Table 1. Average yield of dwarf peach trees.

Planting configuration	No. trees/ha	Mean yield[z] (t·ha^{-1} ± SD) year after planting 2	3	4	5	6	Total yield
Hexagonal	1242	9.1 ± 0.3	11.4 ± 0.9	53.5 ± 1.3	62.2 ± 2.8	67.9 ± 2.5	204.1 ± 4.1
Hexagonal	2475	17.0 ± 1.8	34.6 ± 1.1	65.0 ± 5.0	72.1 ± 2.3	61.8 ± 1.8	250.5 ± 6.16
Hexagonal	3757	30.1 ± 0.5	49.9 ± 5.4	71.1 ± 2.2	49.4[y] ± 2.3	59.8 ± 3.4	260.4 ± 7.15
Hexagonal	4970	39.3 ± 3.2	55.8 ± 4.4	53.8[y] ± 2.6	67.4 ± 3.4	69.4 ± 0.4	285.7 ± 6.93
Hexagonal	7452	47.7 ± 2.5	47.7 ± 9.2	53.8[y] ± 1.1	79.8 ± 5.0	61.8 ± 1.5	290.8 ± 6.14
Single hedgerow	2989	18.6 ± 0.5	50.5 ± 2.3	51.4 ± 3.3	69.6 ± 2.1	59.0 ± 2.7	249.1 ± 5.30
Double hedgerow	3072	17.6 ± 1.2	49.5 ± 2.5	40.6[y] ± 2.4	40.9 ± 3.2	48.0 ± 1.3	196.6 ± 5.03

[z]Grand average based on measurements of 90 trees.
[y]Trees in alternate rows removed in September of the previous year (see text).

the double hedgerow treatment (Table 1). However, the cumulative yields of the high-density plantings were about 35 t·ha^{-1} greater than the cumulative yield of the low-density planting (1242 trees/ha), largely due to the high productivity per unit area of the dense plantings prior to the onset of competition effects.

More than 95% of the fruit harvested during the first production year were at least 6.4 cm in diameter, declining gradually in subsequent production years to 88% (year 5) and 81% (year 6) for the hexagonal planting configuration. The decrease in the average size of fruit, from trees planted in hedgerows, during the 5th year appeared to be due to variability in fruit maturity, a relatively premature harvest, and an unusually heavy crop load.

Beutel and Gerdts (1) reported the results of a high-density yield trial that included several standard cultivars. This trial was conducted between 1972 and 1979 at the Univ. of California Kearney Field Station, the site of our experiment.

The standard cultivar, O'Henry, planted in hedgerows at a density of 1121 trees/ha, provided the greatest yield/ha of the several density treatments they studied. It provided no fruit the 2nd year in contrast to the dwarf genotype's 18.6 t·ha^{-1}, when planted at 2989 trees/ha. 'O'Henry's cumulative productivity over the first 7 years of this trial was 115 t·ha^{-1} vs. the dwarf's 249 t·ha^{-1} during the 7 years of our yield trial. During the 6th and 7th year 'O'Henry' produced an average of 38 t·ha^{-1} vs. the dwarf's 64 t·ha^{-1} in the 6th and 7th year of our trial. We conclude from this, and other comparisons, that dwarf dw/dw genotypes are more precocious than standard cultivars, and when planted at densities of about 2989 trees/ha will easily outproduce standard cultivars.

These results cannot be applied immediately to increase the efficiency of fruit production, since high-quality *dw* peach cultivars are presently unavailable. To remedy this situation, a breeding program was initiated at the Univ. of California, Davis, in 1976 to improve the quality of fruit produced by *dw* dwarf genotypes.

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Wine Grape Vine Radiation Balance and Temperature Modification with Fine-mist Nozzles

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Additional index words. microclimate, energy balance, net radiometer, infrared thermometer, vineyard

Wine grape (*Vitis vinifera* L.) vineyards in much of the desert Southwest are frequently exposed to intense solar radiation, high vapor pressure deficits, and high air temperatures. Although wine grape production in this region has increased during recent years, the harsh environment often results in growth conditions that may be suboptimal for photosynthesis and other plant processes, ultimately affecting fruit yield, wine color, and acidity.

Sprinkling has been shown to be effective in reducing heat stress in a variety of plants (2, 4, 6). Gilbert et al. (3) used overhead sprinklers to reduce grape leaf petiole temperatures by as much as 14°C in California. Kliewer and Schultz (5) decreased grape leaf and fruit temperatures by as much as 22° using continuous sprinkling. Although the cooling increased acidity and lowered pH, they questioned the practicality of using overhead sprinklers under vineyard conditions. Similar questions were raised by Aljibury et al. (1).

Ultra-fine mist systems may be used to cool plant canopy air evaporatively. In addition to reducing water consumption, these systems may have an added advantage over conventional sprinkling systems in that the decreased wetting of plant surfaces may reduce disease (2).

A preliminary study using an experimental fine-mist system was conducted in Summer 1983 in a 7-year-old vineyard located at the Univ. of Arizona Campus Agricultural Center in Tucson. The purpose of the study was to determine the effect of a fine mist injected within the canopy on foliage temperature and radiation balance during mid-day.

The vineyard contained a mixture of 39 wine grape varieties planted within a block of 4 plants. All vines were cordon-trained and spur-pruned with 10 spurs per vine. There were about 10 shoots per meter of row and about 40 to 200 leaves per shoot, depending on variety. The vineyard had 7 rows, 2.7 m apart, with a 1.4-m plant spacing. Mean can-

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opy height on the standard 2 wire trellises was about 2 m. Vine varieties within the experimental mist area included 'Gamey Beaujolais', 'Pinot blanc', and 'Trebbiano'.

The mist system was installed at a height of 1 m on the trellises of 3 adjacent rows near the center of the vineyard. About 3 m of each of the rows received mist, which was injected upward into the vines from nozzles manufactured by the Bete Co. (Greenfield, Mass.). The impingement nozzle design chosen for this study directed the pressurized water through a 0.25-mm diameter orifice onto a small tip, which caused the stream to break up. This produced a 90° cone-shaped mist, with a large percentage of the droplets being <1.27 μm in diameter. When operated at the test pressure of 414 kPa, each nozzle delivered 5 liters·hr^{-1}. As nozzle spacing along the rows was 0.75 m, each plant effectively received the spray from two nozzles, or about 10 liters·hr^{-1}. This application rate corresponded to an areal application rate of about 2.4 mm·hr^{-1}, which is generally lower than continuous uniform application rates with conventional rotating sprinklers (2).

Depending on wind velocity and vine leaf density, the mist generally was contained within the canopy, although visual observations indicated that only about 20% to 50% of the leaf area was directly wetted. Very little of the interrow soil surface was wetted by the mist. Because of other concurrent studies at the vineyard, long-duration misting was done only on 1 July, 19 July, and 5 Aug. Continuous misting occurred for about 5 to 6 hr on each of those days (actual times of misting are given in Table 1).

Foliage temperature, air temperature, vapor pressure, windspeed, solar radiation, and net radiation conditions were measured throughout the study. All instruments and sensors used to make the measurements were mounted on masts within or near the mist system. An infrared thermometer (IRT) (Everest Interscience, Tustin, Calif., Model 110 with 3° field-of-view, and 8- to 14-μm bandpass) measured foliage radiant temperature (T_f, °C) during daylight hours from a height of about 1.0 m above a 'Pinot blanc' vine near the center of the mist system. Vapor pressure deficit (VPD, saturation minus actual vapor pressure, kPa) in unmisted air 2 m above the misted vines was determined using a Campbell Scientific (CSI) (Logan, Utah) Model 201 humidity sensor. Wind speed 2 m above the vines was measured with a Met-One (Grants Pass, Ore.) Model 014A sensor. Air temperature (T_a, °C) (CSI 101 thermistor) was measured 1.2 m above ground between two adjacent unmisted rows. Net radiation (R_n, W·m^{-2}) (incoming minus outgoing radiation) was measured with a Fritschen net radiometer (Micromet Systems, Beaverton, Ore.) placed about 0.1 m above the vine on which foliage temperatures were measured. Incoming global solar radiation (R_s, W·m^{-2}) was measured with a LI-COR (Lincoln, Neb.) Model LI 200S pyranometer placed several meters away from the mist system. Signal output from each sensor was scanned at 10-sec intervals by a CSI CR21 Micrologger. Fifteen-minute averages of all processed data were recorded on cassette tape with the Micrologger.

Table 1. Vine temperature and radiation balance parameters, vapor pressure deficit, and wind speed conditions on selected days in 1983 with and without mist.

			Mean ± SD[z]				
Mist	Date	Time (HR)	T_f (°C)[y]	T_f–T_a (°C)[x]	R_n : R_s (W·m^{-2} : W·m^{-2})[w]	VPD (kPa)[v]	wind speed (m·s^{-1})
Off	30 June	1000–1500	30.3 ± 0.9	−5.9 ± 0.5	0.58 ± 0.02	5.5 ± 0.1	1.1 ± 0.1
On	1 July	1000–1500	28.6 ± 1.6	−7.3 ± 0.6	0.61 ± 0.01	5.3 ± 0.2	1.2 ± 0.1
Off	18 July	0830–1430	33.5 ± 2.3	−3.6 ± 0.5	0.60 ± 0.03	6.7 ± 0.2	1.7 ± 0.3
On	19 July	0830–1430	30.1 ± 1.8	−8.4 ± 1.7	0.65 ± 0.02	6.4 ± 0.1	1.7 ± 0.4
Off	25 Aug.	0900–1400	30.8 ± 3.2	−3.7 ± 1.4	0.67 ± 0.04	5.2 ± 0.1	1.3 ± 0.3
On	5 Aug.	0900–1400	31.0 ± 2.5	−6.9 ± 0.8	0.67 ± 0.03	5.4 ± 0.2	1.4 ± 0.5

[z]Values are averages of 15-min readings.
[y]Foliage temperature measured with infrared thermometer.
[x]Difference between foliage temperature and air temperature.
[w]Ratio of net radiation to global solar radiation.
[v]Vapor pressure deficit in air during 1200 to 1300 HR only.

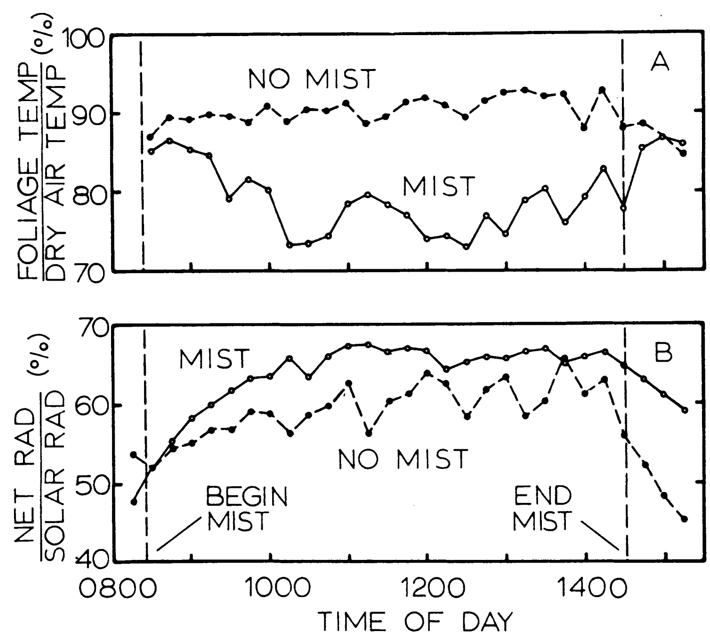

Fig. 1. Microclimatic conditions of an un-misted (18 July 1983) and a misted (19 July 1983) grapevine in Tucson, Ariz. (**A**) Ratio of vine foliage temperature to ambient dry air temperature (1.2 m above ground near vines) for both days. (**B**) Ratio of net radiation to incoming solar radiation for both days.

Misting did reduce foliage–air temperature differences relative to differences on environmentally similar (i.e., similar VPD and wind speed) days with no mist. This effect is shown in Table 1 and in Fig. 1. Mean (T_f–T_a) was as low as −8.4°C on 19 July (mist day), whereas it was only −3.6° on 18 July (no mist day). As illustrated in Fig. 1, the ratio of T_f : T_a averaged about 0.9 and 0.75 on 18 July and 19 July, respectively. The ratio of R_n : R_s was slightly higher on mist days compared to non-mist days. A possible reason for this difference was that the evaporative cooling reduced T_f and thus reduced the outgoing longwave radiation emitted from the foliage. This reduced longwave radiation was evidenced by the decreased emission within the atmospheric "window" region (8 to 13 μm) corresponding about to the IRT bandpass. The mist may also have affected the canopy shortwave reflectivity, and thus the net radiation.

This preliminary study demonstrated the potential for using fine-mist nozzles to cool wine grape vines. The lower water consumption of misting systems compared to conventional sprinkling systems may reduce water requirements for cooling. Full vineyard studies are needed, however, to evaluate the effectiveness of the mist under a broader range of VPD and wind speed conditions. Research should consider the economics and design of the misting system, and the practicality of various misting strategies (e.g., intermittent vs. continuous, overhead mist vs. mist within canopy), which could further reduce water requirements. Also, the effects of misting on transpiration, phenological development, yield, and disease incidence should be studied.

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Techniques for Water Emasculation and Cut Seedstalk Pollination in Celery

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Hybridization in celery is a difficult task faced by the breeder due to the complex floral biology. Celery flowers are hermaphroditic but protandrous and are arranged in compound inflorescences or umbels, formed by small groups of flowers or umbellets disposed in whorls (3). The different developmental stages of the flowers in the umbel makes it difficult to control pollinations effectively. Pollen from young flowers will pollinate old ones that have receptive stigmas in the same inflorescence or anywhere else on the plant. Honma (4) reported a useful technique for celery hybridization, which is the standard procedure used today by breeders. The accuracy of this method depends on the faithful drop of stamens before any of the stigmas become receptive; otherwise, accidental self-pollinations will occur.

In experiments dealing with pollen viability under storage, D'Antonio and Quiros (2) found a substantial amount of selfed seed in unpollinated control umbels of the annual celery strain PI 257228 when handled by Honma's technique. Close examination revealed a large number of flowers with receptive stigmas and stamens still present (Fig. 1, upper left), also reported by Orton and Arus (7). We expanded our observations to include a large array of accessions during seed increase activities and concluded that the timing of the floral developmental events varies widely from cultivar to cultivar and also might be influenced by environment. Furthermore, the synchronization of the flowers chosen for pollination is not absolute. Some flowers might develop faster than others in the same umbel or umbellet. For backcross breeding programs and for inheritance studies, it is critical to avoid seeds developed by accidental self-pollinations.

In this article we describe an alternative approach to that reported by Honma (4). The procedure, adapted from lettuce (6), is useful for emasculating any celery accession regardless of its level of protandry.

The technique consists of selecting umbels with about 80% to 90% open flowers but with undeveloped styles, regardless of their whorl order (Fig. 1, lower left). Umbellets and flowers at bud stage are removed from the umbels. A total of 5 to 7 good umbellets are kept per umbel. The number of flowers left per umbellet should range from 10 to 15. The umbel is held gently between the fingers of one hand, and a water stream from a household cleaning fluid spray bottle is applied to force anthers and pollen from the flowers (Fig. 1, upper right). After all the water drips from the umbels, they are covered with white 18 × 5 cm paper bags (Law-

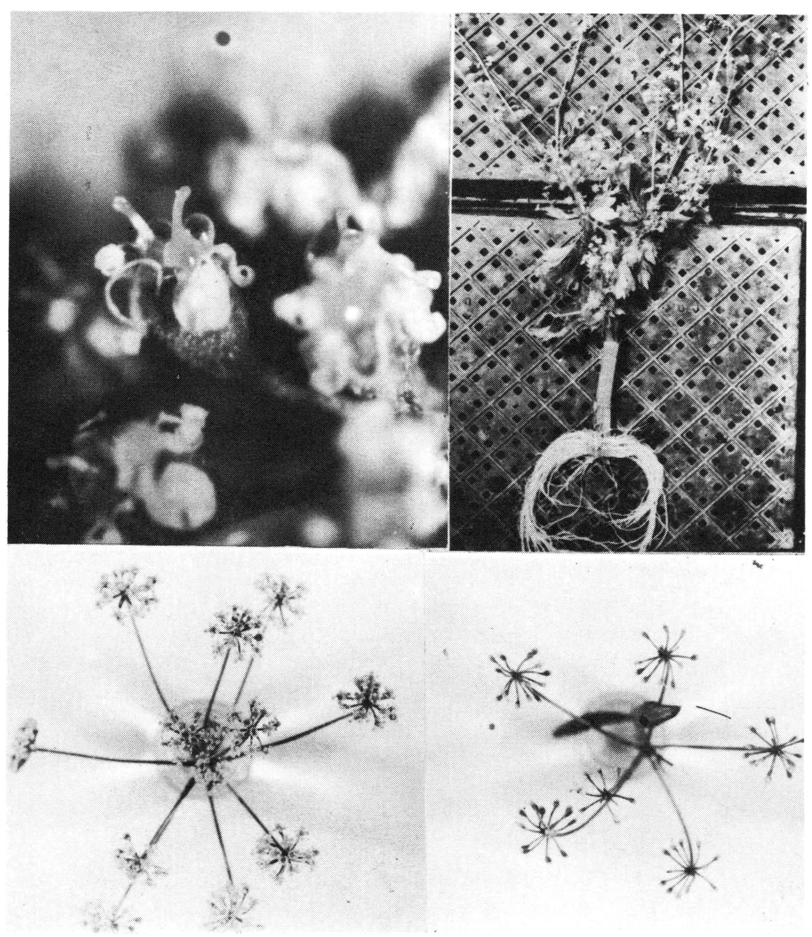

Fig. 1. (**Upper left**) Celery flowers of accession PI 257228 showing simultaneous presence of anthers and receptive stigmas. (**Lower left**) Celery umbels before washing and trimming. (**Upper right**) Celery umbels after washing and trimming, ready to cover. (**Lower right**) Rooted primary seedstalk branch after three weeks in water.

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