mediated ethylene synthesis. As we have shown, ethylene production by seedlings from genetically different cultivars, responds differently to light exposure. The variable response to light of cucumber cultivars may prove useful in delineating the system responsible for light-stimulated ethylene production.

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Spray Chrysanthemum Production with Controlled-release Fertilizer and Trickle Irrigation[1]

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Additional index words. cut-flowers, water, Osmocote, urea formaldehyde, *Chrysanthemum morifolium*

Abstract. **Various rates, types, and formulations of controlled-release fertilizers were evaluated as potential components in a trickle irrigation production system for spray chrysanthemums (*Chrysanthemum morifolium* Ramat.). Optimum rates of total-N, with 34 kg N/ha as soluble 6-2.6-5 (N-P-K) and the remainder as 14-6.1-11.6 Osmocote, were estimated to be from 489-501 kg per planted hectare in 2 tests. Other formulations or ratios of Osmocote and urea formaldehyde fertilizers at similar rates did not improve production or were not comparable to Osmocote 14-6.1-11.6 or to the commercial practice of weekly overhead liquid fertilization. A water savings of 70-80% was estimated with the controlled-release fertilizer-trickle irrigation system compared to overhead irrigation, while yields (marketable stems and height) were similar to those produced with overhead-liquid fertilization practices.**

Trickle irrigation systems can be used to conserve water, compared to overhead irrigation systems, by confining water to the cropped area. Trickle irrigation systems have occasionally become inoperative in areas with poor quality water. Addition of water soluble fertilizers and the presence of other salts, sulfur, algae and bacteria have further compounded distribution problems and limited the use of trickle irrigation systems (3, 4, 11, 19). Controlled-release fertilizers incorporated in the soil may increase the efficiency of delivery systems by removing an antagonistic component to poor water quality.

Controlled-release fertilizers have been evaluated for production of many horticultural crops (9). Kofranek and Lunt (5) found that one application of coated 25-4.6-4 produced quality potted chrysanthemums and Waters (15) reported that split applications of heavily coated 9-4-5 or 10-4.6-8 produced quality pot-mums. Simpson et al. (13) and Bivins and Kofranek (2) showed that a combination of coated fertilizer and liquid fertilization produced good quality plants. Sharma and Patel

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(12) reported that potted chrysanthemums grown with single applications of Osmocote 14-6.1-11.6 performed better than those grown with other slow release materials tested, and suggested supplemental fertilization with readily available soluble nutrients for the latter. Tjia et al. (14) also observed that potted chrysanthemums produced with urea formaldehyde and sulfur coated fertilizers required supplemental fertilizer. Kofranek and Lunt (6) indicated that greenhouse production of standard chrysanthemums was successful using a combination of coated and liquid fertilizers, while Waters (16) found that a single application of Osmocote produced good growth of field grown spray chrysanthemums.

These studies were conducted to evaluate controlled-release fertilizers used with trickle irrigation for the field production of spray chrysanthemums.

Materials and Methods

General cultural practices. All experiments were conducted under polypropylene 25% shade cloth. The pH of the soil (Myakka fine sand) was adjusted each season to 6-6.5 with use of 560-1120 kg/ha dolomite. Additionally, 560 kg/ha single superphosphate and 22 kg/ha FTE 503 was incorporated in the soil at this time. Raised beds 20 cm high by 91 cm wide were formed and fumigated with 732 kg/ha methyl bromide 2 weeks before planting. Plot sizes were 2.4 × 0.9 m for tests in the Fall 1975 (Sept.-Dec.) and Spring 1976 (Feb.-May) and 1.1 × 0.9 m for tests in the Fall 1976-Spring 1978, inclusive.

Controlled-release fertilizers were incorporated 2.5-3.5 cm deep just prior to planting. All fertilizer rates were based on a planted hectare (broadcast basis of 0.9 m bed width × length of the plot). In treatments where a readily available source of soluble nutrients was desired, 34 kg per planted hectare of N as soluble 6-2.6-5 was incorporated preplant with the controlled-release fertilizer. Nutrileaf (soluble 20N-8.7P-16.6K) was applied overhead weekly to 1 treatment (control) to simulate the grower practice of injecting fertilizer in overhead sprinkler systems. The total amount of soluble nitrogen per planted ha in the control plots was applied equally over 12 weeks with fertilization terminating 10-14 days before harvest. Control plots received 7.6 liters of the appropriate Nutrileaf solution overhead followed by 7.6 liters of water to remove excess salts from the foliage for tests conducted in the Fall 1975 and Spring 1976, and half these amounts in the Fall 1976-Spring 1978, inclusive.

All plots were irrigated with 2 or 3 Viaflo tubes spaced 60 or 30 cm apart down the bed, respectively. Time clocks were used to regulate watering frequency and quantity to approximate 4,500 kl per planted ha (18 acre inches) for the season. Rainfall and water applied were recorded for the Fall 1976-Spring 1978 experiments, inclusive.

Rooted cuttings of 'Manatee Yellow Iceberg' were spaced at 15 cm intervals across the bed and at 20 cm intervals down the bed. Plants were pinched 2 weeks after planting, leaving at least 4 nodes above the soil surface. Plants were maintained vegetatively for the first 5 weeks of each experiment by lighting with incandescent lamps which provided at least 120 lux at plant height from 2200-0200 daily.

Stems were cut 20 cm above the ground at the commercially acceptable stage of flowering (18). The number of marketable stems from 18 plants (3 center rows across the bed), the length of 18 stems chosen at random, and percent leaf nitrogen in the uppermost mature leaf at harvest of at least 18 stems were recorded. Marketable stems were those greater than 80 cm in length, with 5 or more open flowers/stem, and judged strong enough for a cut flower. The experimental design for all tests was a randomized complete block with 3 replications.

Expt. 1, Fall 1975. All plots received 34 kg of soluble N per planted ha preplant. Osmocote 14-6.1-11.6 (Osm-14; 3 month release formulation) was applied at rates to give a total of 168, 225, 281, 337, 393, 449, and 562 kg nitrogen per planted ha. Weekly applications of Nutrileaf (soluble 20-8.7-16.6) at a total of 562 kg of N per planted ha were also included for a control treatment.

Regression analyses indicated a quadratic relationship for the effects of fertility on the number of marketable stems and height, and a linear relationship for leaf nitrogen (Fig. 1). The maximum yield (marketable stems) was estimated to be at 492 kg N/ha while maximum height was at 501 kg N/ha.

The 562 kg Osm-14 rate was comparable to the liquid fertilizer treatment for yield and leaf nitrogen (Table 1, Expt. 1). However, plants fertilized with the 562 kg rate of Osm-14 were significantly taller than the liquid fertilized plants.

Expt. 2, Spring 1976. This experiment was similar to the Fall 1975 test except the 168 kg rate of Osm-14 was deleted and a treatment of 505 kg Osm-14 was added.

Quadratic relationships (Fig. 2) were again found for number of marketable stems (maximum = 490 kg/ha) and height (maximum = 489 kg/ha), and a linear trend was found with leaf nitrogen within the rates tested. Plants grown with liquid fertilizer showed no significant differences in marketable stems, height, or leaf nitrogen compared to the 505 kg rate of Osm-14 (Table 1, Expt. 2).

Expt. 3, Fall 1976. Liquid fertilization at 562 kg N per planted ha was compared to rates of 449 and 562 kg N/ha as Osm-14, Osmocote 18-2.6-10 (Osm-18; 9 month release),

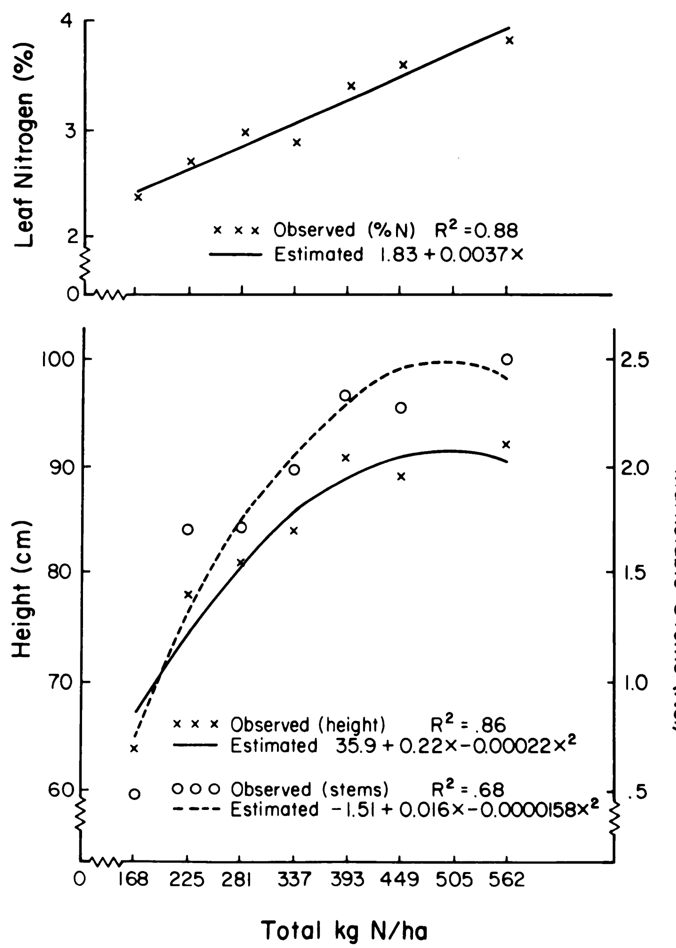

Fig. 1. The effect of rates of Osmocote 14-6.1-11.6 (N-P-K) on the number of marketable stems, height, and percent leaf nitrogen on *Chrysanthemum* 'Manatee Yellow Iceberg'. Fall, 1975. All plots received 34 kg of the total N as soluble 6-2.6-5. Observed means represent 54 observations (3 18-plant replications).

Table 1. Influence of rates and types of controlled-release fertilizer on number of marketable stems/plant, height, and % leaf nitrogen of *Chrysanthemum* 'Manatee Yellow Iceberg.'

Expt. no.	Season	Fertilizer treatments: Source (% total N)	Fertilizer treatments: Total N/ha	Marketable stems (no.)	Average height (cm)	Leaf nitrogen (%)
1	Fall 1975	Nutrileaf 20-8.7-16.6 (94%) + soluble 6-2.6-5 (6%)	562	2.7	87 b[z]	3.9
		Osmocote 14-6.1-11.6 (94%) + soluble 6-2.6-5 (6%)	562	2.5 n.s.	93 a	3.9 n.s.
2	Spring 1976	Nutrileaf 20-8.7-16.6 (94%) + soluble 6-2.6-5 (6%)	562	2.4	117	3.7
		Osmocote 14-6.1-11.6 (93%) + soluble 6-2.6-5 (7%)	505	2.6 n.s.	112	3.6 n.s.
3	Fall 1976	Nutrileaf 20-8.7-16.6 (94%) + soluble 6-2.6-5 (6%)	562	2.5	108	5.0a
		Osmocote 14-6.1-11.6	449	2.4	110	3.9 d
		Osmocote 14-6.1-11.6	562	2.3	112	3.9 d
		Osmocote 18-2.6-10 (92%) + soluble 6-2.6-5 (8%)	449	2.3	100	4.4 b
		Osmocote 18-2.6-10 (94%) + soluble 6-2.6-5 (6%)	562	2.5	104	4.4 b
		Osmocote 18-2.6-10:14-6.1-11.6 (66:33%)	449	2.6	104	4.1 cd
		Osmocote 18-2.6-10:14-6.1-11.6 (66:33%)	562	2.3 n.s.	107 n.s.	4.3 bc
4	Spring 1977	Nutrileaf 20-8.7-16.6 (93%) + soluble 6-2.6-5 (7%)	562	2.3 a	87 a	2.7 a
		Osmocote 14-6.1-11.6	505	2.0 a	84 a	2.6 ab
		Osmocote 14-6.1-11.6 + weekly water	505	1.7 a	87 a	2.5 ab
		Osmocote 18-2.6-10 (93%) + soluble 6-2.6-5 (7%)	505	1.6 a	78 a	2.3 abc
		Scott's 23-1.7-11.6 (93%) + soluble 6-2.6-5 (7%)	505	.6 b	62 b	2.2 bc
		Osmocote 18-2.6-10:14-6.1-11.6 (25:75%)	505	1.9 a	82 a	2.0 c
		Osmocote 18-2.6-10:14-6.1-11.6 (33:66%)	505	2.3 a	85 a	2.7 a
		Osmocote 18-2.6-10:14-6.1-11.6 (50:50%)	505	1.7 a	86 a	2.5 ab
		Osmocote 18-2.6-10:14-6.1-11.6 (66:33%)	505	1.6 a	83 a	2.7 a
		Osmocote 18-2.6-10:14-6.1-11.6 (75:25%)	505	2.2 a	84 a	2.4 abc
5	Fall 1977	Nutrileaf 20-8.7-16.6 (94%) + soluble 6-2.6-5 (6%)	562	2.1 a	95 a	4.6 a
		Osmocote 14-6.1-11.6	505	1.9 b	96 a	4.0 c
		Scott's 25-4.4-8.3 (93%) + soluble 6-2.6-5 (7%)	505	1.5 c	86 b	3.7 c
		Osmocote 15-2.2-17.4	505	1.9 b	95 a	3.8 c
		Osmocote 18-2.6-10:14-6.1-11.6 (50:50%)	505	2.3 a	95 a	4.3 b
6	Spring 1978	Nutrileaf 20-8.7-16.6 (94%) + soluble 6-2.6-5 (6%)	562	2.9 a	95 a	2.6 a
		Osmocote 14-6.1-11.6	505	2.7 a	91 a	2.9 b
		Osmocote 19-2.6-8.3	505	1.7 b	82 b	2.8 b
		Scott's 25-4.4-8.3 (94%) + soluble 6-2.6-5 (6%)	562	1.8 b	81 b	2.8 b

[z]Mean separation in columns within seasons, by Studentized T test (Fall 1975, Spring 1976) and Duncan's multiple range test (Fall 1976 through Spring 1978), 5% level.

or a 2:1 nitrogen ratio of Osm-18:Osm-14. For the liquid fertilizer and Osm-18 treatments, 34 kg of the total N was incorporated preplant as soluble N.

The number of marketable stems and height were not differentially influenced by any treatment. Only leaf nitrogen showed an effect from fertilizer treatments (Table 1, Expt. 3).

Expt. 4, Spring 1977. Liquid fertilization at 562 kg N per planted ha was compared to 505 kg N/ha as Osm-14; Osm-18; 1:1, 1:2, 1:3, 2:1, 3:1 Osm-18:Osm-14; and Scott's urea formaldehyde 23-1.7-11.6 (Scot-23; 3-4 month formulation). The Scot-13 treatment, Osm-18 treatment, and the liquid treatment had 34 kg of the total N as preplant-soluble N. Another treatment of 505 kg N/ha as Osm-14 irrigated overhead with 7.6 liters water/plot per week (in addition to the Viaflo irrigation) was included to test the influence of the water applied with liquid fertilizer in the control plots.

Plants grown with Scot-23 formulation had fewer marketable stems and shorter stems than all other treatments (Table 1, Expt. 4). Increasing water by irrigating weekly overhead did not influence effect of 505 kg/N as Osm-14. Types or ratios of Osmocote did not significantly affect yield or height, but did influence leaf nitrogen.

Expt. 5, Fall 1977. Liquid fertilization at 562 kg N per planted ha was compared to 505 kg N as Osm-14, Scott's 25-4.4-8.3 (Scot-25) urea formaldehyde formulation, Osmocote 15-2.2-17.4 (Osm-15, experimental 6 month formulation), and a 1:1 N ratio of Osm-18:Osm-14. The liquid fertilization and Scot-25 treatments had 34 kg of the total N as soluble 6-2.6-6-5.

The number of marketable stems was lowest with the Scot-25 treatment. Plants produced with Osm-15 and Osm-14 had an intermediate number of stems, which were significantly greater than the Scot-25 treatment but less than the liquid control or 1:1 ratio of Osm-18:Osm-14. Plants grown with Scot-25 were shorter than those grown with other treatments, which also affected the number of marketable stems. Many stems had satisfactory strength and flower number, but were too short for the cut flower market. Leaf nitrogen varied in a manner similar to that in the previous tests.

Expt. 6, Spring 1978. Liquid fertilization and Scot-25 at 562 kg N per planted ha (34 kg of total N as 6-2.6-5) were compared to Osmocote 19-2.6-8.3 (Osm-19, 20% uncoated and 80% 9 month release = Sierrablen) and Osm-14 at 505 kg N/ha.

The number of marketable stems and height were greater with either liquid fertilization or Osm-14 compared to Scot-25 or Osm-19 (Table 1, Expt. 5). Leaf nitrogen was highest with liquid fertilization.

Discussion

The maximum number of marketable stems and height of spray chrysanthemums were estimated in 2 tests to be produced with a total of 489-501 kg N per planted ha as Osm-14 (34 kg of the total N was soluble 6-2.6-5). Similar yields were achieved over a number of seasons with 449 or 505 kg N per planted hectare as Osm-14 (no soluble N) and with 562 kg N per hectare as weekly liquid fertilization (simulated grower practice with 6% soluble N). Other formulations of Osmocote did not significantly

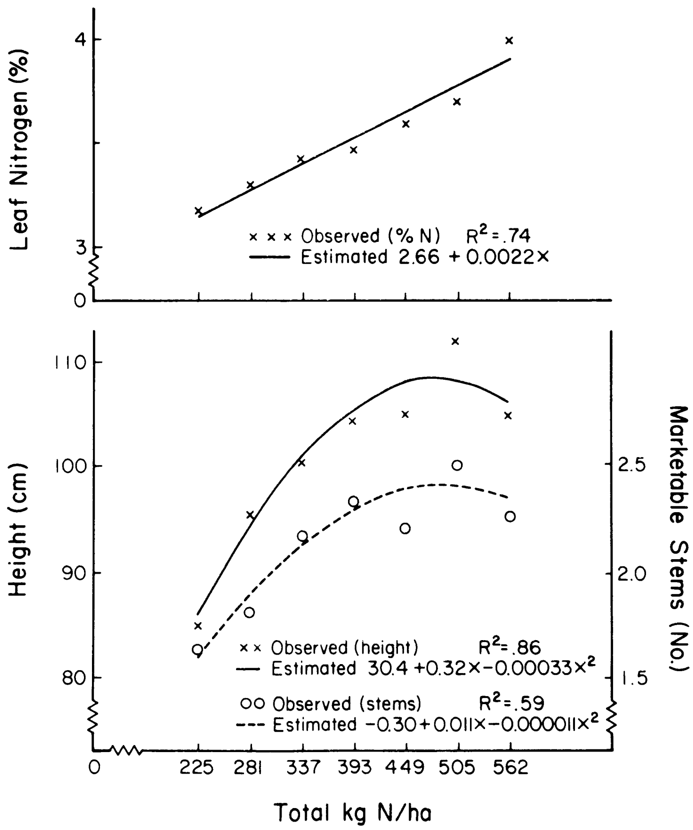

Fig. 2. The effect of rates of Osmocote 14-6.1-11.6 (N-P-K) on the number of marketable stems, height, and percent leaf nitrogen of *Chrysanthemum* 'Manatee Yellow Iceberg,' Spring, 1976. All plots received 34 kg of the total N as soluble 6-2.6-5. Observed means represent 54 observations (3 18-plant replications).

improve yields and Scott's urea formaldehyde formulations were not comparable to Osm-14 or liquid fertilization.

The addition of Osm-18 to Osm-14 (ratios) was to supplement the fast release pattern of Osm-14 (10) with a long lasting formulation. This would create a release pattern with 1 application similar to the split applications found beneficial to pot chrysanthemums (15). While no significant benefits were detected from Osmocote ratios in 2 tests, increased yield in the Fall 1977 test indicated conditions might arise where a change in release rates would improve yield over Osm-14. More research is needed to define environmental conditions early in the crop cycle that may cause a decline in the performance of Osm-14 so corrective action could be taken if necessary. However, fertilization of cut-chrysanthemums may not be as critical as pot-chrysanthemums because the lower foliage of cut-chrysanthemums (which shows chlorosis from N deficiency first) is removed at harvest. In pot-chrysanthemums, the foliage is a necessary part of the marketable plant.

In the first 2 tests, leaf nitrogen at harvest increased linearly with respect to applied rates of fertilizer up to the 562 kg N per planted ha rate of application. However, yield and height responses indicated rates above 489-501 kg N/ha would not benefit yield. In all tests, leaf nitrogen at harvest was greater with liquid fertilization treatments than with 449 or 505 kg Osm-14 rates. Since high levels of nitrogen in leaves at harvest were found to reduce keeping quality of cut chrysanthemums (16, 17), the relatively lower leaf nitrogen in Osmocote plots was not considered detrimental. Preliminary tests on post-harvest responses of cut-chrysanthemums produced with the 562 kg N rate as liquid fertilization versus Osm-14 indicated keeping quality was not noticeably different even though foliar nitrogen was lower in association with Osm-14.

An average of 4,214 kl per planted ha (16.6 acre inches) of water per crop was applied through the trickle irrigation system. An additional average of 25 cm of rain fell each season, concentrated at the beginning (Fall) or end (Spring) of the production cycle. Thus, the total amount of water available to the crop was about 20-30% as much as suggested for overhead systems for chrysanthemums in Florida (18). Similar water savings with trickle irrigation on sandy soils have been reported for strawberries (8), peppers (1), and tomatoes (7). The delivery system was functional for the entire crop and only a minor decrease in water flow from Viaflo was detected at the end of each season.

These tests indicate that production practices for spray chrysanthemums involving incorporation of controlled-release fertilizers in the bed at planting and trickle irrigation can be an acceptable alternative to overhead irrigation and liquid fertilization programs. In areas where water conservation is necessary, and/or injecting fertilizer in trickle irrigation systems increases water distribution problems, a controlled-release fertilizer-trickle irrigation production system offers a viable management tool for cut-flower production.

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Sensory Characteristics of Apple Fruit[1,2]

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Additional index words. Malus domestica, maturity, storage, quality

Abstract. **A profile was developed to describe sensory characteristics of 'Golden Delicious', 'Miller Spur', 'Redspur', 'Rome Beauty', and 'York Imperial' apples (*Malus domestica* Borkh.). Ten sensory attributes were selected and the intensities of the attributes were plotted on a circular graph. The patterns of the plots differed among cultivars and patterns of some cultivars changed with successive harvests and storage of apples. The patterns were used to describe the general sensory characteristics of apples.**

The quality of apples is difficult to describe simply because apples have many divergent attributes that are associated with acceptability and/or desirability. Firmness, soluble solids and titratable acid contents are measured routinely to determine relative condition and to determine time of harvest, based on findings of Haller et al. (3) and Wright and Whiteman (5). These measurements do not necessarily characterize the quality of an apple.

Although many scientists have used taste panels to determine quality of apples, most studies dealt with preference or differences among samples. Some researchers have used hedonic scales (1, 6) or intensity scales (2) to correlate sensory measurements with other measurements but only a few attributes were evaluated. Williams and Carter (4) made an extensive study of attributes that panelists recognized in 'Cox's Orange Pippin' apples. The quality of apples can be characterized best by identifying the significant attributes, as undertaken by Williams and Carter (4), and then determining the intensities of these attributes.

In this paper, we describe quality characteristics of apples based on a semi-profile method for selecting and measuring intensities of important sensory attributes. Firmness and soluble solids and titratable acids contents were also measured to describe conditions of apples as objectively determined.

Materials and Methods

Fruit of 5 apple cultivars, harvested at 4 weekly intervals and stored for 3 periods, were used for the study. The cultivars, which included 'Golden Delicious', 2 'Delicious' sports ('Miller Spur' and 'Redspur'), 'Rome Beauty', and 'York Imperial' were obtained from growers in the apple-growing region of southcentral Pennsylvania, western Maryland and the eastern panhandle of West Virginia. (Only the first part of a 2 part name of a cultivar will be used for identification in this paper.) Apples were harvested at weekly intervals, starting 2 weeks before and ending 1 week after the estimated optimum harvest date as indicated by the grower. 'York' apples were harvested only 3 times, beginning 1 week before optimum date. Harvested fruit were treated with ethoxyquin (Stop Scald), placed in slit-polyethylene-lined fiberboard cartons and stored at $1^{\circ} \pm 1^{\circ}C$ for 0, 2.5 and 5 months. Apples were removed from the cartons after storage, placed at 18° for a 7-day ripening period in trays, and then evaluated for sensory attributes, firmness, soluble solids and titratable acid. Each treatment consisted of two 10-fruit samples. All analyses except pressure tests were made on the composite of the 10 fruit.

Objective measurements. Pressure tests were made with a 11-mm (7/16-inch) diameter Magness-Taylor probe mounted in an Instron testing machine and driven 7.9 mm into the pared apple flesh at a speed of 2.54 cm/min. Force measurements were converted to newtons with the conversion formula 1 pound = 4.448 newtons (N). The average of 2 maximum force measurements (on the blushed side and its opposite side) was used as the pressure test value for each apple. The average of measurements from 10 fruit was used for the composite value in statistical analyses. For chemical analysis, juice from apple slices was extracted with a Juicerator and centrifuged. Soluble solids content of the juice was determined with a bench-top model Bausch and Lomb Abbe-56 refractometer. The titratable acid content was determined by titrating the apple juice to pH 7.0 with 0.1N NaOH; the results are reported as percent malic acid.

Sensory evaluation. The taste panelists, who were selected on the basis of interest and ability to communicate sensory responses, had no special knowledge of apple quality criteria. During the development of the profile, all 15 panelists met together; however, only 6-10 panelists met for routine testing and each scored a given sample.

To develop the subjective quality profile, we asked the panelists to describe apples of various cultivars and maturities (1 or 2 at a time) in terms that were clear to someone completely unfamiliar with apples. After each panelist had tasted a representative sample and written his or her description, the group of panelists discussed selected terms until they reached a consensus on the meaning of each term. Food samples and chemicals – for example cinnamon and nutmeg for spiciness, and different quality beef steaks for toughness – were used to demonstrate some of the terms. Redundant terms, including antonyms, were eliminated. Attributes selected for describing the apple are shown on the ballot (Fig. 1). At each session, reference standards were provided for direct comparison with

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