

DESIGN, DEVELOPMENT AND EVALUATION OF AN ELECTRICAL HEATER FOR PROTECTING TREE FROM WINTER INJURY

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ABSTRACT - When woody plants are subjected to a sudden large drop in temperature, injury or even death of plants can occur. An electrical heater unit designed for cold protection tree in winter. It made up from three layers. Material of middle layers was from glass wool and two outer layers were from waterproof rubber covering. Thermal wires were placed inside the layers. Electrical heater of tree could be used for trees with trunk diameter between 15 cm to 45 cm. The electrical heater around the trunk was wrapped, and then in a cooler chamber was placed. Tests carried out in five different temperatures (-8, -12, -15, -18 and -20 °C) with five replications on the same trunk. Essential power and voltage for this electrical heater was 54.6 W and 24 V. Tests results indicated that the tree heater kept trunk in temperature 20, 19, 18, 15 and 14°C while cooler chamber temperature was -8, -12, -15, -18 and -20°C, respectively.

Key words: Tree heater, Tree injury, Protecting tree, Electrical heater, Cold climate.

INTRODUCTION

The effects of temperature vary with plant species, stage of growth, age, general health and water content. Winter damage, however, does not always show up as direct injury. Freezing temperatures that are not sufficient to kill can cause a plant to be predisposed to other problems such as bacterial blight, phytophthora root rot, and several other pest problems (Anonym, 1997). Young, actively growing, flowering, and/or dehydrated plants tend to be most vulnerable (Bradley and Horticulture, 1998). It was found that development and growth of fruits and leaves were limited by low temperature, which would cause damage symptoms such as fruit abscission, chilling injury and leaves injury (Huang *et al.*, 2005). Frost injures plants by causing ice crystals form in plant cells, making

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water unavailable to plant tissues and disrupting the movement of fluids (Anonym, 2003). Symptoms of freeze injury could include desiccation or burning of foliage, water-soaked areas that progress to necrotic spots on leaves stems or fruit and death of sections of the plant or the entire plant (cold 20% protection).

Protecting trees from cold damage is a difficult task. The problems of tree care, a shortage of trees and increasingly frequent freezes have generated a new interest in protecting trees from possible damage by cold (cold 20% protection). The best way to prevent winter injury is to ensure maximum acclimation by optimizing growing conditions during the growing season and minimizing stressful conditions. Supplying adequate moisture and balanced nutrition are essential (Anonym, 1997).

Several methods used for cold protection. One method is using tree canopy covers. These can reduce cold injury. Tree canopies elevate minimum night temperature under them by reducing radiant heat loss from the ground to the atmosphere (Ingram and Yeager, 2003). Another way is using soil banks. Soil banks must be put up before danger of cold and removed as soon as possible after the threat of cold has passed. Excellent insulating value, Conforms well to large or irregularly shaped trees and no cost for material are the number of advantages. Although, expensive labor, maintain difficulty

and problems of disease are disadvantage of using this method.

Heaters are devices for cold protection. Orchard heaters provide heat by direct radiation and convection. Stack heaters give out 25-30 percent radiant heat, which moves along a straight line from the heater to the trees. Air around the immediate area of the heater is heated by convection. Because of the need for fuel-burning efficiency and pollution reduction, orchard heaters have evolved to the upright stack design. The greatly increased cost of fuel has practically eliminated heaters from the growers cold protection strategy. Tree wraps were most useful protecting young trees. Tree wraps protect only the trunk and leaf loss. Most tree wraps, unlike soil banks, can be attached anytime during the year and left on the tree throughout the year or even for several years. Types of tree wraps are Fiberglass wrap, Polyurethane foam, Rigid Polystyrene Foam (Thick-Walled) and Closed Cell Polyethylene Foam (Jackson and Parsons, 1994). Completely drape the plant from top all the way to the ground. Do not allow any openings for warmth to escape. This procedure will trap the heat radiating from the soil and maintain a more humid atmosphere around the plant foliage (Bradley and Horticulture, 1998).

This paper describes the development and testing of an electrical heater for protecting fruits trees from cold temperatures.

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MATERIALS AND METHODS

An electrical heater unit (*Fig.1*) designed for cold protection tree in winter. As shown in *Fig. 2* it made up from three layers. The materials of inside layer was glass wool with thickness 3 cm and outer layers were waterproof rubber covering. The layers have an overall dimension of 150 cm in length, 77 cm in width. For high absorption of sunray, one of the outer layers had a dark color.

Thermal wires were placed inside the layers which were connected by some rope.

As shown in *Fig. 3* this electrical heater had two groups of thermal wires that were parallel connected. Each series had six thermal wires with length of 70 cm, diameter of 0.01cm and resistance of 126.6Ω . Intervals between wires were 10 cm and placed parallel on the glass wool layers. Essential power required 54.6 W by 24 V DC supply e.g. Tractor battery.



Figure 1- The electrical heater unit of tree

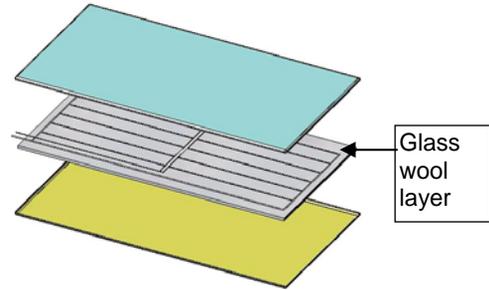


Figure 2 - The three layers of electrical heater of tree

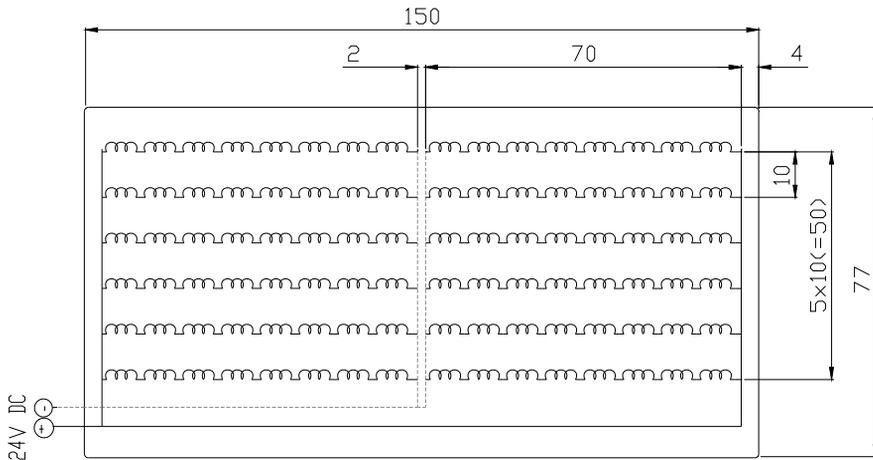


Figure 3 - The arrangement thermal wires on the inside layered (dimensions in cm)

With respect to the facts that in Iran temperature of some cities at winter times does fall to -20°C , therefore, in this study the maximum temperature range for experiments -20°C was chosen. For conducting the experiments on these electrical heater, a cooler (Model CA12-2232, Baradaran, Iran, was applied (Fig. 4). The cooler chamber had the ability of changing temperature inside its chamber from $-25^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$ to $5^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$.

Electrical heater of tree could be used for trees with trunk diameter

between 15 cm to 45 cm. Tests carried out by a trunk with diameter of 21 cm. The electrical heater was wrapped around the trunk and was placed in the cooler chamber. Temperature between electrical heater and trunk was measured by thermometer (PT100).

Tests were executed in five different chamber temperatures range (-8 , -12 , -15 , -18 and -20°C) on the same trunk. For each temperature range, experiments were conducted in five replications.

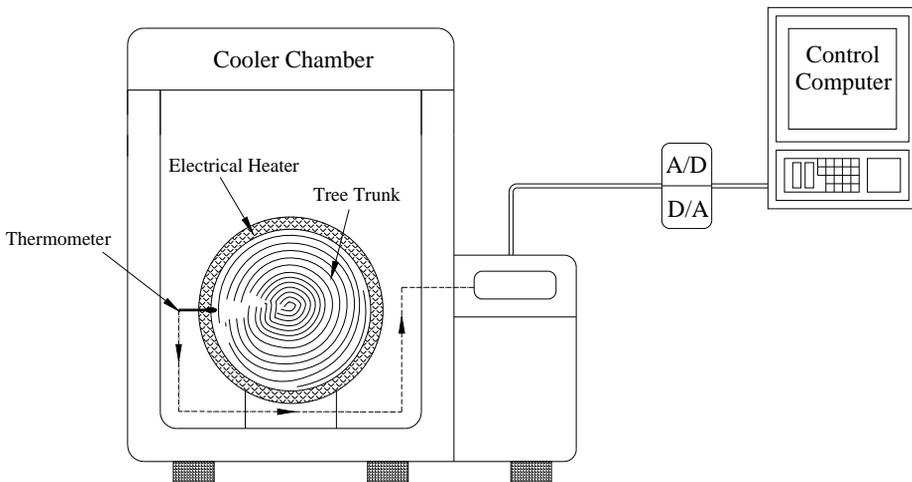


Figure 4 - The cooler chamber

RESULTS AND DISCUSSION

The results of tests for trunk placing in five different temperature (-8 , -12 , -15 , -18 and -20°C) are shown in Fig.5. Tests results indicated that the tree heater kept trunk in temperature 20, 19, 18, 15 and 14°C while cooler chamber temperature

was -8 , -12 , -15 , -18 and -20°C , respectively. Voltage and electric flux of thermometer for all tests were constant. As shown in Fig. 5 an initial high rate of thermal sorption followed by slower absorption in the latter times. In all of the tests after 4 h trunk temperature reaches steady temperature.

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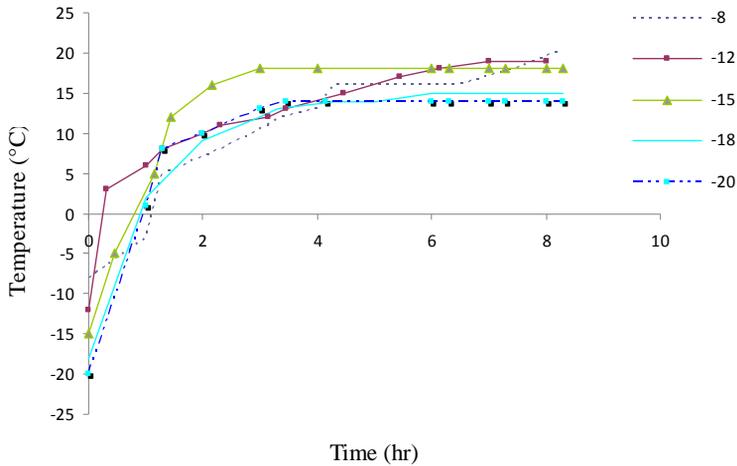


Figure 5 - The temperature between electrical heater and trunk in five different chamber temperatures range versus experiment time

CONCLUSION

This paper presents the design modification and evaluation of an electrical heater unit of tree. The results indicated that the tree heater kept trunk in temperature 14°C while cooler chamber temperature was -20°C. Therefore, the electrical heater unit could protect trees in winter times at -20°C against freezing.

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