Improving Nutrient and Water Management in Nurseries

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INTRODUCTION

Inefficient irrigation practices have had a major influence on the development of container media and on fertiliser use in nurseries. In New South Wales (NSW) more than 80% of nurseries with automatic watering use overhead sprinklers (Doumit, 1991). Sprinklers have two main short comings. Firstly, they water an area of ground or bench regardless of whether plants are present. At plant spacings normally used in nurseries, just 20% to 30% of the bench or floor area is covered with pots (Rolfe et al., 1994). Consequently up to 80% of irrigation water either falls between pots or on unproductive ground such as roads or pathways. The second shortcoming is that sprinklers generally do not distribute water evenly over the production area. Large irrigation volumes are needed to ensure that pots in dry areas receive adequate water. In some commercial nurseries, there can be a 6 to 7 times difference in water applied between the driest and the wettest pot and the average rate of water application over the area can be 3 to 4 times what should be needed to replace water loss. This heavy water use promotes high rates of leaching and runoff.

With over-watering common in nurseries, it is not surprising that potting media have been developed which are free draining and well aerated. These characteristics reduce the risk of water logging and reinforce the need for over-watering. This is because media which drain readily must be watered more often than those which don't.

A survey of 13 NSW production nurseries has revealed that concentrations of nutrients in leachate tend to vary substantially both within and between nurseries (Table 1). The highest nutrient concentrations are found in leachate from recently potted plants and from propagation areas and the lowest in leachate from established plants which have not been fertilised for some time. Concentrations of nitrogen, phosphorus, iron, and manganese in leachate regularly exceed NSW water quality guidelines. Although environmental regulations generally target nitrate, the survey revealed that calcium, sulphur, and potassium are usually present at higher concentrations in leachate.

Monthly nutrient losses (Table 1) are high relative to the amounts normally applied as fertiliser. Given the leaching rates recorded in this survey, preplant applications of N, P, and K would last 11, 20, and 5 months, respectively. However, additional losses from plant uptake, N drawdown, volatilisation, and chemical fixation mean that deficiencies are likely. Huett (pers. com.) found that growth of several short-term ornamental plants receiving recommended rates of organic or inorganic fertilisers was around 50% of that obtained where nutrient supply was not affected by leaching. The major limiting nutrient in this experiment was nitrogen.

Leaching of fertilisers from pots is more severe in summer than in winter (Table 2). Heavier water use at this time (in Sydney around 60% more water in summer

Table 1. Leachate, dam water composition and seasonal effects on nutrient losses in Sydney nurseries.

Element	Mean conc. (mg $litre^{-1}$)	Leachate[z]	Dam water	Rate of loss g m^{-2} per month Summer	Winter
Calcium	64	(900)	16	180	38
Sulphur	61	(1712)	16	158	38
Potassium	60	(457)	9	113	29
Nitrogen (NO_3)	48	(776)	3	155	31
Sodium	36	(476)	26	72	19
Magnesium	26	(741)	8	58	16
Phosphorus	5	(152)	0.3	6	1
Iron	0.6	(7)	0.3	0.3	0.2
Zinc	0.3	(3)	0.01	0.5	<0.1
Manganese	0.2	(10)	0.08	2	<0.1
Copper	0.1	(1)	0.09	0.2	<0.1
Boron	0.1	(1)	0.05	0.4	<0.1

[z] Maximum recorded concentration in brackets.

Table 2. Monthly leaching losses of nutrients from nursery containers during summer and winter.

Element	Rate of loss (g m^{-3} per month) Summer[1]		Winter[2]	
Calcium	180	(186)	38	(35)
Sulphur	158	(136)	38	(31)
Nitrogen (NO_3)	155	(204)	31	(42)
Potassium	113	(92)	29	(27)
Sodium	72	(36)	19	(16)
Magnesium	58	(44)	16	(17)
Phosphorus	6	(8)	1	(2)
Manganese	2	(3)	<0.1	(<0.1)
Iron	0.8	(0.8)	0.2	(0.2)
Zinc	0.5	(0.4)	<0.1	(<0.1)
Boron	0.4	(0.3)	<0.1	(<0.1)
Copper	0.2	(0.2)	<0.1	(<0.1)

[1]Based on 10 estimates from data obtained in January and February from four Sydney nurseries.
[2]Based on 18 estimates from data obtained in August and September from four Sydney nurseries.
Note: Standard deviations from the mean are in brackets.

than in winter), accelerated release of nutrients from CRF (controlled release fertilisers) at high temperatures, and the higher incidence of freshly potted plants in the nursery in summer would also contribute to high leaching losses.

Nutrient losses are highest in the first 2 weeks after potting up. This initial flush of nutrients comes from basal fertiliser including damaged CRF prills and organic sources if used. Nutrients (particularly urea) incorporated during the production of wood-waste based media to overcome nitrogen drawdown are also subject to early leaching (Huett, pers. comm.).

This brief review of the current status of nutrient and water management in nurseries was intended to draw attention to two points. Firstly, that some irrigation and fertiliser practices which have wide acceptance in the industry are inherently inefficient, and secondly that these inefficiencies are both costly to the nursery and potentially damaging to the environment.

Four main areas of nutrient and water wastage can be identified in nursery systems: (1) delivery of water to pots, (2) retention of water in pots, (3)retention of nutrients in pots, and (4) the collection and reuse of waste water.

DELIVERY OF WATER TO POTS

More of the Irrigation Water Must Reach Pots, Less Must Fall in Unproductive Areas of the Nursery. Drip or subirrigation systems offer water savings of 75% or more over sprinklers (Neal and Henley, 1992).

The efficiency of overhead sprinkler systems can be increased by improving the uniformity of water application and increasing the density of pots within an irrigation bay. Sprinklers must be correctly spaced, matched with line pressures and properly maintained for optimum performance (Rolfe et al., 1994).

Losses from water falling between pots can be reduced by increasing pot density. Changing from a square to a triangular pattern allows closer spacing.

RETENTION OF WATER IN POTS

Less Water Must Drain from Pots After an Irrigation. Work by Biernbaum (1992) and in Australia by Huett (pers. comm.) has shown that a leaching fraction (LF) of 12% is sufficient to wash away salts without reducing plant growth.

However, Nelson (1990) reports that in the United States 40% to 50% leaching is normal and the author has found leaching fractions in excess of 80% in NSW. Clearly the potential for saving water in nurseries by minimising leaching is good.

This can be done by watering only when needed and keeping the length of the irrigation to a minimum. Watering programs controlled by clocks should be periodically reset to account for seasonal changes in crop water use. When irrigation is controlled by soil moisture instead of a clock, water savings of 75% to 90% are possible (Lieth and Burger, 1989). Ideally, pots should be watered when 60% to 70% of the available water in the medium has been used (Biernbaum, 1992). Moisture sensors have been used to detect this condition (Lieth and Burger, 1989; Groot, 1993) but weighing of pots is also effective. Irrigating according to need works best when plants with similar water needs are grouped together.

Nursery container media can differ greatly in their water-retention capabilities. In recent trials of wood waste and peat-based media some were found to retain as much as 80% of applied water, with 20% draining away to waste whereas others retained just 20%, with 80% lost in drainage. Naturally the ability of potting mix to rewet has a major impact on how long an irrigation cycle must be run. For example, to replace 100 ml of water lost through evapotranspiration from the most retentive medium would require 125 ml of irrigation water but would require 500 ml of irrigation water for the least retentive medium.

Clearly, water-efficient media are important in nurseries with overhead sprinkler irrigation. Efficiency can also be improved by:

- Avoiding media which are difficult to rewet or tend to shrink during drying (use a wetting agent).
- Using the lowest rate of water application possible. Somewhere between 10 and 20 mm h^{-1} is recommended. At higher rates, water drains through most media too quickly for efficient absorption to take place.
- Irrigating more often but for shorter periods ("pulse watering").
- Using mulch matting to encourage more even wetting of media and to reduce evaporation. Biernbaum et al. (1991) found that pot covers could reduce water use by 20% to 50%.

RETENTION OF NUTRIENTS IN POTS

Reducing the leaching fraction not only saves water but also means that less fertiliser is washed from pots in irrigation water. In turn, this means less nutrients in runoff water and better plant growth at lower fertiliser rates. Yelanich and Biernbaum (1990) found that poinsettias could be grown at 100 ppm N instead of 400 ppm N when the LF was reduced from 50% to 12%. This change in nutrient and water management gave a 10-fold reduction in fertiliser costs, a 40-fold reduction in N runoff with no reduction in plant growth rate or quality. Significant savings can also be expected when CRF are used (Huett pers. comm.).

Controlled-release fertilisers are less prone to leaching than other soluble fertilisers or liquid feeding. Uncoated inorganic fertilisers and organic fertilisers must be supplied in regular, small amounts to minimise leaching losses.

Wood-based media used in Australia have a CEC (cation exchange capacity) around 56 meq $litre^{-1}$ which is low compared with a clay soil (100 to 300 meq^{-1}). Minerals such as zeolite, vermiculite, and kaolite can be used to increase the CEC of growing media. Increasing CEC will stabilise pH and assist the retention of cations, including calcium, magnesium, potassium, and ammonium but not nitrogen which is normally supplied as nitrate, an anion.

COLLECTION AND REUSE OF WASTE WATER

Capturing runoff water for reuse benefits the nursery in three ways.

Minimises the Risk That Environmental Laws Will be Breached. The nutrient content of waste water will be diluted by fresh water draining into a dam from unproductive areas of the nursery including walkways, roads, carparks, and buildings. Nutrients will also be removed by chemical fixation and exchange with soil and by nutrient scavenging by weeds, turf, and trees. The extent of dilution and nutrient scrubbing that normally takes place can be appreciated from the difference in nutrient composition of leachate and nursery dam water (Table 1).

Reduces the Water Bill. Collection and recycling of runoff can bring considerable savings. In one large Sydney nursery the money spent on building dams and concrete drains as well as the equipment used to disinfect the captured water was recovered within 3.5 to 4 years from savings in excess water rates.

Reduces the Fertiliser Bill. With proper monitoring of water quality, nutrient contaminants in recycled water can be used to supplement the supply to plants, reducing the need for fertiliser.

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