found in the 1st internodes if the younger runner plant was not present or treated (Table 1). These results, based on field application of (*methyl*-^{14}C)glyphosate, indicate that glyphosate is translocated into expanding runner plants, and the amount of ^{14}C translocated into the mother plant depended upon the site of application of the (*methyl*-^{14}C)glyphosate. We suggest from these results that interrow weeding of nonfruiting strawberry with glyphosate does not pose a residue problem from translocation of this herbicide when spray is intercepted by the stolons and runner plants. The results also confirm those reported previously (2) that injury to the mother plants does not occur because there is little translocation of glyphosate from the stolons.

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Ascorbic Acid, Riboflavin, and Thiamin Content of Strawberries during Postharvest Handling

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Abstract. **California and Florida strawberries from wholesale and retail stores in the greater New York area were analyzed for ascorbic acid (AA), riboflavin, and thiamin upon arrival. Retail samples also were analyzed after 3 days of simulated consumer storage at 5.5° and 90% RH. Locally-grown New Jersey strawberries were analyzed the day of harvest and after 4 and 7 days of storage at 5.5°C and 90% RH. Levels of AA in California and Florida berries were, on average, 8 mg/100 g fresh weight lower in wholesale than in retail samples. The average AA content of New Jersey berries was 31 mg/100 g fresh weight less than combined values of berries from California and Florida. Riboflavin levels in all samples were about 80% less than reported in standard nutrient tables. Thiamin was higher than reported in standard tables.**

Strawberries, one of our most popular fruit, are available almost year-round. In metropolitan New York, 19,274 MT were received in 1981, 98% of which came from California and Florida (5, 10). The strawberry is 11th in ascorbic acid (AA) content, 17th in riboflavin, and 36th in thiamin among 42 fruit and vegetables ranked for nutritive value (11). These water soluble vitamins are affected by temperature, moisture, light, oxygen, internal enzyme activity, and acidity. Commodity handling conditions between harvest and consumption also affect vitamin content (12). Thiamin in solution is destroyed by storage at room temperature at pH 7 or higher (4). Riboflavin is destroyed rapidly by light (3). Ascorbic acid is relatively stable. In one early study, strawberries stored for 2 days at 24°C and 5 days at 4° retained 90% and 95% of their AA (9).

This research was conducted to determine concentrations of thiamin, riboflavin, and AA in strawberries from California and Florida, obtained from 4 wholesale warehouses and 6 retail stores in metropolitan New York. Also analyzed were berries from 3 New Jersey growers. 'Tufts', 'Douglas', and 'Pajaro' strawberries from California and Florida, were grown under polyethylene mulch with trickle irrigation and fertilization, and were matured under higher soil pH and cooler temperatures than 'Raritan', 'Earliglow', and 'Guardian' strawberries grown under matted row culture in New Jersey. Berries from California and Florida were in transit for 2 to 5 days at 1° to 2°C in refrigerated trucks. New Jersey berries were placed on ice and transported in 1 to 2 hr to New Brunswick. Maturity of freshly-harvested New Jersey berries was similar to that of California and Florida berries at retail level.

In 1981 and 1982, analyses for thiamin, riboflavin, and AA in each category of berries were replicated a total of 16 to 19 times. Six 1-pint (0.55 liter) containers were taken at random from a flat of wholesale berries and analyzed the day of arrival in New York. Two pints were purchased at each of 6 different retail stores, one pint analyzed the day of purchase, the other stored 3 days at 5.5°C and then analyzed. Strawberries from 3 New Jersey growers were analyzed the day of harvest and after 4 and 7 days of storage at 5.5° and 90% RH. Berries were prepared for extraction by capping and comminution.

A continuous flow Technicon Autoanalyzer II (Technicon Industrial Systems, Tarrytown, N.Y.) was used to analyze strawberries for thiamin, riboflavin, and ascorbic acid (14, 15, 16). A different mixing manifold and proper light filters were required for each vitamin.

A modification of methods of Defibaugh et al. (7) and Technicon (16) was used for thiamin analysis. Samples (20 g) were extracted with 100 ml of 0.1 M HCl and blended for 3 min at 20,500 rpm in a microblender. Blended extracts were autoclaved for 30 min at 121°C, adjusted to pH 4.3 with 1.25 M sodium acetate, and 50 ml of the extract was diluted to 100 ml with pH 4.3 metaphosphoric acid. Extracts were filtered through Whatman 2V filter paper and analyzed fluorometrically. Analysis of thiamin was based on potassium ferricyanide oxidizing thiamin in extracted filtrate to thiochrome. Thiochrome fluoresces in ultraviolet light at 435 nm after excitation at 365 nm. To obtain blank values, the tube supplying potassium ferri-

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Table 1. Mean ascorbic acid, riboflavin, and thiamin content (fresh weight) of California and Florida strawberries at different marketing levels in Metropolitan New York.

Marketing level	Vitamin content		
	Ascorbic acid mg/100g	Riboflavin µg/100g	Thiamin µg/100g
Wholesale[z]	60 a[y]	12 a	66 a
Retail	68 b	21 b	62 a
Simulated consumer storage	68 b	11 a	48 a
Overall means	65	15	59

[z]Wholesale berries procured 2–5 days from harvest and shipped at 1.7°C.
[y]Means separation among marketing levels by Duncan's multiple range test, 5% level.

cyanide was placed in distilled water, and duplicate samples were run.

The AOAC method (2) was used to analyze for riboflavin. Samples (20 g) were extracted by autoclaving 30 min at 121°C with 100 ml HCl, adjusted to pH 4.3, and brought to volume in the same manner as with thiamin. All extracts were filtered into amber volumetric flasks. Fluorescence of riboflavin was measured at 510 nm in an acidic medium; interfering substances were destroyed by oxidation with potassium permanganate, which is decolorized with sodium bisulfite. Interfering fluorescence was measured separately after reducing riboflavin with sodium hydrosulfite.

For analysis of AA, 20 g comminuted strawberries were blended at 20,500 rpm for 3 minutes with 200 ml 0.5% oxalic acid. Extracted material was filtered through Whatman 1 filter paper into amber volumetric flasks. N-bromo-succinimide was added to convert reduced AA to dehydroascorbic acid, and then orthophenylenediamine dihydrochloride to induce fluorescence. Parallel samples were run in the presence of sodium borate to obtain blank correction. Known standards were run with samples for each vitamin.

Data were evaluated as a completely randomized block design and differences were determined by Duncan's multiple range test (8, 13). Individual vitamins were analyzed separately using Snedecor's randomized complete block design with store and wholesale samples as blocks and marketing period as treatment. Wholesale, retail, and stored berries were analyzed both separately and combined.

Vitamin contents of fresh strawberries for 1981 and 1982 are shown in Tables 1 and 2. California and Florida strawberries contained an average of 59 µg thiamin, 15 µg riboflavin, and 65 mg AA per 100 g fresh-

Table 2. Ascorbic acid, riboflavin, and thiamin content (fresh weight) in freshly harvested New Jersey strawberries held at 5.5°C.

Days at 5.5°C	Vitamin content		
	Ascorbic acid mg/100g	Riboflavin µg/100g	Thiamin µg/100g
0	62 a[z]	16 a	55 a
4	53 b	16 a	41 ab
7	33 c	8 b	26 b
Mean	49	13	41

[z]Means separation among days in storage by Duncan's multiple range test, 5% level.

weight; New Jersey strawberries an average of 41 µg thiamin, 13 µg riboflavin, and 49 mg AA per 100 g fresh weight. Strawberries from California and Florida contained 29 µg more thiamin, 55 µg less riboflavin, and 6 mg more AA per 100 g fresh weight than reported by Adams (1) and Salunkhe (11). New Jersey strawberries contained 11 µg more thiamin, 57 µg less riboflavin, and 10 mg less AA than reported (1, 11).

Mean thiamin concentration in strawberry samples ranged from 29 to 130 µg/100 g fresh weight. Concentrations in wholesale, retail, and consumer-stored strawberries from California and Florida were not significantly different. In comparison, New Jersey berries after 0, 4, and 7 days of storage differed significantly in thiamin retained. Wholesale, retail, and stored strawberries from California and Florida contained, on average, 18 µg more thiamine than New Jersey strawberries (Table 1). Average thiamin concentrations reported in these tests were 11 µg/100 g fresh weight higher than reported on strawberries by Adams (1) and Salunkhe (11).

Riboflavin content in individual strawberry samples ranged from 6 to 29 µg/100 g fresh weight. Concentrations in California and Florida berries from retail markets were higher than those from wholesale markets. Simulated consumer storage of all strawberry samples resulted in significant losses (Tables 1 and 2). Average riboflavin content in berries from the 2 sources was similar, 15 µg/g fresh weight for California and Florida, and 13 µg/g fresh weight for New Jersey. Average values in these tests were considerably lower than the values reported by Adams (1) and Salunkhe (11).

Total AA content in individual strawberry samples ranged from 28 to 82 mg/100 g fresh weight. Average values for New Jersey berries (49 mg/100 g fresh weight) were less than those of California and Florida (65 mg/100 g fresh weight). New Jersey berries lost significant amounts of AA during storage. No such losses were detected in berries from California and Florida sampled at wholesale and retail markets. The AA content of retail berries was significantly higher than wholesale samples. Average AA content in wholesale, retail, and stored berries was slightly more (6 mg/100 g fresh weight) than reported by Adams (1) and Salunkhe (11), and slightly less (5 mg/100 g fresh weight) than reported by Mayfield and Richardson (9). The New Jersey Strawberries contained much less (18 mg/100 g fresh weight) AA than reported by Mayfield and Richardson (9), and less (7 mg/100 g fresh weight) than reported by Adams (1) and Salunkhe (11).

Factors, such as the amount of exposure to sunlight during growth, differences in degree of ripeness, length of time in transit, transit temperatures, physiological differences among cultivars, and differences in growing area and season, probably account for the variation. Burkhart and Lineberry (6) found considerable variation in Vitamin C during analysis of strawberry samples. Further testing on the effect of maturity on AA content in strawberries is needed to explain the difference found in wholesale, retail, and stored samples.

Variations in riboflavin content could have been due in part to maturity differences and to light degradation during preparation (3). Such variations were not found in samples of bell peppers handled and prepared similarly (unpublished data).

Thiamin content varied very little among wholesale, retail, and stored samples. The minor differences among these berries may have been reflections of the large initial increases that had already occurred before harvest.

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Effect of Triacontanol on Yield and Fruit Composition of Spring-harvested 'Tangi' and 'Dover' Strawberries

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Additional index words. *Fragaria* x*ananassa*, compositional analysis, 1-hydroxytriacontane

Abstract. **Triacontanol (1-hydroxytriacontane) applied as a foliar spray or soil drench to 'Tangi' and 'Dover' strawberries (*Fragaria* x*ananassa* Duch.) did not affect total yields when applied at 0.1 - 5.0 mg/liter. Fresh fruit weight was increased significantly when triacontanol was applied at 2.00 mg/liter. Soluble solids, pH, solids:acid ratio, titratable acidity, ascorbic acid content, and internal color of fruit were not affected by triacontanol.**

Triacontanol [$Ch_3(CH_2)_{28}CH_2OH$], a principal long chain alcohol derived from alfalfa hay (*Medicago sativa* L.), has many characteristics of a plant hormone (5). In some instances, exogenous applications of triacontanol have been shown to increase the growth and development and yield of several crop plants (4).

Mamat et al. (3) reported increases in yield and number of fruits in triacontanol-treated tabasco pepper (*Capsicum frutescens*). Bouwkamp and McArdle (2) found that applications of triacontanol on sweet potatoes (*Ipomoea batatas*) increased percentage of dry weight and percentage of N of the leaves, but had no measurable effect on root yields, root protein, or percentage of dry matter of the root. No effect on muskmelon (*Cucumis melo*) was reported (1).

Preliminary work indicated that triacontanol applied as a foliar spray at prebloom and postbloom was not effective in influencing the fruit production of 'Tangi' and 'Dover' strawberries.

The objective of this research was to evaluate the response to triacontanol applied as a soil drench and as a foliar spray by measuring strawberry production and fruit quality factors.

'Tangi' and 'Dover' strawberries were planted 8 Nov. 1982, in Olivier silt loam soil. Ten plants per plot were established in raised beds covered with 1.5 mil black polyethylene. Rows were 1.22 m apart and the plots were 1.52 m long with plants set 0.31 m apart in double rows.

Triacontanol was prepared according to the method developed by Mamat et al. (3) and was applied to the plants within 24 hr. The 1st application of triacontanol was made by pouring 25 ml of the solution over the roots at transplanting, using concentrations of 0, 1.00, 1.25, 1.50, 1.75, and 2.00 mg/liter. A 2nd treatment was made at first bloom as a foliar spray applied to the point of run-off, using the same 6 concentrations.

Twice weekly harvesting of fruit with 90% red color began on 7 Mar. 1983. All fruit were weighed and counted to determine yield per plot and average fruit size.

A randomized split-plot design was used in the field with cultivar as the main plots and triacontanol treatment within subplots.

Table 1. Effect of triacontanol on yield of 'Tangi' and 'Dover' strawberries.

	Yield (MT/ha)			
Main effects	Early season 6–28 Mar.	Mid season 29 Mar.–29 Apr.	Late season 30 Apr.–16 May	Total season
Triacontanol (mg/liter)				
2.00	2.60	8.55	4.33	15.49
1.75	2.93	8.20	5.04	16.12
1.50	2.57	7.96	4.77	15.29
1.25	2.95	8.07	4.44	15.46
1.00	2.81	8.56	5.05	16.38
0.00	2.64	7.33	5.68	15.76
LSD	NS	NS	1.30	NS
Cultivar				
Tangi	1.86	4.61	7.99	14.49
Dover	3.63	11.61	1.78	17.01
LSD	1.28	2.28	2.39	2.53

NS, Not significant.

Table 2. Fruit size of 'Tangi' and 'Dover' strawberries following triacontanol treatment.

	Fruit size (g/fruit)			
Main effects	Early season 7–28 Mar.	Mid season 29 Mar.–4 Apr.	Late season 30 Apr.–15 May	Total season
Triacontanol (mg/liter)				
2.00	14.1	16.5	9.0	14.1
1.75	13.6	15.0	9.5	13.5
1.50	13.7	14.9	9.2	13.4
1.25	13.4	14.7	8.5	12.8
1.00	13.0	14.9	8.5	12.9
0.00	12.4	15.1	8.3	12.5
LSD	1.4	NS	NS	1.5
Cultivar				
Tangi	10.0	11.0	9.0	10.0
Dover	17.0	19.0	8.0	16.0
LSD	1.9	3.9	0.8	1.8

NS, Not significant.

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