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Apple orchard frost protection with wind machine operation

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Abstract

Research has shown that wind machines are more effective under conditions of strong thermal inversions. Quantitative relationships between the level of protection and inversion strength, however, are not well known, and there are few reports on the effect of fan operation on energy balance. Whether the wind machines should be started before surface cooling causes turbulence damping and atmospheric stratification or if it is possible to delay starting until just before the critical temperature occurs remains a matter of discussion. Therefore, experiments were conducted on 11 spring frost nights during the 1999 and 2000 to assess the effectiveness of a fan operation on frost protection of an apple orchard under different microclimatic conditions. The 11 frost events were characterized by light winds (0.58–1.92 m s^{-1}) and clear skies for most of the night, resulting in an average accumulated radiative loss of 2.67 ± 0.38 MJ m^{-2}. The air temperature increased immediately after the wind machines were started and the temperature rise depended on inversion strength. For each 1 °C increase in temperature inversion strength between 1.5 and 15 m height, wind machine operation caused a 0.3 °C increase of air temperature at a 1.5 m height within the main area affected by the fan operation. Using multiple regression, the area protected was significantly related to the temperature increase and the inversion strength. Wind machine operation reduced flower damage by 60% in 1999 and 37% in 2000. Distribution of flower damage varied spatially, and it was related to wind drift.

Keywords: Frost protection; *Malus pumila* mill.; Frost fans; Night cooling; Freeze damage

1. Introduction

Frost causes more economic losses than any other weather-related phenomenon in the USA (White and Hass, 1975) and probably in many other parts of the world. A wide range of passive (indirect) and active (direct) methods exist for avoiding or reducing frost damage (Rieger, 1989; Kalma et al., 1992; Snyder and de Melo-Abreu, 2005). Passive methods, such as plant selection, site selection, appropriate use of cultural and management practices, and modification of the physical environment of the crop are important to avert or minimize frost damage. Under severe frost conditions, however, these methods are often inadequate to protect crops. Active methods are implemented just before or during a frost night to prevent ice formation within sensitive plant tissue. Wind machines, sprinkling irrigation, and open air heating are the most common active protection methods.

Wind machines mainly provide protection by mixing the cold air near the plants with warmer air above the plants (Gerber, 1979), and they work best when there is

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