From Forest Nursery Notes, Winter 2012

67. © Application of the "4R" nutrient stewardship concept to horticultural crops: getting nutrients in the "right" place. Bryla, D. R. HortTechnology 21(6):674-682. 2011.

Application of the "4R" Nutrient Stewardship Concept to Horticultural Crops: Getting Nutrients in the "Right" Place

David R. Bryla[1]

ADDITIONAL INDEX WORDS. **fertilizer management, plant nutrient uptake, nutrient use efficiency, root development, soil nutrient availability**

SUMMARY. **Right fertilizer placement is one of the 4Rs of an effective nutrient stewardship system and should be combined with considerations for the right fertilizer source, rate, and timing. Fertilizer placement decisions depend on mobility of applied nutrients in the soil and the depth and distribution of the crop's root system. Various methods are used to apply fertilizers to horticultural crops, including broadcasting, banding, fertigation, foliar application, and microinjection. Generally, the most appropriate method for any crop increases productivity and profitability and improves fertilizer use efficiency but varies depending on the nutrient element, fertilizer source, soil characteristics, cultural practices, stage of crop development, weather conditions, and farming enterprise constraints. Comparisons among application methods are available for many crops and provide useful information for improving fertilizer placement practices, but many practical questions such as how fertilizer source and availability are affected by irrigation interactions or whether there are ways to manage crop roots for more effective nutrient uptake still remain.**

The 4R nutrient stewardship concept was introduced by Bruulsema et al. (2009) to define the right source, rate, time, and place to apply fertilizers to produce not only the most economical outcome in any given crop but also to provide desirable social and environmental benefits essential to sustainable agriculture. The concept was structured around agronomic crops, including corn (*Zea mays*), soybean (*Glycine max*), and wheat (*Triticum aestivum*), but the principals are easily adaptable to other cropping systems. In this article, the utility of the concept is illustrated to discuss the importance of "right" fertilizer placement in horticulture.

Proper fertilizer placement is an integral part of effective and appropriate crop nutrient management. It is basically defined as applying the fertilizer to a location in the soil that maximize plant nutrient uptake and minimize soil nutrient losses (because of leaching, volatilization, and runoff as well as immobilization associated with soil chemical and microbiological processes). Considerations include movement and availability of soil nutrients, size and distribution of the crop's root system, and the method of fertilizer application. Fertilizers placed correctly ensure that nutrients are readily available for plant uptake during peak and critical crop demand periods and reduce any potential losses that may result in negative economic and environmental consequences. This article will address fertilizer placement according to common and basic factors, recognizing that final placement decisions are site and situation specific.

Factors affecting fertilizer placement

SOIL NUTRIENT MOVEMENT AND AVAILABILITY. Soil nutrients move to plant roots by a combination of mass flow and diffusion (Barber, 1995). Mass flow occurs when dissolved nutrients are transported to the root surface by convective water movement driven by evapotranspiration and percolation and subsurface flow of water following rain or irrigation. Diffusion, on the other hand, is a result of concentration gradients created when the uptake rate of ions exceed the supply by mass flow. In general, mass flow generally occurs over much longer distances than diffusion. The relative contribution of each process to nutrient movement depends on soil type and conditions, plant species (because of differences in water use and nutrient uptake), and the chemical characteristics of the particular nutrient. In many arable soils, most of the nitrogen (N) in nitrate form (NO_3-N), calcium (Ca), magnesium (Mg), sulfur (S), copper (Cu), boron (B), and manganese (Mn) move to the roots by mass flow, whereas ammonium-nitrogen (NH_4-N), phosphorus (P), potassium (K), iron (Fe), zinc (Zn), and molybdenum (Mo) move largely by diffusion; however, any nutrient may move primarily by diffusion when deficient, and most can move by mass flow when adequately supplied and soil sorption of the nutrient is limited.

Numerous studies have noted the importance of nutrient movement associated with placement of P fertilizer. In most soils, P moves almost entirely by diffusion, especially under cooler conditions, advancing only a few centimeters over several months. Soluble P, whether derived from fertilizer or natural weathering, reacts with clay, Ca, Fe, and aluminum (Al) compounds in the soil and is converted readily to less available forms by soil P fixation. In general, fine-textured soils such as clay loams have a greater P-fixing capacity than sandy, coarse-textured soils (Harris et al., 1996). Potassium is also attracted to the surface of clay minerals, where it may be firmly bound or fixed between the clay layers in a form slowly available to plants. The actual amount of P and K available depends on the type and

Horticultural Crops Research Unit, Agricultural Research Service, U.S. Department of Agriculture, Corvallis, OR 97330

This paper was part of the workshop "Examining the 4R Concept of Nutrient Management: Right Source, Right Rate, Right Time, Right Place" held on 4 Aug. 2010 at the ASHS Conference, Palm Desert, CA, sponsored by the Plant Nutrient Management (PNM) Working Group.

[1]Corresponding author. E-mail: david.bryla@ars.usda.gov.

Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
0.4047	acre(s)	ha	2.4711
0.3048	ft	m	3.2808
3.7854	gal	L	0.2642
2.54	inch(es)	cm	0.3937
1.1209	lb/acre	$kg{\cdot}ha^{-1}$	0.8922