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Groundwater and Nitrogen Management in Willamette Valley Mint Production

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Field measurements of mint grown in the Willamette Valley show that significant amounts of nitrogen (N) are lost to groundwater, resulting in an economic loss to the growers and contributing to degradation of water quality in the underlying aquifers. We suggest two ways to counter this situation:

- Reduce nutrient application by using stem testing
- Reduce nitrogen percolation by improving irrigation management

Stem testing is economical and a proven way to identify sufficient nitrogen supply. Growers making split applications of nitrogen can use this test to decide when additional nitrogen is needed. Overirrigation and poor uniformity of irrigation leach nitrate from the root zone, which in turn prompts the grower to apply more nitrogen. The two key issues in improving irrigation management are irrigation scheduling and system maintenance.

Is Nitrogen Being Lost under Willamette Valley Fields?

Directly below commercial mint fields, percolation in excess of 10 ppm of nitrogen as nitrate (NO_3^--N), the EPA drinking water standard, occurs for much of the year (Figure 1, page 2). Concentrations rise rapidly after irrigation starts in June, indicating that this nitrogen is being pushed through by irrigation water. On average, the groundwater received 100 lb of nitrogen per acre over the 5 years of this study (Feaga and Selker, 2004).

Annual N application of 200 to 225 lb/acre is recommended for mint in western Oregon. Increasing application rates beyond these levels—for example, from 225 lb/acre to 320 lb/acre—does **not** increase mint oil yield (Christensen et al., 2003). Fertilizer should be applied at about 30 lb/acre after harvest to stimulate roots and at 40 lb/acre after spring flaming; the remaining 130 lb/acre should be applied when the postflame crop is growing in June (Jackson et al., 2000). It is especially important to avoid adding excessive nitrogen late in the season. Not only is the risk greater then that nitrogen will leach to groundwater, but the additional N may reduce crop quality (Sullivan et al., 1999).

Stem NO_3^- Tests for Peppermint

When using fertigation or split applications, a stem tissue NO_3^- test is a powerful nitrogen-management tool. Developed over the last 30 years, the test uses a relationship between oil yields and NO_3^- concentration in the mint stem. Stem samples are taken throughout the period of fastest growth to ensure that NO_3^- concentrations in the mint stem do not fall below the critical values shown in Figure 2 (page 2). If the nitrate values are below the critical value, more nitrogen should be applied; if above the critical value, the nitrogen is sufficient. Stems can be tested on a schedule (for example, every 2 weeks) because stem

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nitrate concentrations do not change greatly with the intensity of sun or the time since the last irrigation, and they change only gradually since the last fertigation (Smesrud and Selker, 1998). A sample should comprise stems from at least 30 plants (Brown, 1983). For a list of local laboratories that can analyze samples, see Hart (2002). An analysis costs from about $6 to $10.

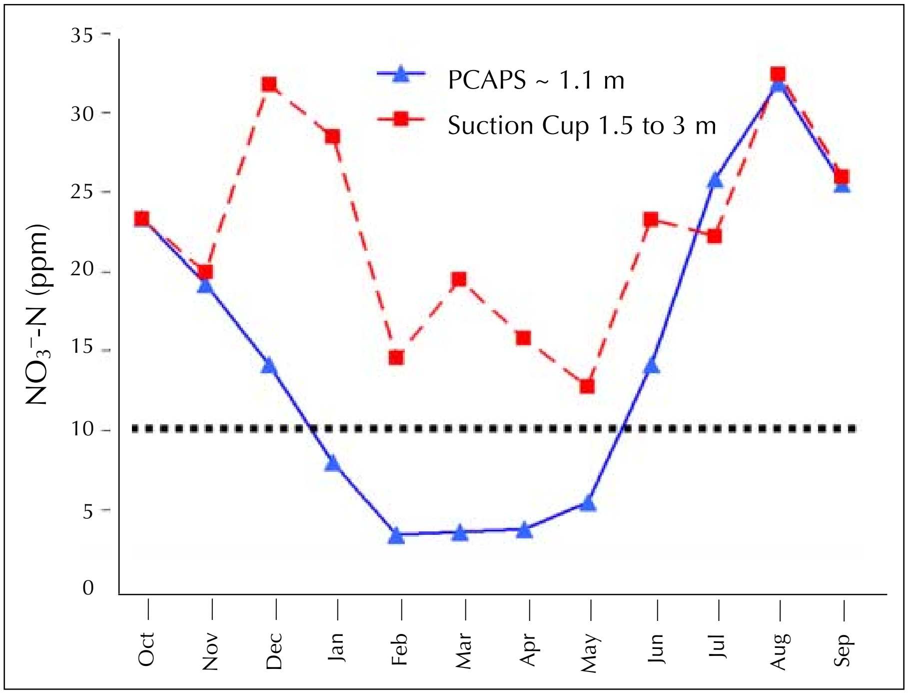

Figure 1. *Measured monthly average NO_3^--N (nitrogen as nitrate) concentrations below seven Lane County mint fields during the 5-year study period. Concentrations were measured by passive capillary samplers (PCAPS) as well as by suction cup samplers. The dotted line indicates the EPA drinking water standard of 10 ppm NO_3^--N (from Feaga and Selker, 2004).*

Irrigating Mint

Mint is sensitive to water stress, so adequate irrigation is essential throughout the growing season (Smesrud et al., 2000). Since nitrate is water soluble, excess irrigation moves the nitrate out of the root zone, leading to inadequate plant-available nitrogen. Thus it is critical to carefully control irrigation to obtain high yields and reduce nitrogen losses.

The first step to successful irrigation is to know how much water should be applied. The amount changes throughout the season. Since most mint in Oregon grows under sprinklers, the two questions are how often to irrigate (how many days between irrigations) and how many hours to run each sprinkler set.

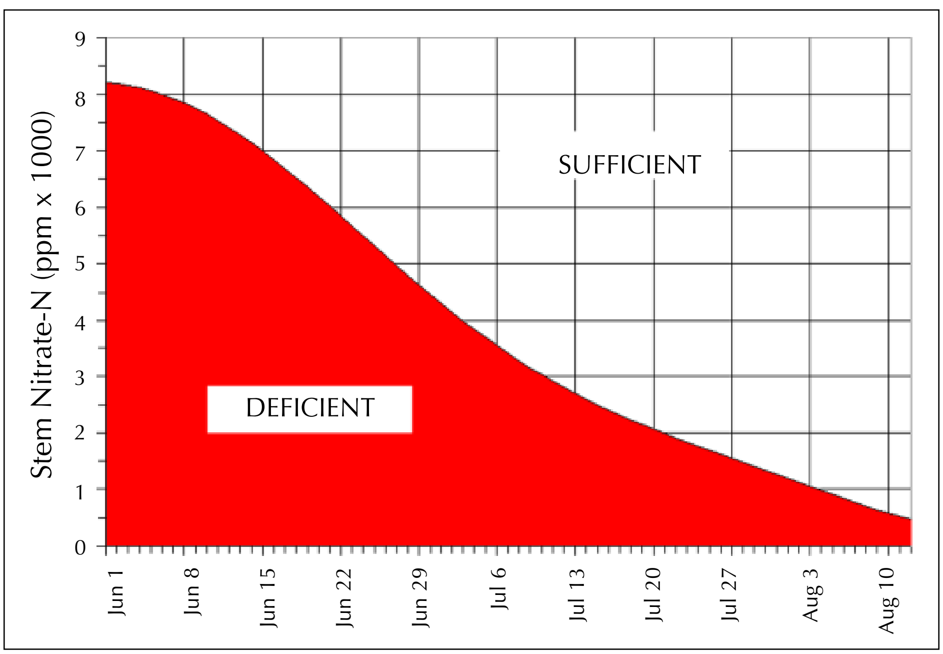

Figure 2. *Critical values for mint stem nitrate to determine adequacy of nitrogen (adapted from Brown, 1983).*

Irrigation frequency is dictated by the soil's ability to hold water. Soil full of water is like a giant sponge: adding more water leads only to loss of water as deep percolation or runoff. Given a silt–loam soil, a 24-inch rooting depth, and mint's inability to tolerate dry conditions, the soil profile would hold 4.8 inches of plant-available water. Under these conditions, you **never** would apply more than this amount of water. Typically, because the soil holds some residual plant-available water before irrigation, you would **need to apply less** than this amount to avoid leaching losses. To estimate the correct irrigation amount and to select an irrigation schedule based on your specific conditions and irrigation system, see the "Western Oregon Irrigation Guides" (Smesrud et al., 2000).

A good first step in irrigation scheduling is to base your calculations on average evapotranspiration rates for peppermint. However, the required irrigation depth is better estimated using actual meteorological observations of evapotranspiration since the last irrigation.

In Oregon, the AgriMet Program of the U.S. Bureau of Reclamation (http://www.usbr.gov/pn/agrimet/graphs.html) provides up-to-date regional observations of what is called the "reference" evapotranspiration. These observations are multiplied by a crop coefficient to arrive at an amount of evapotranspiration specific to mint. The crop coefficient for mint varies from 0.16 to 0.95 and depends on the plant's growth stage (Figure 3). The amount of water you need to replace in the soil is simply the total of every day's evapotranspiration since the previous irrigation. For example, if the daily reference evapotranspiration for the previous 7 days totalled 2.27 inches, and the mint was at 50 percent of its growth stage, you would multiply 2.27 inches by 0.54 (the crop coefficient from Figure 3) to arrive at 1.2 inches of mint evapotranspiration. (If using the "Western Oregon Irrigation Guides," this amount replaces the factor *i**j* in Step 3 of the irrigation schedule worksheet.)

For selected crops and locations, the AgriMet Web site already lists the reference evapotranspiration multiplied by the crop coefficient and calls it "crop water use" (http://www.usbr.gov/pn/agrimet/or_charts.htm).

Even if you irrigate at the right frequency and duration, if your system applies water unevenly, crop yield will be diminished by nitrogen loss where application is too heavy and by drought stress where the water application is too light.

Key ideas in maintaining an efficient irrigation system are:

- **Operating pressure**—Each system has an acceptable range of operating pressures. Deviation from this range leads to poor uniformity of application.
- **Nozzles**—Ensure that nozzles are a consistent make and diameter and are not worn. Periodically (about every 4 years) replace all the nozzles to maintain uniform application.

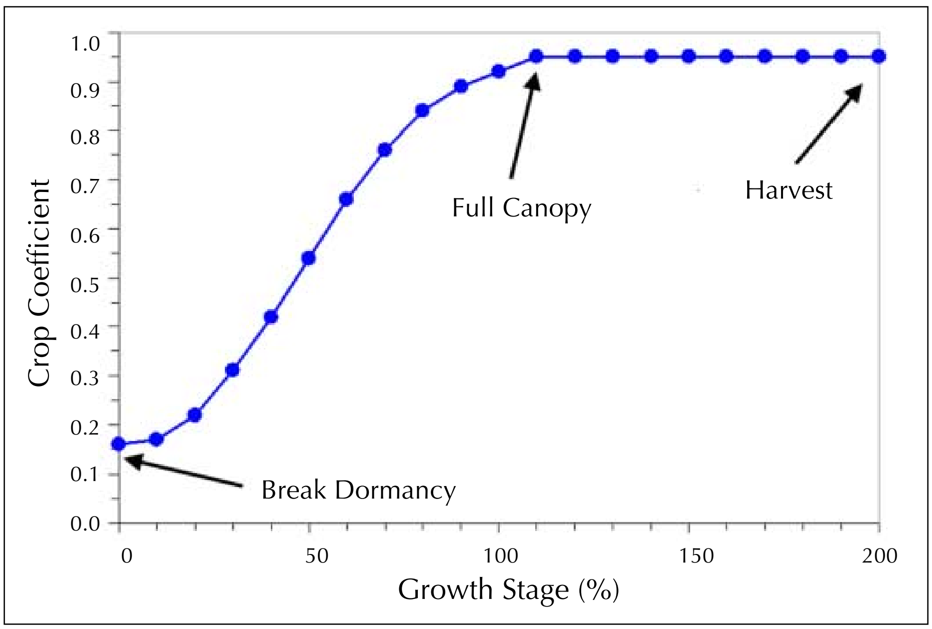

Figure 3. *Crop coefficient for peppermint (from AgriMet, USBR).*

Additional Resources

Stem NO_3^- Testing

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