

Managing Salinity, Nutrients and Pathogens In Recycling and High Efficiency Irrigation Systems

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Recycling irrigation water in nursery and greenhouse production systems is a means of more efficiently using water and nutrient and reducing or eliminating runoff. In any recycling system special consideration must be given to water quality issues. The following constituents in water need to be considered when designing and operating a closed production system:

- Floating debris
- Sand and silt
- Colloidal matter (clay & organic)
- Herbicides
- Other pesticides/growth regulators
- Fungi/bacteria
- Nematodes
- Algae
- pH/alkalinity
- Salts
- Nutrients

This paper outlines management strategies for dealing with salinity and nutrients in several types of reduced runoff and closed production systems.

Whole Nursery Recycling

This system uses conventional irrigation practices (overhead or drip) but captures, treats and recycles runoff within the boundaries of the production facility. Water treatments may involve sedimentation, flocculation/coagulation, filtration, disinfection, blending, and pH adjustment. Fertilization is carried out by means of constant liquid feed, use of controlled release fertilizer (CRF) or a combination of the two. This type of system does not address nutrient leaching to groundwater unless the floor or soil is rendered impervious to water or irrigation efficiency is improved.

Salinity management strategies include, blending recycled and fresh water, grouping plants by relative salt-tolerance, selection of appropriate fertilizer materials and rates and irrigation management.

Salinity runoff will increase with each irrigation cycle. However, if the runoff is reblended with fresh water of lower conductivity the salinity level increases at a slower rate and will reach an equilibrium, often within 6 - 10 cycles. The conductivity at equilibrium is dependent on conductivity of the incoming water; the percentage of makeup water and the percentage increase in salinity per cycle. For example if the fresh water has a conductivity of 0.8 dS/M, the blend consists of 50% runoff and 50% fresh water and the salinity increases 15% per cycle then the salinity will theoretically stabilize at approximately .94 dS/M. The actual blend percentage in the

nursery is often dictated by water storage and use considerations. The percentage increase in salinity per cycle depends on evaporation rate, leaching fraction and degree of salt loading from soil mix components and fertilizer applications. Typical salinity increases per cycle are 7-15 %. Problems associated with salinity are often seasonal with the potential for injury highest in late summer/early fall and lowest during the rainy season.

Salinity is monitored by determining conductivity of collected runoff and of the blended supply. In liquid feed programs appropriate fertilizers are added either to achieve a target EC or ppm nutrient. Since nutrients often account for a significant portion of the salinity it is important to regularly analyze the recycled water for nutrient content. Specific-ion electrodes can be used at the nursery to determine nitrate and potassium levels. Adjustment of pH can be accomplished by mineral acid, or ammonium or potassium hydroxide addition. Liquid feed nutrient levels are usually maintained at levels similar to conventional nurseries but there is on average a 50% reduction in fertilizer cost due to recycling.

Specific ion toxicity can be of concern. Sodium and chloride, which are marginally high in some municipal and well supplies, become increasingly troublesome above 3 meq/l. Use of chlorine for disinfection and muriate of potash for potassium fertilization can accelerate the build up of chloride. Use of composted wastes or manure in soil mixes can contribute sodium and chloride in addition to nutrients. Reclaimed water can have elevated levels of sodium and chloride. Boron can also be elevated in incoming water and should ideally be kept below 0.6 ppm.

Plants exhibit a wide range of tolerance to salinity and specific ions. Growers take advantage of this by grouping plant material in the nursery according to relative salt tolerance. Sensitive plants including liners, azaleas, camellias, ferns and many deciduous plants are located in a portion of the nursery which does not utilize recycled water. Annual color or herbaceous crops along with many common ornamentals have a moderate level of salt tolerance once established and can be grown with water of moderate salinity. Some crops are very salt tolerant and can be irrigated with non-blended runoff. Where sodium and chloride toxicity is of concern, development of leaf burn can be minimized by utilizing drip-irrigation or by irrigating at night to reduce foliar deposition of salts.

Salinity and nutrient levels should be routinely monitored in container soils. Large nurseries often have an in-house program of routine sampling and analysis for E_c and occasionally for pH and extractable nitrate and potassium. Samples should periodically be sent to a reputable laboratory to carry out more complete nutrient and soluble salt analysis and to check the accuracy of in-house determinations. Leaf analysis can also be used as a tool to monitor nutrient and specific ion status.

The potential spread of disease in recirculating water is a concern. The level of water treatment required to reduce the potential for disease outbreaks depends on many factors including plant susceptibility, pathogen concentrations, cultural practices and environmental conditions. Plants vary widely in susceptibility to water born pathogens. Plants can be grouped in the nursery/greenhouse by susceptibility with untreated recycled water used only on plants that have a low degree of susceptibility. Pathogen concentrations can be evaluated by various water baiting techniques and by routine crop scouting. Prompt removal of infected plants can reduce

the number of pathogen propagules released into the system. *Phytophthora* and *Pythium* are the most common pathogens of concern although other fungi, bacteria, virus and nematode pathogens have been reported in recirculating systems.

A number of nurseries/greenhouse operations in Southern California successfully recirculate water without disinfection treatment. In most cases losses due to disease have been minimal. Most nurseries will not use recycled water in propagation and will use non-recycled water on plants that are highly susceptible to water born fungi.

Levels of plant pathogens in recycled water can be reduced by water retention and dilution. Sand filters can further reduce the number of fungal spores and nematodes. More stringent methods of disinfection include microfiltration, chlorination, ozone treatment, ultraviolet light treatment, heat treatment and slow sand filters. Each of these methods has advantages and disadvantages and all require careful management to achieve the desired results.

Recirculating Subirrigation Systems

Ebb and flow floors or trays and trough cultures are examples of recirculating subirrigation systems. Due to high capital costs these systems are best suited for intensive greenhouse production.

Soluble salt accumulation in the soil media can be a problem in subirrigation systems. The nutrient solution moves into the container by capillary action and little leaching is accomplished. Nutrients and other soluble salts migrate to the top of the container and often accumulate to high levels in the surface one-third of the container depth. Although the conductivity in the top layer may greatly exceed the recommended EC of the growing media, it may not be damaging because there are few active roots in this zone. Soil sampling to determine nutrient status should avoid the surface layer or this layer should be sampled separately. Overhead drench applications or top irrigation by the retail store or consumer can move soluble salts into the active root zone.

Subirrigation systems require reasonably good quality water to avoid salt problems. Many European growers and North American growers in higher rainfall areas will collect rainwater to use as low salinity makeup water. In areas of low rainfall and poor quality water, reverse osmosis or deionization of water may be required to control salinity. With RO systems it is best to remove salts from the fresh water source instead of attempting to process the recycled water. With RO systems there is the potential problem of brine discharge.

Research and experience has demonstrated that subirrigated crops should be grown with nutrient solutions containing 30 to 50% less fertilizer than used in conventional top irrigated systems. Optimum soil test levels are lower in subirrigation systems. Conventional nutrient ratios are in most cases appropriate.

As makeup water is added to holding sumps fertilizer is injected usually to a preset conductivity. The pH is often monitored with an in-line meter and automatically corrected using phosphoric, sulfuric, urea/sulfuric or nitric acid or potassium hydroxide. The nutrient solution should be periodically analyzed for nutrient composition.

The incidence of foliar diseases in subirrigation systems is usually lower than found when overhead irrigation is employed. Because these systems are often used for high value crops or in monoculture, stringent disinfection techniques are often used for disease control if the water is recycled .

High Efficiency Irrigation Systems

Irrigation by means of overhead sprinklers can be an extremely inefficient means of delivering water and nutrients to containerized crops. Drip micro-spray technologies are being used on increasing smaller container sizes in both nurseries and greenhouses. Capillary mat systems are used with or without recycling. Intensive use of these systems can significantly reduce runoff. El Modena Gardens in Irvine uses a combination of extensive drip irrigation and capillary mats along with computerized irrigation controllers to minimize water and nutrient runoff. Capillary mat production possess the same salinity and nutrient concern as other subirrigated systems and can be managed in a similar matter with reduced nutrient input as compared to a top irrigated crop. As irrigation uniformity improves in drip systems it will be possible to apply only the amount of water required to meet evapotranspiration and leaching requirements. With a reduced leaching fraction, lower nutrient inputs are required. This is particularly true of nitrogen fertilization where it has been demonstrated that crops grown with a low leaching fraction can be adequately fertilized at one half recommended CRF or liquid feed rates. It should be noted that many of these studies were carried out with incoming water of excellent initial quality. If similar low leaching fractions are attempted with waters of moderate or high salt levels, significant buildup of sodium and other salt constituents can occur. Pulse irrigation and use of wetting agents can reduce channeling of water in containers and can result in more effective leaching. Keeping the soil moisture level high can reduce the concentration of salts in soil solution that occurs during drying. Monitoring media EC and nutrients becomes more critical with the use of high efficiency irrigation systems.

Comments

Whole nursery recycling, subirrigation and high-efficiency irrigation have all been successfully used by nurseries and greenhouses in Southern California to reduce water and nutrient runoff. Each system involves careful attention to water quality, nutrient and pathogen management.

For those producers not ready to make the jump to a closed production system there are a number of management practices available to reduce water and nutrient runoff. A list of best management practices follows.

Nursery Water and Nutrient Management Best Management Practices Checklist

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Water Management

Determine water and nutrient runoff levels

Use Whole Nursery Recycling

Use Recirculating Subirrigation Systems

Ebb and Flow trays, benches or floors

Trough Systems

Capillary Mats with return

Improve irrigation efficiency and uniformity

Properly engineer and maintain overhead systems

Replace worn heads

Use proper pressure and head sizes

Install pressure regulating control valves

Use same types of heads and emitters on a single valve

Hire an irrigation consultant to evaluate system

Conduct can tests/ water audits

Convert to drip or other low volume emitter

Use anti-drain emitter and check valves

Correctly position spray stakes to avoid overspray

Install valves on each sprinkler/block so that only planted areas are irrigated

Use catch trays

Improve pressure uniformity by shortening runs or manifolding in middle of block or bench

Group plants by

container size

age

water requirements

nutrient requirements

salt tolerance

Fill and pack containers uniformly

Use correct container spacing

Consolidate plants and shut off sprinklers or emitters in unused sections

Evaluate soil physical properties to maximize water-holding capacity while maintaining adequate aeration

Use wetting agents to reduce channeling and rewetting problems

Use tensiometers with or without computer control

Use pulse irrigation

Use computer controlled solenoids

Use CIMIS or other ET data to determine crop water requirements

Repair leaking valves, faucets

Train and supervise irrigators

How to evaluate soil moisture and the need for irrigation

How long to apply water to rewet and accomplish any required leaching
To quickly replace or repair damaged, clogged, out-of-place irrigation equipment
Evaluate leaching fraction requirement (In a uniform system it is probably lower than you think). Evaluate maximum allowable soil EC for a given crop.
Use tail-water to irrigate perimeter landscapes

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Nutrient Management

Test runoff for nutrients / pesticides (routinely)
Use Constructed wetlands or vegetative filter
Use microbial denitrification or other form of nitrate removal
Test runoff for nutrients / pesticides (routinely)
Test irrigation water to determine:
 Suitability for irrigation
 Leaching requirement
 Natural Nutrient inputs
 Acid or special nutrient needs (i.e., sulfur, magnesium, boron)
 Potential for small orifice clogging (carbonates, iron, manganese)
Use dual or triple lines in liquid feed programs (clear, low and high feed)
Calibrate injector pumps
Test line water for nutrient levels
 Complete tests at a qualified laboratory
 In-house nitrate, phosphorus, potassium
Design and adjust liquid feed nutrient programs based on
 Soil properties
 Existing nutrient levels in well, reclaimed or recycled water
 Routine soil and or plant analysis
 Individual crop requirements
 Stage of growth (reduced input at flowering for many floral crops)
 Environmental conditions
 Irrigation method (reduce input in high-efficiency, minimal leaching regimes)
Reevaluate use of high phosphorus blends
Use multiple tank systems to independently adjust nitrogen and other nutrients
Avoid precipitation/solubility problems in concentrate tanks
Use a conductivity meter
 To detect changes in water quality
 To avoid catastrophic fertilizer application
 To monitor injector efficiency
 To monitor and determine recycled water blends
 To do in-house pour-through, saturation extract or squeeze method soil salinity testing
Use clear water irrigations for salt management

Calibrate fertilizer hoppers and spreaders
Store fertilizers correctly
Analyze soil mix components
 Nutrient levels, pH, salinity, particle size, C/N ratio
Avoid rapidly decomposable wood residuals with high nitrogen demand (i.e. pine and hardwood sawdust)
Use nutrient rich composts (greenwaste, manure, biosolids, dump soils) in correct proportions
Check soil mixing process to ensure uniform blending of bulk ingredients and fertilizer
Adjust soil mix nutrient and lime additions based on soil test results and recommendations

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Use controlled release fertilizer (CRF) alone or in combination with liquid feed

Plant into soil blends containing CRF shortly after mixing to avoid early nutrient release

Locate soil mixing areas away from surface runoff

Check to make sure that CRF is not damaged during transit, storage or soil mixing

Make sure topdressed fertilizer lands in and stays in container

Test nutrient release of CRF through plant and/or soil analysis

Keep accurate planting date and soil mix records to determine most likely dates to reapply CRF

Adjust CRF rates and formulation depending on

 Soil mix properties

 Individual crop nutrient needs

 Desired rate and duration of release

 Environmental conditions (expected temperatures)

 Irrigation method

 Other nutrient inputs

Apply foliar nutrients (appropriately timed, without runoff, on responsive crops)

Install and maintain backflow preventers

Seek advice from Farm Advisors, Certified Crop Advisors

Read Nursery BMP Manuals available from universities and Cooperative Extension

Solicit ideas from all nursery staff

Stay informed!