both years. That is, if the concn of a given element was low in one clone compared with others in 1975, the same relationship existed for 1976. For either year, the K concn in the fruit was the highest followed by N, P, Ca, Mg, Fe, B, Mn, Zn, and Cu, respectively. 'Tioga' and 'Florida Belle' generally had the highest fruit N, P, and K concn both years. The elemental concn of the calyx was greater than that of the fruit (Table 3).

The P, Fe, Zn, and Cu concn of the fruit were generally highest at the beginning of the harvest season and declined thereafter (See Fig. 1, 2, and 3). The Ca concn of the fresh fruit increased from the first to the last sampling date during both years. The Mg concn of the fruit was high at the end of the season, but no definite trend existed for the 2 years. The B and K concn of fruit showed no definite trend because of sampling date.

The amount (kg or g/ha) of each element in the fruit for a season is given in Table 4. The variation among clones is greater in Table 4 than in Table 2 because yield is a factor in Table 4. The values given in Table 4 can be used as reasonable estimates of the elemental content of a strawberry crop grown under similar conditions. Although the calyx is about 1% of the combined fruit and calyx wt, it contained more than 1% of any given element. This is the result of the greater elemental concn of the calyx as noted previously. The variation in the elemental content of the calyx vs. that of the fruit is quite

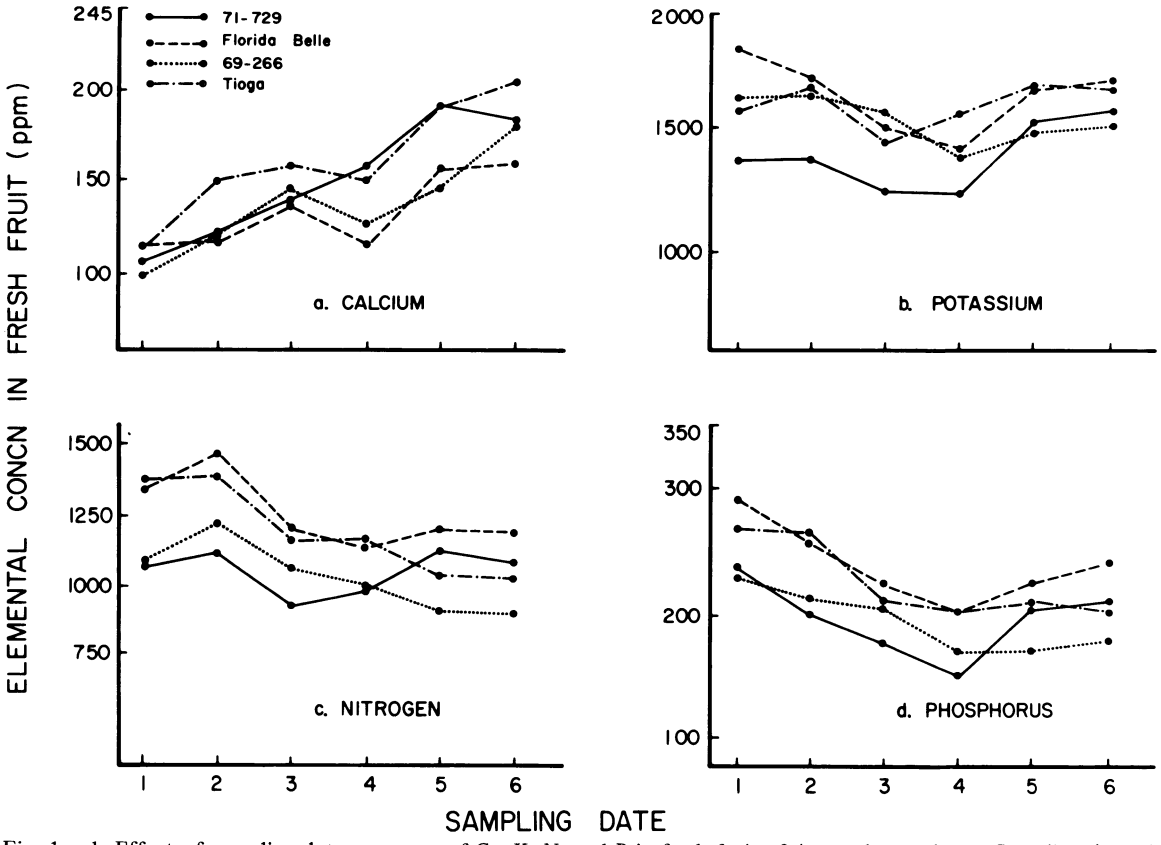

Fig. 1 a-d. Effect of sampling date on concn of Ca, K, N, and P in fresh fruit of 4 strawberry clones. Sampling dates 1 through 6 for 1975 (month/day) are 1/14, 2/4, 2/28, 3/14, 3/27, and 4/10 and for 1976 are 1/16, 2/12, 2/26, 3/12, 3/25, and 4/9, respectively. Data are average of 2 years.

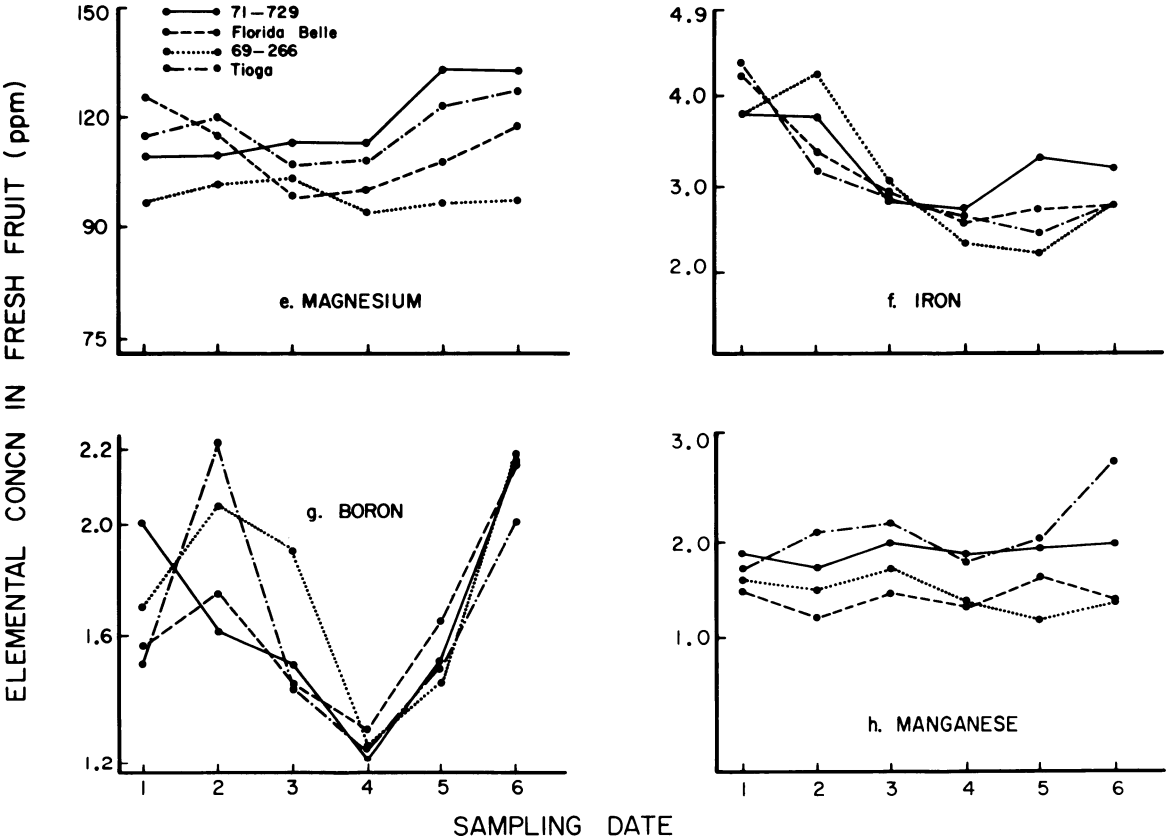

Fig. 2 e-h. Effect of sampling date on concn of Mg, Fe, B, and Mn in fresh fruit of 4 strawberry clones. Sampling dates 1 through 6 for 1975 (month/day) are 1/14, 2/4, 2/28, 3/14, 3/27, and 4/10 and for 1976 are 1/16, 2/12, 2/26, 3/12, 3/25, and 4/9, respectively. Data are average of 2 years except for Mn.

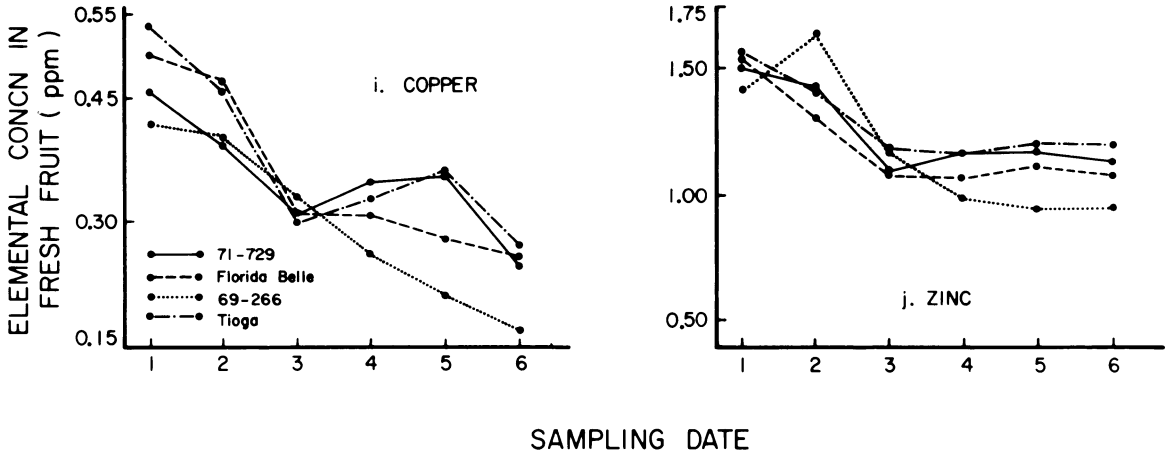

Fig. 3 i-j. Effect of sampling date on concn of Cu and Zn in fresh fruit of 4 strawberry clones. Sampling dates 1 through 6 for 1975 (month/day) are 1/14, 2/4, 2/28, 3/14, 3/27, and 4/10 and for 1976 are 1/16, 2/12, 2/26, 3/12, 3/25, and 4/9, respectively. Data are averages of 2 years except for Cu.

large with the calyx containing about 20% of the Ca but only about 2% of the K.

Discussion

The data presented can be used in determining the amount of each of the 10 elements removed by the fruit and calyx. Since only the fruit and calyx are removed from the field, the information presented indicate the total amount removed by a crop. By incorporating a grower's normal yield into the data, an estimate of the amount removed by a crop can be obtained. Since losses or gains of soil nutrients by other means are not considered here, they should be calculated into the fertilization program. Variation from the data presented may result with plants not adequately fertilized, when the soil composition is changed, and possibly when different cultural practices are used. Differences as a result of genotype also need to be taken into consideration with fertilization. The differences between a genotype containing the highest concn of an element in the fruit for a season vs. one with the lowest concn was 8 to 29% in our trials.

The data can be used to indicate the nutritive value of the strawberry fruit with respect to the 10 elements tested and how the fruit composition of these elements may vary during the harvest season.

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