Foliar Application of Adenosine Increases Fruit Size of *Solanum lycopersicum*, *Citrus reticulata*, and *Persea americana*

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Abstract

Adenosine applied daily to the root zone of 'Super Sweet 100' cherry tomato plants (*Solanum lycopersicum*) in 5 kg of soil mix in 9.5-L plastic pots over a 75-day growing period (3.25 µg/plant) significantly increased total fruit number per plant 1.9- and 2.3-fold and fruit diameter 1.6- and 1.7-fold compared to untreated control plants in two separate experiments, respectively. A single annual foliar application of adenosine (58 g/ha) to 'Fina Sodea' Clementine mandarin (*Citrus reticulata*) trees in a commercial orchard when fruit were 25 mm in diameter (July, during exponential fruit growth) significantly increased 3-year cumulative yield of fruit of packing carton sizes large (57.2-63.5 mm transverse diameter) and jumbo (63.5-69.9 mm) as both kilograms and number of fruit per tree, without reducing total yield in any year of the study, compared to untreated control trees. The result was a net increase of 5.1 11-kg cartons of commercially valuable large fruit per tree. Two foliar applications of adenosine (58 g/ha) alone, or with triiodobenzoic acid (58 g/ha), to 'Hass' avocado (*Persea americana*) trees in a commercial orchard prior to periods of exponential fruit growth in summer (July) and in spring (January) of the high-yield on-crop year resulted in a net increase of 4,424 and 5,750 kg of large size fruit (213-269 g/fruit) per hectare, respectively, with no reduction in total yield in the treatment year or following year compared to untreated control trees. The two treatments increased 2-year cumulative yield of large size fruit by 4,908 and 7,163 kg per ha, respectively. Adenosine has significant potential to increase grower income by increasing fruit size without reducing total yield or fruit quality.

INTRODUCTION

The fresh fruit industries of California contribute significantly to the economy of the State. The California fresh market tomato industry is comprised of 35,000 bearing hectares that in 2011 produced 563,598 metric tons of tomatoes valued at US$ 377.7 million [USDA National Agricultural Statistic Service (NASS), February 2102]. In 2011, the California citrus industry produced 395,539 metric tons of easy-peeling mandarins valued at US$ 183.0 million on 38,000 bearing hectares (USDA NASS, October 2012). California produces 95% of all avocados produced in the United States. The 2011-2012 California avocado crop was 209,699 metric tons produced on 24,132 bearing hectares with a value of US$ 381.9 million (California Avocado Commission, http://california avocado growers.com/selling/industry-statistical-data). However, the costs (land, taxes, labor, water, fertilizer) associated with growing a commercial fruit crop in California are high and continue to increase. To remain competitive and thus, sustain these commodity-based industries, growers must increase yield, especially of commercially valuable large fruit, to increase net profit per hectare. The potential for the metabolite adenosine to assist growers in meeting this goal was investigated.

Adenosine is of interest because purine salvage reactions in plants convert adenosine to adenosine monophosphate (AMP), which is in turn sequentially metabolized to adenosine diphosphate (ADP) and adenosine triphosphate (ATP), an important building block for the synthesis of DNA and RNA and the major energy intermediate in cellular metabolism. Radiolabeled adenosine supplied to developing citrus fruit was incorporated equally into nucleotides (AMP, ADP and ATP) and nucleic acids (DNA and RNA) with less than 2% catabolized (Tomlinson and Lovatt, 1987). Adenosine monophosphate, and to a lesser degree ADP and ATP depending on the plant species, serve as substrates for isopentenyl transferase in the first step committed to cytokinin biosynthesis (Letham and Palni, 1983; Sakakibara, 2006). Metabolic evidence supports the conversion of adenosine to cytokinins (Nishinari and Syono, 1980; Letham and Palni, 1983; Mok and Mok, 2001).

Taken together, the roles of adenosine in plant metabolism discussed above suggest that exogenous application of this metabolite might stimulate plant growth. The goal of the research presented herein was to test the potential of soil- and foliar-applied adenosine to increase yield or fruit size of three commercial fruit crops of economic importance to California and worldwide. The results presented are preliminary. They are the results obtained in the first experiments utilizing adenosine on each crop and represent our best guess as to concentration and application time.

MATERIALS AND METHODS

Tomato

The hybrid, indeterminate cherry tomato (*Solanum lycopersicum* var. *cerasiforme*) 'Super Sweet 100' (Ferry-Morse Seed Co., Jacksonville, FL) was used in this research. Two experiments were conducted in a greenhouse at the University of California-Riverside (33.95°N, 117.40°W) from April to July and October to December of the same year, respectively. Prior to the start of the experiment, 9.5-L plastic pots were filled with 5 kg University of California Soil Mix I (Baker, 1957). Seeds were imbibed overnight on a moistened towel and then sown in the pots. Distilled water was applied to maintain soil moisture at field capacity. After germination, plants were thinned to four plants per pot. There were five treatments: (1) untreated control receiving distilled water only; (2) iso-pentenyladenine (IPA) dissolved and applied in 64.8 mL of water per pot every 10 days (from day 10 to 70) for a total of 0.0325 µg per plant at the end of the 75-d growing period; and treatments (3) IPA, (4) 6-benzyladenine (BA), and (5) adenosine each dissolved and applied in 64.8 mL of water per pot daily (days 1-70) for a total of 3.25 µg per plant at the end of the 75-d growing period, respectively. All hormones and adensoine were purchased from Sigma (St. Louis, MO). For both experiments, each of the five treatments was replicated four times in a completely randomized design. A replicate was a pot of four cherry tomato plants, with the yield parameters of the four plants averaged to give one value per pot.

1. Experiment 1. Plants were grown in the greenhouse in April through July. Photo-synthetic photon flux density (PPFD), measured at canopy level with a quantum sensor (Li-COR, Lincoln, NE), averaged 1050 µmol/m^2/s midday under cloudless conditions. Day length averaged 13 h per day over the 75-d period. Greenhouse temperatures averaged 34°C maximum and 18°C minimum. Distilled water was applied to maintain soil moisture at field capacity as needed. No fertilizer was supplied.

2. Experiment 2. Plants were grown in the greenhouse from October until December, during which time PPFD averaged 949 µmol/m^2/s midday under cloudless conditions. Day length was maintained at 13 h per day with 400 watt high pressure sodium grow lights. Greenhouse temperatures averaged 21°C maximum and 8°C minimum. All plants were watered with Shive's nutrient solution, containing 5 mM $Ca(NO_3)_2$, 2 mM $MgSO_4$, 2 mM K_2SO_4, 1 mM KH_2PO_4, 1 mg/L Fe, 1 mg/L Mn, 0.13 mg/L Cl, 0.1 mg/L Zn, 0.1 mg/L B, 0.01 mg/L Cu and 0.01 mg/L Na (Shive and Robbins, 1938), at 150 mL per pot weekly. If needed, distilled water was applied to maintain soil moisture at field capacity.

Mandarin

Five-year-old commercially bearing 'Fina Sodea' Clementine mandarin trees in an orchard near Grapevine, CA (34.94°N, 118.83°W) were used in the research for three sequential crop years. Treatments consisted of (1) an untreated control and (2) adenosine (58 g/ha) (Sigma, St. Louis, MO). Adenosine was applied foliarly when fruit transverse diameter averaged 25 mm (July, exponential fruit growth phase) in 1869 L of water (final pH of 5.5) per ha, and included the surfactant Silwet L77® (General Electric Co.) at a final concentration of 0.01% (v/v). A 2758-KPa handgun sprayer was used to give full canopy coverage. Each treatment was replicated on 15 individual trees in a randomized complete block design with buffer trees between treated trees within a row and buffer rows between treated rows. All trees received grower standard soil-applied fertilizer. Trees were harvested annually in January. Just prior to harvest, a random sample of 25 fruit per tree was collected around the circumference of the tree at height of 1.5 m, pooled and used for the analysis of fruit quality parameters, including: fruit fresh mass (g), juice mass (g), percent juice (calculated), soluble solids (°Brix) by refractometry, percent acidity (by titration), and soluble solids:acids ratio (calculated). Total yield (kg) per tree and fruit size distribution (pack out) as the kilograms of fruit in each size category were determined at harvest for each data tree, using a portable, commercial in-field fruit sizer. The following fruit size categories based on fruit transverse diameter (mm) were used: small (44.5-50.8), medium (50.8-57.2), large (57.2-63.5), jumbo (63.5-69.9), and mammoth (69.9-76.2). The mass of 150 fruit (10% of the total fruit per tree) in each size category was used to calculate the total number of fruit and number of fruit in each size category per tree. Fruit were packed by number (based on size) per 11-kg carton. Fruit count per carton was: small, 40; medium, 34; large, 26; jumbo, 19.5; and mammoth 15. Average US dollars per carton (retail) of fruit of each size category was based on FOB prices supplied by large grower, packer, and shipper of mandarins in the Central San Joaquin Valley, CA: < small, US$ 0; small, US$ 3.50; medium, 3.75; large, US$ 4.10; jumbo, US$ 4.10; mammoth, US$ 4.10; > mammoth, US$ 0.

Avocado

Twelve-year-old ‘Hass’ avocado trees on Mexican seedling rootstocks in a commercial orchard in Irvine, CA (33.67°N, 117.82°W), were used in this research for two sequential years. Treatments included: (1) untreated control; (2) adenosine (58 g/ha); (3) adenosine (58 g/ha) combined with a natural auxin-transport inhibitor (NATI) (58 g/ha); and (4) adenosine (58 g/ha) combined with the auxin-transport inhibitor triiodo-benzoic acid (TIBA) (58 g/ha). All treatment chemicals were purchased from Sigma (St. Louis, MO). Each treatment was applied to high-yielding on-crop trees just prior to the first period of exponential fruit growth (July) and again before the second period of exponential fruit growth (January) (Rosecrance et al., 2012). For ‘Hass’ avocado trees grown in California, fruit require 12 to 16 months from bloom to mature. Treatments were applied in 1,869 L of water adjusted to pH 5.5 and containing the surfactant Silwet L77® (General Electric Co.) (0.05% final concentration v/v) per ha with a 2758-KPa handgun sprayer to give full canopy coverage. Each treatment was replicated on 20 individual trees in a randomized complete block design with buffer trees between treated trees within a row and buffer rows between treated rows. All trees received grower standard soil-applied fertilizer. At harvest, total yield was determined as kilograms of fruit per tree. A randomly selected subsample of 100 to 150 fruit per tree, representing approximately 20% to 100% of the fruit per tree, was collected for each data tree. The mass of each fruit in the subsample was determined. These data were used to determine pack out, i.e., kilograms of fruit of each commercial packing carton size per tree, and to estimate the total number of fruit per tree and in each size category. The following packing carton fruit sizes (g/fruit) were used: 84 (99-134), 70 (135-177), 60 (178-212), 48 (213-269), 40 (270-325), 36 (326-354), and 32 (355-397). In addition, at harvest, two fruit were selected randomly per tree and allowed to ripen at 22 ± 2°C. The number of days from harvest to “eating ripe” was recorded. When ripe, external peel color was rated and fruit internal mesocarp quality was evaluated for discoloration, vascularization (presence of vascular bundles and associated fibers), seed germination and stem-end decay. Fruit quality parameters were rated on a scale from 0 (normal) to 4 (peel 100% black and high incidence of discoloration, vascularization and stem-end decay). In addition, fruit length, fruit width, seed diameter, and mesocarp width were measured.

Statistical Analyses

The data were analyzed using the General Linear Model procedure of the SAS 9.2 statistical program (SAS Inst., Inc., Cary, NC). Repeated measure analysis was used to test for treatment effects on mandarin yield parameters, including fruit quality, with year as the repeated measure. Dunnett's two-tailed *t*-test or analysis of variance with means separated using Fisher's Protected LSD were used to determine treatment effects at P = 0.05. For data presented as a percent of the untreated control, statistical analyses were performed on the raw data before expressing the data as a percent.

RESULTS

Tomato

1. Experiment 1. The number of vegetative and reproductive branches produced by 'Super Sweet 100' cherry tomato plants was significantly increased by all cytokinin and adenosine treatments over the 75-d growing period relative to untreated control plants (Table 1). Adenosine also resulted in significantly more vegetative branches than BA and fruiting branches than IPA (both the low and high concentrations). Adenosine and IPA at the low concentration significantly increased the number of fruit produced per plant compared to untreated control plants (1.9-fold) and BA-treated plants (1.7-fold) (P < 0.0445) (Table 1). Fruit size (transverse diameter) was significantly greater for plants treated with adenosine compared to plants in all other treatments (P = 0.0001) (Table 1).

2. Experiment 2. This experiment was conducted from October through December under temperature conditions averaging 10°C lower than in Experiment 1, which was conducted from April through July. Also PPFD was 10% lower in Experiment 2. These differences reduced the number of vegetative and reproductive branches produced by control plants in Experiment 2. In contrast, the hormone- and adenosine-treated plants in Experiment 2, with the exception of those treated with the low concentration of IPA, produced a similar number of both types of branches as in Experiment 1 (Table 2). Adenosine-treated plants produced significantly more branches of each type than plants in all other treatments (P < 0.0001) (Table 2). Control plants in Experiment 2 produced 66% less fruit than in Experiment 1, but fruit size (diameter) was on average only 3 mm smaller in Experiment 2. Adenosine significantly increased fruit number compared to both the untreated control (2.3-fold) and the low concentration of IPA (1.5-fold) (P = 0.0047). Adenosine increased fruit size compared to all treatments except BA (P < 0.0001) (Table 2).

Despite the differences in growing conditions between Experiment 1 and 2, adenosine consistently significantly increased the number of vegetative and fruiting branches, number of fruit produced per plant, and fruit diameter compared to the untreated control.

Mandarin

A single foliar application of adenosine (58 g/ha) annually when fruit were 25 mm in diameter significantly increased 3-year cumulative yield of commercially valuable size fruit. This include fruit of packing carton sizes large (57.16-63.50 mm transverse diameter) and jumbo (63.51-69.85 mm) and fruit in the combined pool of packing carton sizes large, jumbo and mammoth (57.16-76.20 mm) as both kilograms (Table 3) and number of fruit per tree (Table 4) compared to untreated control trees. The increased yield of large size fruit was achieved without reducing total yield in any year of the research. Similar results were obtained when yield parameters were averaged across the 3 years of the research by repeated measure analysis with year as the repeated measure (data not shown). Years 1 and 3 were low-yield off-crop years and year 2 was a high-yield on-crop year, in which the trees produced a 3.3- and 2.5-fold greater number of fruit per tree than in years 1 and 3, respectively. Year had a significant effect on the yield of fruit in all size categories (packing carton sizes), but there were no significant treatment by year interactions. The effect of adenosine on fruit size was independent of crop load, being greatest in years 2 and 3. Adenosine had an effect on fruit quality only in year 3. Juice from fruit of adenosine-treated trees had a significantly lower percent acidity ($P = 0.0163$) and significantly greater soluble solids to acid ratio ($P = 0.0570$) than the untreated control. Analysis of fruit quality by repeated measure revealed no significant treatment effects on juice weight or percent juice per fruit or on the total soluble solids, percent acidity or soluble solids: acid of the juice. However, year had a significant effect on fruit quality not related to crop load ($P < 0.0001$) and there was a significant treatment by year interaction for percent acidity and soluble solids: acid ($P = 0.0006$) and ($P = 0.0316$), respectively. No other effects on fruit quality were detected during the three years of research. Adenosine had no negative effects on fruit quality in any year of the research.

Avocado

When on-crop 'Hass' avocado trees received a foliar application of adenosine (58 g/ha), either alone or with the auxin-transport inhibitor triiodobenzoic acid (TIBA), just prior to exponential fruit growth in summer (July) and again before exponential fruit growth in spring (January), yield as kilograms of commercially valuable large size fruit (213-269 g/fruit) in the on-crop was significantly increased (1.95- and 2.25-fold, respectively), without reducing total yield, compared to untreated on-crop control trees ($P = 0.0464$) (Table 5). Only adenosine combined with natural auxin-transport inhibitor (NATI) increased total yield in the on-crop year ($P = 0.0783$). The following year's total yield confirmed that the trees were alternate bearing. Yield of the on-crop control trees was reduced 97% compared to the previous year, consistent with a low-yield off-crop year. All trees treated with adenosine the previous year, alone or combined with an auxin-transport inhibitor, produced numerically, but non-significantly, more kilograms of total fruit and large fruit per tree than the untreated control trees in the off-crop year. For example, adenosine alone or with TIBA produced 2.8- and 6.0-fold more large size fruit (213-269 g/fruit) per tree compared to the untreated control trees, which contributed to a significant net increase in 2-year cumulative yield of commercially valuable large size fruit (213-269 g/fruit) of 4,908 and 7,163 kilograms per ha, respectively ($P = 0.0154$) (Table 5). Similarly, when combined with either one of the auxin-transport inhibitors, adenosine resulted in a significant net increase in 2-year cumulative total yield of 11,237 and 10,273 kilograms per ha for adenosine plus NATI and adenosine plus TIBA, respectively ($P = 0.0154$) (Table 5). The results expressed as number of fruit were the same (data not shown). There was no treatment effect on any fruit quality parameter evaluated in either year of the experiment.

DISCUSSION

In two separate experiments, adenosine applied to the soil over a 75-d growing period significantly increased the number of vegetative and reproductive branches and the number of fruit produced by 'Super Sweet 100' cherry tomato plants compared to the untreated control plants. Despite significantly increasing total fruit number in both experiments, adenosine also significantly increased fruit size above that of all other treatments in Experiment 1 and all other treatments except BA in Experiment 2. Adenosine resulted in 92% and 132% net increase in yield and fruit were 61% and 75% larger than the untreated control in Experiments 1 and 2, respectively. These results demonstrated that the effect of adenosine on cherry tomato yield and fruit size was consistent despite differences in average maximum and minimum temperatures, PPFD, day length, and nutrient supply during the 75-d growing period in the two experiments. The benefits of adenosine treatment relative to the untreated control were greater under the lower temperature and light conditions prevailing in the greenhouse from October through December. Moreover, the results demonstrated that the effect of adenosine on cherry tomato yield and fruit size was equal to or greater than those of known cytokinins applied at lower or equal concentrations, supporting adenosine's role as a precursor of cytokinin biosynthesis and suggesting a possible added benefit from the salvage of adenosine to AMP, ADP and ATP.

A single, annual foliar application of adenosine (58 g/ha) during exponential fruit growth of Clementine mandarin significantly increased the 3-year cumulative yield of commercially valuable large (57.16-63.50 mm transverse diameter) and jumbo (63.51-69.85 mm) size fruit, resulting in a net increase of 5.1 cartons (packed by number) per tree. The effect of adenosine on fruit size was independent of crop load, with no negative effects on total yield in the current year or following year and no negative effects on fruit quality in any year. At typical planting densities of 412 to 1,074 trees/ha, the potential yield increase from foliar-applied adenosine was 2,101 to 5,477 cartons/ha. At an average price of US$ 4.10 per carton, in this research adenosine would have generated US$ 8,614 to US$ 22,456 more per ha for the three years compared to the untreated control trees.

Small size fruit, which have a reduced dollar-value in the market, are a significant economic problem in the on-crop year of an alternate bearing ‘Hass’ avocado orchard. In this research, adenosine (58 g/ha) was applied to the canopy only in the on-crop year, alone or combined with an auxin-transport inhibitor, in July just prior to the first (summer) period of exponential fruit growth and again in January before the second (spring) period of exponential fruit growth. The results of our first use of adenosine as a foliar spray alone and combined with an auxin-transport inhibitor demonstrated the capacity of adenosine, especially when combined with TIBA, to significantly increase the yield of commercially valuable larges size fruit in the on-crop year. Adenosine alone and combined with TIBA also had a positive but non-significant effect on the yield of large size fruit in the off-crop year. This contributed to a significant increase in 2-year cumulative yield of commercially valuable large size fruit (213-269 g/fruit), with no reduction in total yield in the current year or the following year, compared to untreated control trees. Adenosine alone resulted in a 2-year cumulative net increase of 4,908 kg per 272 trees per ha of commercially valuable size fruit (213-269 g/fruit). At US$ 2.78 per kilogram (based on data provided by the California Avocado Commission, 2009), adenosine would have resulted in US$ 13,679 more per ha over two years than the untreated control trees.

In each of the preliminary experiments reported herein with three different crops, adenosine was successful in significantly increasing fruit size. However, additional research is planned to optimize the concentration and application time to maximize the effect of adenosine on these and other crop plants.

CONCLUSIONS

Adenosine increased fruit size (transverse diameter) of cherry tomato in two separate experiments, the 3-year cumulative yield of commercially valuable large size fruit (57.16-69.85 mm transverse diameter) of Clementine mandarin and 2-year cumulative yield of commercially valuable large size fruit (213-269 g/fruit) of avocado, with no reduction in yield of either tree crop in the current year or following year and no negative effects on any fruit quality parameter evaluated. Taken together, these preliminary results provide strong evidence that adenosine has significant potential to increase grower income.

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Tables

Table 1. Effect of the cytokinins isopentenyladenine and 6-benzyladenine and the metabolite adenosine on branching, total fruit number and fruit size of 'Super Sweet 100' cherry tomato plants 75 days after planting in Experiment 1. Data are the sum of the number of vegetative and fruiting branches and fruit harvested 55 and 75 days after planting; fruit diameter was determined for fruit harvested 75 days after planting.

Treatment	µg per plant	Vegetative branches (No./plant)	Fruiting branches (No./plant)	Total fruit (No./plant)	Fruit diameter (mm)
		------------------- *% untreated control*			---------------------
Control		100.0 c [1,2]	100.0 c	100.0 b	100.0 d
Isopentenyladenine	0.0325	203.4 ab	250.0 b	190.4 a	145.3 b
Isopentenyladenine	3.25	205.5 ab	239.7 b	160.0 ab	132.7 c
6-Benzyladenine	3.25	185.1 b	298.5 ab	114.4 b	143.3 b
Adenosine	3.25	235.3 a	423.5 a	192.0 a	160.7 a
P value		<0.0001	0.0023	0.0445	<0.0001

[1] Means within a column are significantly different by Fisher's Protected LSD at $P \leq 0.05$.

[2] Number of vegetative branches, number of fruiting branches, total fruit number and fruit diameter (mm) for the untreated control are 23.5, 6.8, 12.5 and 15.0, respectively.

Table 2. Effect of the cytokinins isopentenyladenine and 6-benzyladenine and the metabolite adenosine on branching, total fruit number and fruit size of 'Super Sweet 100' cherry tomato plants 75 days after planting in Experiment 2. Data are the sum of the number of vegetative and fruiting branches and fruit harvested 55 and 75 days after planting; fruit diameter was determined for fruit harvested 75 days after planting.

Treatment	µg per plant	Vegetative branches (No./plant)	Fruiting branches (No./plant)	Total fruit (No./plant)	Fruit diam. (mm)
		% untreated control			
Control		100.0 d [1,2]	100.0 e	100.0 c	100.0 d
Isopentenyladenine	0.0325	223.6 c	285.7 d	157.9 b	140.0 c
Isopentenyladenine	3.25	257.3 b	437.1 c	178.9 ab	140.7 c
6-Benzyladenine	3.25	246.1 b	528.6 b	192.1 ab	162.8 ab
Adenosine	3.25	309.0 a	694.3 a	231.6 a	174.8 a
P value		<0.0001	<0.0001	0.0047	<0.0001

[1] Means within a column are significantly different by Fisher's Protected LSD at $P \leq 0.05$.

[2] Number of vegetative branches, number of fruiting branches, total fruit number and fruit diameter (mm) for the untreated control are 17.8, 3.5, 3.8 and 12.5, respectively.

Table 3. Effect of a single foliar application of adenosine (58 g/ha) annually when fruit were 25 mm in diameter on 3-year cumulative total yield and yield of commercially valuable size fruit (kg/tree) of 'Fina Sodea' Clementine mandarin.

Treatment	Total	Packing carton size based on transverse diameter (mm)					
		Mammoth[2]	Jumbo	Large	Medium	Small	La+ Ju+ Ma
	Total kg/tree						
Control	110.9 a[1]	4.2 a	10.4 b	28.2 b	36.9 a	24.4 a	42.9 b
Adenosine	126.3 a	3.5 a	15.4 a	34.7 a	37.0 a	23.6 a	53.6 a
t test	NS	NS	*	*	NS	NS	*

[1] Means followed by different letters are significantly different by Dunnett's *t*-test at $P \leq 0.05$; NS, not significant.

[2] Mammoth, 69.86 mm to 76.20 mm; Jumbo, 63.51 mm to 69.85 mm; Large, 57.16 mm to 63.50 mm; Medium, 50.81 mm to 57.15 mm; Small, 44.45 mm to 50.80 mm.

Table 4. Effect of a single foliar application of adenosine (58 g/ha) annually when fruit were 25 mm in diameter on 3-year cumulative total yield and yield of commercially valuable size fruit (number of fruit per tree) of 'Fina Sodea' Clementine mandarin.

Treatment	Total	Packing carton size based on transverse diameter (mm)					
		Mammoth[2]	Jumbo	Large	Medium	Small	La+ Ju+ Ma
	Total number per tree						
Control	1467.0 a[1]	26.9 a	86.5 b	292.7 b	493.8 a	431.7 a	406.1 b
Adenosine	1529.3 a	22.9 a	128.3 a	360.9 a	497.1 a	417.1 a	512.1 a
t test	NS	NS	*	*	NS	NS	*

[1] Means within columns followed by different letters are significantly different by Dunnett's *t*-test at $P \leq 0.05$; NS-Not significant.

[2] Mammoth, 69.86 mm to 76.20 mm; Jumbo, 63.51 mm to 69.85 mm; Large, 57.16 mm to 63.50 mm; Medium, 50.81 mm to 57.15 mm; Small, 44.45 mm to 50.80 mm.

Table 5. Effect of foliar adenosine (58 g/ha) applied alone, or with a natural auxin-transport inhibitor (NATI) or triiodobenzoic acid (TIBA), just prior to the first period of exponential fruit growth (July) and again before the second period of exponential fruit growth (January) only during the on-crop year on yield and fruit size of 'Hass' avocado.

Treatment	On-crop yield		2-Year cumulative yield	
	Total	213-269 g	Total	213-269 g
	kg/272 trees per hectare			
Control	21,091 b[z]	4,639 b	21,722 b	4,911 c
Adenosine	26,199 ab	9,063 a	27,649 ab	9,819 ab
Adenosine+NATI	31,928 a	6,815 ab	32,959 a	7,267 bc
Adenosine+TIBA	28,828 ab	10,443 a	31,995 a	12,074 a
P value	0.0783	0.0464	0.0379	0.0154

[z] Means within a column followed by different letters are significantly different by Fisher's Protected LSD at $P \leq 0.05$.