Intermittent Sprinkler Irrigation Reduces Water Loss from Container-Grown Plants

Nabila S. Karam, Alex X. Niemiera and Robert Wright
Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061-0327

Water application efficiency can be improved by approximately 4% to 10% via intermittent irrigation. However, efficiency, regardless of application method, is primarily a function of pre-irrigation moisture content and the volume of water applied; efficiency decreases as volume and substrate moisture content increases. For pine bark, relatively high efficiencies can be achieved if irrigation occurs when the pre-irrigation substrate moisture content is below 88% and the volume of water applied does not exceed 300 ml (0.32 qt).

INTRODUCTION

Overhead sprinkler irrigation is the predominant system to irrigate plants grown in small containers (12 liter, 3 gal). Due to the relatively porous nature of soilless substrates, a significant fraction of the applied water leaches from containers. Intermittent irrigation, application of a plant's daily water allotment in more than one application with prescribed intervals between applications, is an irrigation strategy to reduce the amount of water and fertilizer lost from containers following irrigation. Intermittent irrigation was first proposed by Karmeli and Peri (1974) working with mineral soil and was termed "pulse irrigation." Since the commercial irrigation industry uses the term pulse irrigation for a specific water delivery mechanism, this paper will use the term intermittent irrigation. Intermittent irrigation has been shown to increase water application efficiency of spray-stake-irrigated plants compared to applying the daily water allotment in a single continuous application (Lamack and Niemiera, 1993), but no work has occurred with sprinkler irrigation. Thus, the objective of this overhead sprinkler irrigation project was to determine how water application efficiency was influenced by the duration of the interval between intermittent applications and by pre-irrigation substrate moisture content.

MATERIALS AND METHODS

A simulated overhead sprinkler irrigation system delivered water at 1.4 cm/h (0.55 in./h) to containers. Pine bark (PB) was amended with sand (S), 9 PB : 1 S (v/v), and dolomitic lime at 0.19 lb/ft^3 (3 kg/m^3). Approximately 3.5 liters (3.7 qt) of substrate were added to each 3.8 liter (1 gal) container. Marigold (*Tagetes* 'Apollo') seedlings were transplanted into substrate-filled containers and greenhouse-grown. Plants were fertilized with Osmocote 14-14-14 (0.7 oz/container) and hose irrigated as needed until the commencement of the experiments. Plants facilitated removal of water from the container via evapotranspiration (ET) to prescribed container moisture levels prior to irrigation treatments. After irrigation treatments (to be discussed), leachate was collected and water application efficiency computed using the formula: [(vol applied - vol leached) ÷ vol applied] × 100. Treatments were replicated at least six times.

Time Interval Between Intermittent Applications. Water was applied continuously (single application) or intermittently in which three applications (each one-third of ET) were applied with 20-, 40-, or 60-min intervals between applications. Containers were weighed when fully wet (weight before ET) and before irrigation (weight after ET). The volume of water applied was the difference between wet weight and weight before ET. Pre-irrigation moisture content ranged from 73% to 94% of container capacity (CC) and the volume of water applied (= ET) ranged from 66 to 663 ml (0.07 - 0.7 qt).

Substrate Moisture Distribution After Irrigation. Two hundred and seventy-five ml (0.3 qt) were applied continuously or intermittently in which 33%, 66%, or 100% of the 275 ml was applied in one, two, or three applications, respectively. Each intermittent application was one-third (92 ml) of the total volume and interval duration between applications was 60 min. Leachate volume was measured at the end of each interval just prior to the start of the next application to determine efficiency of each application. After the last application in both continuous and intermittent treatments, containers were covered, drained for 45 min, weighed and leachate volume measured. Substrate in each container was transversely tri-sectioned into approximate equal sections (5 cm, 2 in). After removing roots,

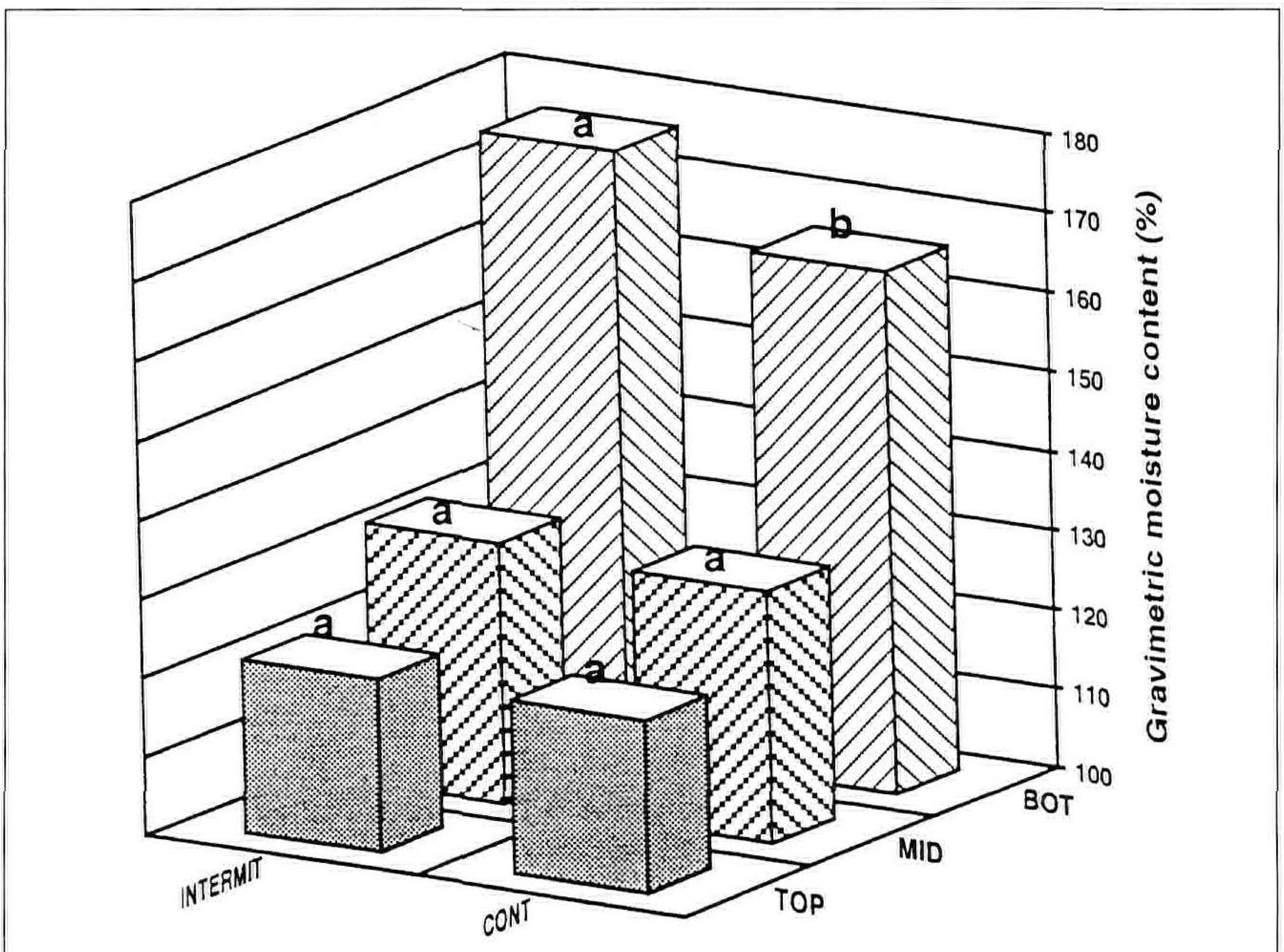

Figure 1. Gravimetric moisture content (%) of top, middle (MID), and bottom (BOT) sections of a 9 pine bark : 1 sand (v/v) substrate after receiving the same volume of water continuously (CONT) or in three intermittent (INTERMIT) applications. Letters above columns indicate section differences between continuous and intermittent irrigation at P = 0.01 (Substrate moisture distribution after irrigation, Expt. 1).

substrate in each section was mixed thoroughly and a sub-sample of each section was weighed then oven-dried to determine gravimetric moisture content.

RESULTS AND DISCUSSION

Time Interval Between Intermittent Applications. There was a positive linear relationship between irrigation efficiency and interval duration between intermittent applications (Table 1). Results are in general agreement with a trickle irrigation study (pine-bark-filled 11-liter container) in which irrigation efficiency increased by 10% (absolute basis) when interval duration increased from 20 to 40 min (Lamack and Niemiera, 1993). Increasing the interval duration between irrigations decreased the time averaged application rate (TAAR). As interval duration between intermittent applications increased, the time for water to move through the substrate and enter micropores was increased and thus allowed for more absorption of water by the medium As substrate moisture content and volume applied increased, leachate volume decreased (Table 2).

Substrate Moisture Distribution After Irrigation. Following irrigation, regardless of irrigation treatment, gravimetric water content increased with increasing substrate depth (Fig. 1) which was expected due to the greater gravitational force acting on the top third than on the bottom third of the container (Bilderback and Fonteno, 1987, Spomer, 1990). Only the bottom third collected more water with intermittent irrigation compared to continuous. The likely reason that the bottom third collected more water (9%) is that the intermittent time intervals between irrigations allowed water to be adsorbed to less accessible micropore sites and absorbed into intra-particle sites

Table 1. Influence of continuous (single application) versus intermittent (three applications with 20-, 40-, or 60-min intervals between applications) irrigation on application efficiency

Irrigation treatment	Application efficiency (%)	Time averaged application rate (cm/h)
Continuous	85	1.40
20 min	87	0.73
40 min	89	0.50
60 min	91	0.38
Significance[z]		
Linear	***	-
Quadratic	NS	-
Cubic	NS	-

[z] NS,*** Nonsignificant or significant at P = 0 001, respectively, n = 42.

Table 2. Volume of water leached for intermittent and continuous irrigation as influenced by irrigation volume and substrate pre-irrigation moisture content (% of container capacity)

Volume applied (ml)	Volume leached (ml) Pre-irrigation moisture content (% CC) 73	80	87	94
		Intermittent		
125	0	0	0	75
250	0	0	57	149
375	0	34	125	223
		Continuous		
125	0	0	0	79
250	0	0	70	167
375	0	55	152	255

LITERATURE CITED

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