Water Quality of Stored and Runoff Water in Plant Nurseries and Implications for Recycling

Elizabeth A. James
Institute for Horticultural Development (Agriculture Victoria), Private Bag 15, SE Mail Centre, VIC 3176

INTRODUCTION

This project was initiated by the Australian nursery industry and the Horticultural Research and Development Corporation in response to the increased impact of water use on available water resources and government strategies to reduce the environmental effects of water use and improve the quality of discharged wastewater. Its aim is to provide information and practical advice for Australian growers wishing to recycle excess water from the irrigation of nursery and cutflower crops.

Australia has a water quality management strategy which is developing a national approach to the environmental management of water use. It is important to consider the whole catchment when determining environmental management goals, and the emphasis of water management in Australia will become increasingly catchment-based. Legislation is currently enacted separately in each State and so regulations differ. In the future, it is hoped that the States will follow guidelines developed for a cohesive national approach to environmental management. The most recent government document,*Australian Water Quality Guidelines for Fresh and Marine Waters* (Australian and New Zealand Environment and Conservation Council, 1994) provides guidelines for States to follow in the development of policy.

Information is scarce on the quality requirements of stored water for use for irrigation, and also on the composition of irrigation run-off which may either leave a property or drain into stored water reserves which are subsequently used for irrigation.

In addition to being a further source of irrigation water, run-off water usually contains plant nutrients and can contain water-borne plant pathogens and chemical residues. In small concentrations, the nutrients can provide valuable input as fertiliser. However, high or uncontrolled concentrations of various dissolved substances can be damaging to plants. The acceptable levels of the various parameters for optimum plant growth depend on the particular crops grown and method of production, guidelines for irrigation water are given by Biernbaum (1993) and Aikman (1983). Individual management practices will enable growers to produce good quality crops with water which varies from the analyses therein. The composition of the water also affects the suitability of the water treatment methods which can be used to minimise the risk of spreading plant pathogens in irrigation water.

This paper describes the results of a water-quality survey conducted at nurseries and cutflower farms in Australia and discusses them in relation to plant production and disease control.

MATERIALS AND METHODS

Irrigation run-off water or stored water was sampled nine times over a year (March, April, June, August, October, November, December 1994, and January and February 1995) from a total of 29 properties in Queensland, New South Wales, Victoria, and South Australia, a total of approximately 250 samples per parameter. Samples were kept cold and transported to the State Chemistry Laboratories, Victoria, for analysis. Samples were analysed for the parameters listed in Table 1. Samples collected in December were also tested for ultraviolet transmission at 254 nm either unfiltered or filtered through 80, 45, 25, or 5 μm filters.

Table 1. Water quality parameters measured at nurseries and cut-flower properties participating in the water quality survey.

Parameters measured (mg litre^{-1} unless specified)	
Carbonate alkalinity pH 8.3 (mg $CaCO_3$ litre^{-1})	Colour (hazen)
Bicarbonate alkalinity pH 4.5 (mg $CaCO_3$ litre^{-1})	Electrical conductivity (dSm^{1})
Silicon dioxide	Total calcium
Chloride	Total magnesium
Fluoride	Total sodium
Nitrate	Total potassium
Phosphate	Total copper
Sulphate	Total zinc
pH (unit)	Total iron
Turbidity (NTU)	Total boron

RESULTS

Results are given for selected parameters only. Nitrate was detected at least once in all nurseries surveyed and in 74.8% of samples. In 46 samples (18.1%) the nitrate level exceeded 44 mg litre^{-1}. Phosphorus was detected in 20 nurseries and in 43% of samples. At five nurseries, concentrations of P exceeded 20 mg litre^{-1}. Iron was detected at all nursuries and in 69.8% of samples. Eight samples (3.1%) exceeded 1 mg litre^{-1} iron. The pH ranged from 7.0 to >9.0 with most samples above 7.5. Electrical conductivity ranged from 0.01 to 3.24 dS m^{-1} with 62% of nurseries with readings always below 0.8 dS m^{-1} (general safe limit). Of the remaining nurseries where readings exceeded 0.8 dS m^{-1} on at least one occasion, samples were equally likely to be from run-off water or from dam water. Ultraviolet transmission rates are shown in Table 2. Fluoride was detected in all but one of the nurseries sampled on at least one occasion. It was detected in 47% of samples and in 2.5% of samples the concentration exceeded 1 mg litre^{-1}. Copper was detected in four out of the 29 nurseries sampled and in 9.8% of all samples analysed. Copper concentrations were below 0.2 mg litre^{-1} in 19 out of the 27 samples containing copper with the remaining samples containing less than 0.4 mg litre^{-1} except for one sample of run-off water, the copper concentration was 6.32 mg litre^{-1}. Boron was detected in all nurseries sampled and in 51.2% of samples analysed. All samples contained less than 0.31 mg litre^{-1} boron except for one sample with 0.79 mg litre^{-1} boron. Potassium was detected at all nurseries and in 96.5% of samples. The concentration was below 45 mg $litre^{-1}$ in all cases except one where the potassium concentration was 133 mg $litre^{-1}$. Zinc was detected infrequently. It was rarely above 0.1 mg $litre^{-1}$ and never over 0.42 mg $litre^{-1}$.

Table 2. Percentage UV transmission (254 nm) of water samples before and after filtration.

Sample	Filter size (μm) unfiltered	80	45	25	5
Tap water	89				
Nursery:					
Mean %±sd	42.1 ± 21.7	42.3 ± 21.4	42.4 ± 21.3	43.0 ± 21.6	49.6 ± 19.8
Range %	6 - 87	7 - 87	8 - 86	7 - 87	10 - 89

DISCUSSION

Few nurseries had consistently high nutrient or other water quality factors which could be detrimental to plant growth, but many had peaks of various nutrients which could cause problems. These peaks and troughs will only be detected if monitoring is done on a regular basis over the year. Comprehensive monitoring will enable the identification of factors which are likely to vary. It may then be possible to monitor fewer parameters. The quality of run-off water is a combination of the quality of the source water plus the nutrients, organic particles, and acids which are picked up as the water passes through a container and over the drainage surface.

Nitrate levels greater than 44 mg $litre^{-1}$ (equivalent to 10 mg $litre^{-1}$ nitrogen in the form of nitrate) in run-off or dam water may not be a problem for plant production, but could contravene some state environmental legislation depending on the fate of the water. If water is to be treated with chlorine or ozone before its re-use, the presence of organic material, including nitrate, will increase the amount of chemical required before disinfection would occur. The use of a combination of chlorine and bromine or chlorine dioxide is advisable where the amount of nitrogenous matter may be high. The compounds formed from the reaction of bromine and nitrogen, bromamines, are effective biocides, whereas those formed with chlorine, the chloramines, are only weak biocides (de Hayr et. al., 1994). Chlorine dioxide acts directly as a biocide and is less sensitive to nitrogen levels (Armitage, 1993). The use of chlorine gas is subject to strict occupational health and safety regulations and the use of liquid chlorine compounds (sodium hypochlorite) is preferable.

Phosphorus levels below 30 mg $litre^{-1}$ are generally considered to be safe for irrigation, however, phosphorus levels above 10 mg $litre^{-1}$ may cause toxicity in sensitive plants such as some members of the families Proteaceae and Mimosaceae. Elevated phosphorus and nitrogen levels in dam water can result in algal blooms causing blockages to irrigation equipment (Rolfe et. al., 1994).

Readings of pH were 8.0 or above in 79.3% of nurseries at least once over the sampling period. The use of liquid chlorine to disinfect water will be ineffective unless the pH can be reduced to pH 7.5 or below. Acidification is an option. Alternatively, a combination of chlorine and bromine or chlorine dioxide could be used, as they are effective biocides at more alkaline pH.

The use of ultraviolet (UV) light for water disinfection requires that the UV can penetrate the water sample as it passes the UV lamp. Pathogens are irradiated directly by the UV beam and cannot replicate. The transmission of UV light through water depends on the presence of UV-absorbing compounds such as iron and organic acids, colloids and particulate matter. Although UV disinfection systems can be designed for water with very poor transmission rates, the costs become uneconomical. Filtration of samples through 5 μm filters did not greatly improve the UV transmission of a wide range of samples (Table 2). If 50% UV transmission is taken to be the lowest rate for economic reasons, then only 44.8% of nurseries sampled in December could consider UV disinfection as an option without specialised pre-treatment.

Fluoride levels of 1 mg litre^{-1} have been shown to cause damage to cutflowers (Tija et. al., 1987) but container-grown stock are less sensitive (Conover and Poole, 1982). The levels measured in the water samples are unlikely to cause damage.

Boron, potassium, and zinc were not detected at high enough levels to cause damage.

Monitoring must be an integral part of production management because the levels of various compounds can differ significantly at the same nursery at different times. A good understanding of the water composition is essential if water is to be re-used. Changes to production protocols may be required to reduce the levels of nutrients and physical quality indicators in water to ensure that disinfection systems in place for pathogen control are effective and that nutrient imbalances are minimised.

Acknowledgements. I would like to thank the nursery managers and cut-flower growers who participated in the water survey and to David Beardsell, Keith Bodman, and Michelle Bankier who helped with the collection of water samples for the survey and staff at the State Chemistry Laboratories for analysing the samples. Martin Mebalds has been working on the pathology aspects of the project.

This project was funded by the Horticultural Research and Development Corporation, the Nursery Industry Association of Australia and the Flower Growers Group of the Victorian Farmers Federation.

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