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Effect of Overhead Sprinkler Irrigation on Watercress Yield, Quality, and Leaf Temperature[1]

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Abstract. **Water was applied to watercress (*Nasturtium officinale* R. Br.) by overhead sprinkling for various day periods during the warm-season (summer) and cool-season (winter) to determine its effect on leaf temperature and yield. Intermittent overhead sprinkling throughout the day increased watercress yield and quality during the warm-season, but not the cool-season. Sprinkling reduced leaf temperature by as much as 4.8°C during the warm-season and by only 1.1°C during the cool-season. The increased yield and quality was attributed to substantially reduced leaf termperature during the warm season.**

Watercress, a leafy salad crop, is native to England (4) and is generally acknowledged as being a cool season vegetable crop (6). Commercial production of watercress in Hawaii is maintained throughout the year due to moderate year-round air and water temperatures. Peak production occurs during the cooler months from October through April. Production declines during the warmer summer period, apparently due to the higher air temperatures during this season. Further, local growers have observed that intermittent daytime rain showers during the warm-season have improved the growth and quality of watercress.

Overhead sprinkling to reduce heat stress has been studied on cool-season crops such as pears (5), grapes (3) and apples (7). Unrath and Sneed (8) reported that overhead sprinkling reduced fruit temperature of the early apple crop by 5.6°C with a subsequent improvement in quality and yield.

To study this phenomenon on watercress, sprinkler treatments were established in a commercial watercress field in Aiea, Hawaii. Sprinkler treatments were applied during the morning, midday, afternoon, and all-day. The morning, midday and afternoon treatments each covered a time span of 3 hours, beginning at 7:15 AM, 11:15 AM, and 3:15 PM, respectively. The all-day treatment covered a time span of 12 hr beginning at 6:30 AM. In each treatment, sprinklers were on 15 min and off 45 min every hour. The control was grown under normal field conditions and cultural practices with no overhead sprinkling. In all of the sprinkler treatments, low angle heads with a 1.5 m sprinkling radius were used. The heads were placed on 60 cm risers and calibrated to deliver 2.5 liters per min. Sprinkler water temperature ranged from 23° to 25°C.

This study was conducted during 2 different seasons. Cool-season experiments were conducted from March 1 through May 11, 1979 and again from January 23, 1980 through March 1, 1980. Warm-season experiments were performed from June 21 through September 16, 1979. Each plot was 9 m^2 (3 x 3 m) and was grown in 2 to 3 cm of continuously flowing fresh water at a rate of about 10^7 liters per ha per day. When the length of the watercress stems reached 25 to 30 cm in the best plots, all plots were harvested. Data were taken on the fresh weight yield per m^2 and on quality, using a rating system of 1 (poor) to 5 (excellent). A quality rating of 3 was considered to be an average crop of marketable quality. During both warm and cool season trials, the crop was harvested 3 times so that 3 data sets, consisting of 2 replicates per treatment were taken. Data were pooled over the 3 sets and analyzed (9). Each plot was replanted after harvesting by using the vegetative material obtained from the harvested area.

Air, water and watercress leaf temperatures were measured with 0.13 mm diameter calibrated thermocouples attached to a voltmeter via a cold junction. Temperatures of both the sprinkled and unsprinkled leaves were measured on the under surface of the leaf while air temperature was measured in the shade 2.5 m away from the sprinkled site. Temperatures were taken on clear days with the normal northeasterly tradewinds at about 16 to 24 km per hr on September 6 through September 8, 1979 during the warm season and February 25, 1980 during the cool season.

Overhead sprinkling did not affect yield of the watercress grown during the cool-season (Table 1) and yields generally were highest during the cool-season. Watercress subjected to all-day sprinkling during the warm-season showed a 57% gain over the unsprinkled control. Further, yield obtained with the warm-season all-day treatment was similar to yield of the unsprinkled cool-season control.

Quality of the various treatments showed a similar response as that of yield. Overhead sprinkling had no effect on the quality of cool-season watercress; however, the all-day sprinkler treatment gave better quality than the unsprinkled control during the warm-season (Table 1).

Overhead sprinkling during the warm-season resulted in a substantial reduction in leaf temperature (Table 2). Temperatures of sprinkled and unsprinkled leaves were nearly identical before the sprinkling period, but differed by as much as 4.8°C after the sprinkling period. Sprinkling stabilizes leaf temperature below air temperature by providing a source of free water from which evaporation can take place, thus dissipating a significant quantity of energy. These results are similar to those reported with several other crops (1, 2, 3, 5, 7, 8). In contrast, there was only a little decrease in leaf temperature due to overhead sprinkling during the cool-season (Table 2). Apparently, the

Table 1. Effect of overhead sprinkling on watercress yield and quality.

Sprinkling period	Fresh wt of watercress (kg/m^2)		Quality rating[z]	
	Warm-season	Cool-season	Warm-season	Cool-season
No sprinkling	1.25a[y]	2.02a	2.8a	3.5a
Morning	1.50ab	1.80a	3.2a	4.0a
Midday	1.55ab	2.22a	3.2a	4.3a
Afternoon	1.56ab	2.08a	3.5ab	4.0a
All-day	1.96b	1.97a	4.7b	4.8a

[z]1 = poor quality, 5 = excellent.
[y]Mean separation in columns by Duncan's multiple range test, 5% level.

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Table 2. Effect of overhead sprinkling on leaf temperature during the warm- and cool-season.

Sprinkling period	Data point	Temperature (°C) Warm-season Before sprinkling	Warm-season After sprinkling	Cool-season Before sprinkling	Cool-season After sprinkling
7:30 – 7:45 AM	Air	21.8	22.8	18.0	18.0
	Unsprinkled leaf	21.6	22.3	18.0	18.0
	Sprinkled leaf	19.9	22.1	18.0	17.5
10:30 – 10:45 AM	Air	29.8	30.1	21.7	21.7
	Unsprinkled leaf	29.6	29.8	21.4	20.9
	Sprinkled leaf	29.1	25.0	21.4	20.3
1:30 – 1:45 PM	Air	32.7	32.7	26.7	24.1
	Unsprinkled leaf	30.6	31.8	24.9	23.7
	Sprinkled leaf	30.1	27.9	24.5	22.6
4:30 – 4:45 PM	Air	28.9	28.9	25.5	24.7
	Unsprinkled leaf	28.2	26.9	24.8	24.1
	Sprinkled leaf	28.2	24.1	23.8	23.2

reduced solar radiation during the cool-season resulted in substantially lower air and leaf temperatures than during the warm-season, and little leaf cooling resulted.

The use of overhead sprinkling during the warm-season and cool-season trials had no effect on the water temperature in the plots. The temperature of water from its underground source remained relatively constant at 20°C throughout the year. The temperature of water flowing through the plots during the cool-season ranged from 20° to 24.8° while during the warm-season the range was from 20° to 25.1°.

The use of overhead sprinkling can play a major role in the reduction of leaf temperature through evaporative cooling. This creates a more favorable growing condition for watercress during the warm-season in Hawaii. Use of such a system during the warm-season in Hawaii can improve both yield and quality comparable to that obtained during the cool-season.

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Bee-sticks, an Aid in Pollinating Cruciferae[1]

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Abstract. **Effective, inexpensive, disposable pollination aids (bee-sticks) can be made by gluing the thoraxes of dead honey bees (*Apis mellifera* L.) to the tips of wooden toothpicks. Bee-sticks also are suitable for the short and long term storage and for shipment of pollen.**

For some time I have been experimenting with the use of dead, dried and sterilized honey bees as an alternative to soft hair brushes or forceps in pollinating crucifers and as a way of collectting and storing pollen. Hair brushes frequently carry static electrical charges which repel pollen reducing pollination efficiency. When making large numbers of controlled crosses with forceps, pollination is often slowed by having to wait between crosses until forceps have been decontaminated. Described below is the manufacture and use of these inexpensive disposable "Bee-sticks."

Large quantities of dead honey bees, obtained from the local USDA/SEA Bee Investigations Laboratory, University of Wisconsin-Madison, were dried in brown paper bags at 60°C for 24 hr. Dried bees were then fumigated for 12 hr in a closed container in which 10 ml of propalene oxide had been added, then stored in 4 liter paper cartons. Bee-sticks were made by holding the honey bee by the wings and removing the abdomen, head and legs with fine forceps or a dissecting needle. A quantity of separated thoraxes are usually produced first; then, with a small drop of fast-drying model cement applied to the tip of a double-pointed round toothpick, the thorax is glued to the toothpick by inserting the tip into a hole in the thorax left by the junction of the head or abdomen (Fig. 1). Bee-sticks can be placed in a soft styrofoam cup or block to dry. It is usually convenient to leave the wings on the thorax until it has been glued to the toothpick. Bee-sticks can be conveniently stored in 20 × 70 mm glass screw-cap vials.

Supplies of dead honey bees should be available from local amateur or professional bee keepers, either in early spring when apirists are cleaning their hives in preparation for the honey flow or in late summer or fall when honey is being removed from the hive. Some producers kill their colonies before removing the honey, and in such cases large quantities of bees are available. Young bees with hairy thoraxes are preferable to older bees which have lost much of their hair. About 2,500 dried bees occupy a volume of 1 liter.

The feeding activity of dermestid beetles (carpet beetles) in the stored, dried bees has proved to be an additional aid in the manufacture of bee-sticks. Dermestid larvae remove much of the internal dried tissue of the bee and frequently exit by making a small hole in the thorax. This hole is particularly convenient for inserting the tip of the toothpick while gluing the thorax to the stick.

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