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Nutrient-flow wick culture system for potted plant production: System characteristics and plant growth

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Abstract

To compliment the current subirrigation systems used for production of potted plants, a nutrient-flow wick culture (NFW) system was developed and compared with other subirrigation systems, such as an ebb and flow culture (EBB) system and a nutrient-stagnant wick culture (NSW) system in relation to their system characteristics and plant growth. Kalanchoe (*Kalanchoe blossfeldiana* cv. New Alter) was cultivated in a 6 cm pot for 10 weeks in each subirrigation system. The water-absorption pattern of the medium, water content of the medium, water loss, algal growth, salt-buildup and plant growth under various culture systems were observed. The water contents of medium under the NFW and EBB systems showed fluctuations from 30 to 40% and from 50 to 60% (by volume), respectively, whereas the water content under the NSW system gradually increased to over 40% without fluctuation. Relative to other systems, the water loss in the NFW system was 50–70% due to the reduction in the evaporation from the surfaces of the trough and medium. Algae appeared in the NSW system because the nutrient solution was always stagnant in the trough, while it was not observed under the NFW system. The dissolved oxygen in the nutrient solution was the highest during the irrigation period and the salinity in the medium was the lowest in the NFW system. With regard to system characteristics, the NFW system was simple, water-saving and efficient. In addition, the growth of kalanchoes in the NFW system was similar to those in the NSW and EBB systems at an irrigation frequency of five times a day.

Keywords: Subirrigation; Nutrient-stagnant wick culture; Ebb and flow system; Algae; Water loss; DO; Water content; Kalanchoe

1. Introduction

Irrigation methods affect the growth of potted plants regardless of source and rate of nutrient solution (Argo and Biernbaum, 1994; Dole et al., 1994; Molitor, 1990). They influence the water-absorption pattern and various other factors that may affect plant growth (Argo and Biernbaum, 1994; Ku and Hershey, 1991; Molitor, 1990). In a number of studies where current irrigation methods were compared, subirrigation systems were found to be more economical and efficient than overhead irrigation systems in container plant production (Klock-Moore and Broschat, 2001; Morvant et al., 1997).

Among the subirrigation systems such as ebb and flow (EBB) system, capillary mat system and wick culture system, the EBB system has been widely used in Europe and America. Although the EBB system is technically simple and reliable, it needs expensive and robust materials and a carefully maintained water level during the irrigation period. Simple and less expensive systems, which perform as well as the EBB system would be desirable.

Following the use of wick culture system in the cultivation of hubbard squashes and caster beans (Raines, 1937), a self-watering system using wick was introduced by Dolar and Keeney (1971) and Helmut (1972). Further, simplifying of this system resulted in a nutrient-stagnant wick culture (NSW) system (Toth et al., 1988). Although this system has many advantages such as continuous water-supply, reducing labor and being able to control the temperature of root medium, it also has many disadvantages such as susceptibility to excessive evaporation, algal growth associated with nutrient solution and wick and leakage from culture beds (Dolar and Keeney, 1971; Toth et al., 1988).

In this study, we describe a nutrient-flow wick culture (NFW) system which allows the nutrient solution to circulate on inclined troughs, so that the duration and frequency of irrigation can be controlled. The primary objective of this study

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was to compare the system characteristics of the NFW, NSW and EBB systems as they affect the growth performance of *Kalanchoe blossfeldiana*.

2. Materials and methods

2.1. Water content of root media (Experiment I)

2.1.1. Experimental conditions

An experiment was conducted in venlo-type glasshouses at Seoul National University in Korea from February 25 to March 2, 2002. The effect of subirrigation method on water content of the growing medium was investigated using 120 pots (6 cm in diameter) containing a 7:3 mixture of peat moss and perlite (v/v) without plants. We chose to use 6 cm pots because they are economical and convenient in a trough system. Nine aluminum troughs, 300 cm × 8.5 cm × 4 cm ($L \times W \times H$), six for the NFW system and three for the NSW systems and three aluminum troughs, 300 cm × 13 cm × 4.5 cm ($L \times W \times H$), for the EBB system were used. The nutrient solution of 11.7N-1.5P-5.5K, based on Sonneveld solution (Sonneveld, 1989), was maintained at 1.6 dS m^{-1} and pH 6.5 in the tank and circulated in the NFW system with the troughs held at 1% slope (Fig. 1). For equal compaction, pots filled with the medium were dropped 20 times from 3 cm hight. A wick, 12 cm × 1 cm ($L \times W$), was inserted into each pot in the NFW and NSW systems, in such a manner that the wick length inside the pot and outside, below the pot and above the surface of nutrient solution, was 3 cm. Initial water content of the medium was about 24% on volume basis. Average daily air-temperature and cumulative irradiation were 24.8 °C and 2.2 mol m^{-2} d^{-1} during the 7 day experiment, respectively.

2.1.2. Irrigation treatments

Four irrigation treatments were applied as follows: NFW (4×) – irrigation four times (09:00, 12:00, 14:00 and 17:00 h) of 15 min each per day; NFW (2×) – irrigation two times (09:00 and 14:00 h) of 15 min each per day; NSW – continuous irrigation; EBB – 10 min irrigation per day at 09:00 h. Irrigation was controlled using a timer function of a CR10X (Campbell Scientific Incorporated, USA). The irrigation time and frequency in the NFW system used here were based on best results from the preliminary experiment. Water level in the NSW system was maintained at 1 cm. In the EBB system, water level was 1.5 cm, which was one-fourth of the height of the pot when flooded. Irrigation time and water level in the EBB system were those used in the previous studies (James and van Iersel, 2001; Morvant et al., 2001; Treder et al., 1999).

2.1.3. Water content of medium

Wet medium weight was measured by an electronic balance at 08:00, 10:00, 15:00 and 18:00 h. Volumetric water content was calculated using the relationship, [(wet medium weight-dry medium weight)/volume of medium]. To obtain the dry medium weight, wet medium was dried for 24 h in 105 °C dry oven (FS-420, Advantec, Japan) after the termination of the experiment.

2.2. Comparison of plant growth and system characteristics (Experiment II)

2.2.1. Experimental conditions

The experiment was conducted from June 12 to August 20, 2002. Irrigation treatments were identical to the previous irrigation systems except for the NFW (4×) system. The irrigation frequency was increased to five times [NFW (5×)] due to high air-temperature and irradiation. In the NFW (5×) system, pots were irrigated at 01:00, 09:00, 12:00, 14:00 and 17:00 h a day. The cuttings of *K. blossfeldiana* (cv. New Alter) were planted in 120 pots (6 cm in diameter) containing a growing medium [(peat moss and perlite 7:3 (v/v)] on May 30, 2002. Ten pots each containing one plant were placed in a trough. Cuttings, after rooting, were subjected to short days (9/15 h, day/night) on June 12, 2002 for about 8 weeks and irrigated with the nutrient solution. After 1 week of rooting, plants were sprayed with PGR (diminozide) at 2500 ppm. Short-day exposure was terminated after 8 weeks, when the plants started to bloom. The nutrient solution was maintained at 1.6 dS m^{-1} and pH 6.5, by adjusting these every 3 days, if needed and was renewed every other week. At the initiation of

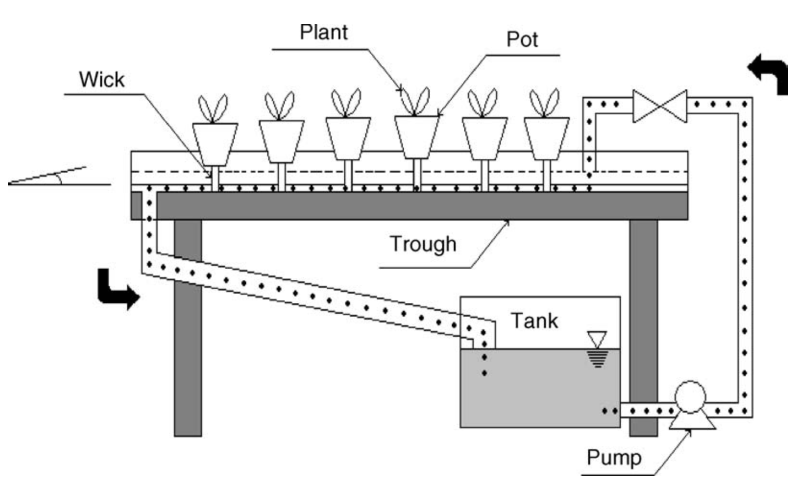

Fig. 1. Schematic diagram of the nutrient-flow wick culture (NFW) system.