

FALL NUTRIENT SPRAYS IN TREE FRUIT



Introduction

Carbon (C), oxygen (O), and hydrogen (H), taken up in the form of carbon dioxide (CO₂) and water (H₂O), are the most important nutrients for tree fruit growth and development, representing more than 95 percent of the tree dry matter (Marschner 2002). The rest of the nutrients represent the other five percent, and their uptake occurs mainly through the roots, between bloom and the rapid vegetative growth phase. In most perennial tree fruit, initial spring growth and early fruit development rely on reserves accumulated the previous season (Weinbaum et al. 1984). Thus, fall nutrient management strategies have had positive effects on building those reserves in apples (Nielsen et al. 1996) and cherries (Lang 2005). However, the effectiveness of fall sprays will depend on the overall tree health, deficiency level, and demand. This publication presents some considerations to decide whether fall sprays are needed.

In tree fruit and other plants, macronutrients such as nitrogen (N), potassium (K), phosphorus (P), calcium (Ca), magnesium (Mg), and sulfur (S) are required in much larger amounts than micronutrients (Table 1). In most intensive cropping systems, the demand for macronutrients can surpass soil availability (or

soil supply), requiring nutrient correction or maintenance. For example, potassium (K) demand in a ‘Gala’ orchard can be 400 times the demand for boron (B) (calculated from Cheng and Raba, 2009). Nutrient uptake is most effective through plant roots; thus, soil application is preferred under adequate growing conditions (healthy roots, soil pH between 5.5 and 7.5, well-drained soil, moderate soil temperatures, among other factors).

Micronutrient uptake can be affected by root growth-limiting factors, including anoxia, parasitic nematodes, diseases, alkaline soils (pH above 7.5), and low soil temperatures, where zinc (Zn), copper (Cu), manganese (Mn), iron (Fe), and boron (B) are precipitated and unavailable. Given that micronutrients are required in small quantities (parts per million), they can effectively be managed with foliar sprays, especially when there are some underground limitations (Fernandez et al. 2013). Micronutrients required early in the season, before root uptake starts, can effectively be managed with delayed dormant sprays, especially in areas with low soil temperatures. Keeping adequate levels of micronutrients in the soil will benefit root growth and tree health.

Table 1. Ranges of nutrient concentration (% dry weight) in tree fruit.

Element	Percent (% d.w.)
Carbon (C)	40–50
Oxygen (O)	42–44
Hydrogen (H)	6–7
Nitrogen (N)	1–3
Phosphorus (P)	0.1–0.3
Potassium (K)	1.5–3.0
Calcium (Ca)	1.5–2.5
Magnesium (Mg)	0.35–0.6
Iron (Fe)	0.008–0.02
Other micronutrients	< 0.01

Source: Adapted from Silva and Rodríguez (1995) and Faust (1989).



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Fall nutrient sprays can be utilized for different purposes: to ensure adequate reserves for the following season (Johnson et al. 2001; Dong et al. 2002), to manage vigor and return bloom or for disease control (Beresford et al. 2015; Burchill 1968; Carreño and Pinto de Torres 1982). However, before making a decision, it is important to define your needs and management goals. In the following sections, a few examples and considerations are provided for deciding if N, Zn, and B fall sprays are needed.

Nitrogen (N)

Nitrogen is required in large quantities for tree fruit production systems and is a highly mobile nutrient in the plant and in soils (Table 2). In plants, N is a component of many compounds, such as chlorophyll, amino acids, proteins, and nucleic acids, and is also part of many metabolic processes.

The wide range in N demand reflects the variability of N use in trees that is dependent on cultivar, rootstock, tree density, vigor, tree shoot to fruit balance, among others (Cheng 2010). For example, ‘Gala’ on M26 rootstock demands 2.6 lb of N per ton of fruit (calculated from Cheng and Raba, 2009), while preliminary data on the ‘Cosmic Crisp’ apple has shown a demand of 1.2–1.4 lb of N per ton of fruit over M.9 and G.41, respectively, in a three-year study developed by Sallato (unpublished data). Thus, the importance of determining N demand needs to be addressed for specific cultivars, regions, and even individual orchard blocks.

During the fall, N within the plant is mobilized and translocated to the roots where it remains stored until the following season (Nielsen and Nielsen 2003; Cheng et al. 2002; Dong et al. 2001; Dong et al. 2005; Ouzounis and Lang 2011). In perennial trees, N and carbohydrate reserves are the main source of energy and nutrients for initial growth and early fruit development. This is particularly important in species where pollination and fertilization occur before leaves are fully expanded, such as cherries, apricots, peaches, nectarines, apples, and pears (Nielsen et al. 1996; Lang 2005). In apples, Nielsen and Nielsen (2003) showed that remobilized N contributed to 50% of the N in shoots the following season, 90% of N in spur leaves, and 60% of fruit N.

Since remobilized N is critical for establishing N reserves for developing flowers, leaves, and fruit, fall N applications can build up reserves for the following season’s crop (Sanchez et al. 1990; Johnson et al. 2001; Ouzounis and Lang 2011; Sallato and Whiting, forthcoming). When needed, fall N sprays should be done after harvest, between October and November but before natural leaf fall when leaves start to turn yellow, to ensure absorption and remobilization to the roots, trunk, and buds (Sanchez et al. 1990; Johnson et al. 2001; Ouzounis and Lang 2011). The efficacy of fall foliar N sprays can vary from 30 to 80 percent, depending on weather conditions. Guak et al. (2004) reported 48% absorption in apples sprayed with 2% urea. Before spraying, a decision is required to assess whether the block needs additional N reserves—under adequate nutrient conditions, foliar sprays are ineffective (Wójcik and Morgaś 2013; Faust 1989; Guak et al. 2004; Sallato and Whiting, forthcoming) and can sometimes contribute to toxicity or excessive vigor.

Conditions That Indicate the Need to Build Up Reserves

1. *Nitrogen deficiency*: nutrient deficiency can be diagnosed using visual indicators like shoot growth or vigor (Figure 1) (Righetti et al. 1998), complemented with leaf tissue samples. Concentrations in recently matured leaves (midsummer) below 1.7% in apples (Nielsen and Nielsen 2003), 1.8% in pears, and 2.0% in cherries are indicative of deficiency (Sallato et al. 2019).

In apples, N deficiency can lead to biennial bearing. In an “off year,” fall N can promote shoot-to-fruit ratio for the upcoming “on year.” Avoid fall N sprays to prevent excessive growth the following season.

2. *Highly productive orchards*: when trees have been cropped heavily, the demand for N increases and trees can decline in vigor. Table 2 can be used as a guide to estimate N demand based on yield. If the demand surpasses all the inputs (soil organic matter, N in the irrigation water, compost, etc.), growers can apply up to 20 lb N per acre in a single foliar application during the fall.

Table 2. Macronutrient demand per ton (US ton) of fruit.

Crop	lb N/US ton	References
Apples	1.2–2.6	Cheng and Raba (2009); Palmer and Dryden (2006); Silva and Rodríguez (1995).
Apricot	6.1–13.6*	Silva and Rodríguez (1995); Fallahi et al. 1993.
Cherry	3.3–12*	Silva and Rodríguez (1995); Weinbaum et al. (1984).
Peach	4.5–12*	Silva and Rodríguez (1995).
Pear	1.3–2.7	Silva and Rodríguez (1995).

*Includes vegetative growth.

Conditions That Indicate No Need for Building Reserves

1. *Adequate N levels:* tree N status can be determined by analyzing leaf tissue N levels during the summer and doing a vigor assessment of the block. If tissue analyses are within adequate values and trees have balanced and adequate vigor, additional N sprays would be ineffective (Wójcik and Morgaś 2013). Adequate levels for N in recently matured leaves (midsummer) should be in the range of 1.7–2.5%. (For more information, visit [Tree Fruit Soil Fertility and Plant Nutrition in Cropping Orchards in Central Washington](#) [Sallato et al. 2019].)
2. *Excessive vigor:* blocks with excessive vigor have sufficient N for the following spring, and additional N could be counterproductive (Figure 1, bottom photo). In blocks with excessive vigor, leaf tissue analysis can be deceiving. In highly vigorous tissue, N concentration can be diluted; thus, determination of N status should include a visual vigor assessment in addition to a tissue test. Excessive vigor can affect return bloom in apples as well as fruit quality, in addition to increasing susceptibility to diseases such as fire blight (Van der Zwet and Keil 1979; Nielsen and Nielsen 2003) and powdery mildew in cherries.

Boron (B)

Boron is a micronutrient that is fundamentally important for meristematic growth (new shoot and root growth), pollen germination and pollen tube growth, fruit set, xylem and phloem development, and, consequently, fruit quality (Marschner 2002; Brown and Hu 1996). Thus, its demand is particularly important for fruit set early in the season (Wojcik and Wojcik 2006; Cheng and Raba 2009). Roots take up boron with water uptake in the form of boric acid. Boron has low mobility in the xylem, although in *Prunus* sp., *Malus* sp., and *Pyrus* sp. it has adequate mobility in the phloem (Brown and Hu 1996).

Deficiencies have been reported widely in the PNW region due to extensive areas with high soil pH, cold soils, excessively drained soils, and dry soil conditions (Nielsen et al. 2004; Peryea et al. 2003). According to Callan et al. (1978) (cited by Faust, 1989), fall application of B is more effective than spring application for increasing B levels in flowers and improving fruit set. However, effectiveness depends on the orchard deficiency levels. Effectiveness has been most consistently reported in trees with confirmed deficiency prior to the application. Peryea et al. (2003) reported that B maintenance sprays in apples and pears are more effective at pink flowering stage and that postharvest sprays in the PNW have not been widely adopted in apples due to logistics and reduced efficacy in late-ripening apple cultivars. More recently, Karlidag et al. (2017) demonstrated that the application of B (1,000 ppm) plus 3% urea during the fall were effective in augmenting N and B in buds, improving flower development and fruit set.

Most soils in the tree fruit regions of Washington State are low in B, and most growers manage the deficiency with foliar sprays. Thus, to monitor B deficiency in the trees, leaf tissue samples are better indicators than soils. Samples should be collected during midsummer in leaves that have reached maturity. Adequate levels should range between 20 and 80 mg/kg (ppm). Although adequate or high levels of B in leaf tissue are not always correlated with fruit B concentrations, if B is low in leaves, deficiency in the fruit is more likely. Precautions should be taken with B sprays, because there is a small margin between deficiency and toxicity. Faust (1989) indicated that one spray per season should be sufficient to prevent deficiencies in apples.



Figure 1. Low nitrogen and chlorosis in sweet cherry (top photo). High vigor and no chlorosis in apples (bottom photo). Photos: B. Sallato.

Zinc (Zn)

Zinc is a micronutrient involved in many enzymatic processes. Deficiency symptoms are very distinctive and include smaller leaves, yellowing, rosetting, and short internodes (Figure 2) (Silva and Rodríguez 1995). Among different tree fruit crops, cherries and apples appear to be highly susceptible to Zn deficiency (Faust 1989; Silva and Rodríguez 1995). Levels in recently matured leaves below 25 mg/kg are indicative of a deficiency.



Figure 2. Zinc deficiency in sweet cherry. Photo: B. Sallato.

In the PNW, deficiencies are most frequent in soils that are cold, wet, sandy, and alkaline (pH above 7.5). Under these conditions, Zn becomes unavailable, as deficiencies are more related to a lack of uptake rather than a lack of supply; therefore, soil application of Zn is inefficient. Foliar sprays of zinc sulfate (ZnSO₄) during the fall and throughout the season have been shown to be effective in managing Zn deficiencies in apples (Nielsen and Nielsen 1994), peaches (Sánchez et al. 2006), sweet cherries (Sallato and Whiting, forthcoming), and tart cherries (Wójcik and Morgaś 2015). However, Zn has low retranslocation and high binding capacity in the plant (Zhang and Brown, 1999, Marschner, 2002), and, as noted by Wójcik and Morgaś (2013) in sour cherry and Sallato and Whiting (forthcoming) in sweet cherries, fall application of Zn only improved bud and flower levels and did not affect overall Zn levels in leaves, suggesting the need for frequent applications when deficiency persist.

Spray Recommendations

For leaf nutrient sprays, mixing micronutrients with urea has been shown to improve uptake (Fernandez et al. 2013; Sánchez and Righetti 2005). There are several formulations for each nutrient. The most common formulations are listed in Table 3. Whatever the product, always check the label recommendation. To calculate the amount of product needed, divide the actual amount by the percentage of the element indicated in the label.

Example: If the amount needed is 8 lb of N per acre, and the fertilizer is urea—46% actual N—then $8 \text{ lb} \div 0.46 = 17 \text{ lb}$ of urea per acre.

Table 3. General fall recommendations for tree fruit with diagnosed deficiency.

Nutrient	Formulation or Salt	Dose (Pounds of actual element in 100 gallons of water per acre)
Nitrogen	Urea (CO [NH ₂] ₂)	8–10 lb of N. When using urea, make sure it has less than 0.25% biuret.
Calcium	Calcium nitrate (CaNO ₃) Calcium chloride (CaCl)	3–5 lb of Ca.
Boron	Sodium borate	1–1.6 lb of B. Boron is not suggested for nonbearing trees.
Zinc	Zinc sulfate (ZnSO ₄)	8–10 lb of Zn for apples and cherries. 3 lb of Zn for peach and nectarine. For nonbearing trees, apply 0.5 lb.

Note: For nutrients containing sulfate (e.g., zinc sulfate), wait until temperatures are below 80°F.

The effectiveness of foliar sprays will depend on the environmental conditions at the time of application (Guak et al. 2004; Fernandez et al. 2013). The most important considerations are:

- Temperature. Do not apply with temperatures below 68°F or above 85°F.
- Wind. High wind reduces drying time of the droplet and reduces absorption.
- Relative humidity. Low humidity influences droplet size and persistence on the leaf surface.

Other Potential Benefits

Fall sprays of urea have also been used to induce leaf drop when sprayed in higher concentrations. For example, urea at 5% has been used to reduce inoculum of *Venturia inaequalis*, which is responsible for apple scab (Qazi et al. 2005; Beresford et al. 2015; Burchill 1968; Carreño and Pinto de Torres 1982). Urea in combination with ZnSO₄ at a 2% concentration has successfully been used to induce early leaf drop after harvest, augmenting cold hardiness (Fernandez et al. 2013; Sallato and Whiting, forthcoming; Ouzounis and Lang 2011).

Summary

- Fall sprays are beneficial and effective only when the trees are deficient for that particular nutrient.
- Fall nitrogen applications can help in building up reserves for critical early growth the next season.
- Fall zinc and boron sprays can improve fruit set and early fruit development.
- Fall spray applications should be applied when growth has ceased but before natural leaf fall.

For More Information

Sallato, B. 2018. [Leaf Tissue Analysis](#). Fruit Matters.

References

- Beresford, R.M., I.J. Horner, and P.N. Wood. 2015. Autumn-Applied Urea and Other Compounds to Suppress *Venturia inaequalis* Ascospore Production. *New Zealand Plant Protection* 53: 387–392.
- Brown, P.H., and H. Hu. 1996. Phloem Mobility of Boron is Species Dependent: Evidence for Phloem Mobility in Sorbitol-Rich Species. *Annals of Botany* 77: 497–505.
- Burchill, R.T. 1968. Field and Laboratory Studies of the Effect of Urea on Ascospore Production of *Venturia inaequalis* (Cke.) Wint. *Annals of Applied Biology* 62: 297–307.
- Carreño, I., and A. Pinto de Torres. 1982. Efecto de las Pulverizaciones Otoñales de Urea en la Reducción del Inoculo Primario de *Venturia inaequalis* (Cke.) Wint., en Manzanos de la Zona de Curicó, Chile. *Agricultura Tecnica* 42: 235–238.
- Cheng, L. 2010. When and How Much Nitrogen Should Be Applied in Apple Orchards? *New York Fruit Quarterly* 18 (4): 25–28.
- Cheng, L., S. Dong, and L.H. Fuchigami. 2002. Urea Uptake and Nitrogen Mobilization by Apple Leaves in Relation to Tree Nitrogen Status in Autumn. *Journal of Horticultural Science and Biotechnology* 77: 13–18.
- Cheng, L., and R. Raba. 2009. Nutrient Requirement of Gala/M.26 Apple Tree for High Yield and Quality. Cornell University.
- Dong, S., L. Cheng, and L.H. Fuchigami. 2001. New Root Growth in Relation to Nitrogen Reserves of Young Gala/M26 Apple Trees. *ISHS Acta Horticulturae* 564: 365–370.
- Dong, S.F., L.L. Cheng, C.F. Scagel, and L.H. Fuchigami. 2002. Nitrogen Absorption, Translocation and Distribution from Urea Applied in Autumn to Leaves of Young Potted Apple (*Malus domestica*) Trees. *Tree Physiology* 22 (18): 1305–1310. DOI: 10.1093/treephys/22.18.1305.
- Dong, S.F., D. Nielsen, G.H. Nielsen, and L.H. Fuchigami. 2005. Foliar N Application Reduces Soil NO₃-N Leaching Loss in Apple Orchards. *Plant and Soil* 268: 357–366.
- Fallahi, E., T.L. Righetti, and E.L. Proebsting. 1993. Pruning and Nitrogen Effects on Elemental Partitioning and Fruit Maturity in ‘Bing’ Sweet Cherry. *Journal of Plant Nutrition* 16 (5): 753–763.
- Faust, M. 1989. *Physiology of Temperate Zone Fruit Trees*. John Wiley and Sons. New York.
- Fernandez, V., T. Sotiropoulos, and P. Brown. 2013. Foliar Fertilization, Scientific Principles and Field Practices. *International Fertilizer Industry Association*.
- Guak, S., D. Nielsen, P. Millard, and N.E. Looney. 2004. Leaf Absorption, Withdrawal and Remobilization of Autumn-Applied Urea-N in Apple. *Canadian Journal of Plant Science* 84: 259–264.
- Johnson, R.S., R. Rosecrance, S. Weinbaum, H. Andris, and J.Z. Wang. 2001. Can We Approach Complete Dependence on Foliar-Applied Urea Nitrogen in an Early-Maturing Peach? *Journal of the American Society for Horticultural Science* 126: 364–370.
- Karlidag, H., A. Esitken, M. Turan, and S. Atay. 2017. The Effects of Autumn Foliar Application of Boron and Urea on Flower Quality, Yield, Boron and Nitrogen Reserves of Apricot. *Journal of Plant Nutrition* 40 (19): 2721–2727.

- Lang, G. 2005. Underlying Principles of High Density Sweet Cherry Production. *Acta Horticulturae* 667: 325–333.
- Marschner, H. 2002. *Mineral Nutrition of Higher Plants*, 3rd edition. Academic Press, London, UK.
- Nielsen, D., P. Millard, G.H. Nielsen, and E.J. Hogue. 1996. Sources of N for Leaf Growth in a High-Density Apple (*Malus domestica*) Orchard Irrigated with Ammonium Nitrate Solution. *Tree Physiology* 17: 733–739.
- Nielsen, G.H., and D. Nielsen. 1994. Tree Fruit Zinc Nutrition. In *Tree Fruit Nutrition: A Comprehensive Manual of Deciduous Tree Fruit Nutrient Needs*, A.B. Peterson and R.G. Stevens (eds.), 85–93. Good Fruit Growers.
- Nielsen, G.H., and D. Nielsen. 2003. Nutritional Requirements of Apple. In *Apples: Botany, Production and Uses*, D.C. Ferree and I.J. Warrington (eds.), 267–302. CABI, Oxford, UK.
- Nielsen, G.H., D. Nielsen, E.J. Hogue, and L.C. Herbert. 2004. Zinc and Boron Nutrition Management in Fertigated High Density Apple Orchards. *Canadian Journal of Plant Science* 84 (3): 823–828.
- Ouzounis, T., and G. Lang. 2011. Foliar Applications of Urea Affect Nitrogen Reserves and Cold Acclimation of Sweet Cherries (*Prunus Avium* L.) on Dwarfing Rootstocks. *HortScience* 46 (7): 1015–1021.
- Palmer, J.W., and G. Dryden. 2006. Fruit Mineral Removal Rates from New Zealand Apple (*Malus domestica*) Orchards in the Nelson Region. *New Zealand Journal of Crop and Horticultural Science* 34 (1): 27–32.
- Peryea, F.J., D. Nielsen, and G. Nielsen. 2003. Boron Maintenance Sprays for Apple: Early-Season Applications and Tank Mixing with Calcium Chloride. *HortScience* 38 (4): 542–546.
- Qazi, N.A., M.A. Beig, and K. Ahmad. 2005. Impact of Post-harvest Urea Application on Primary Inoculum and Infection of *Venturia inaequalis* (Cke.) Wint. and Plant Behaviour of Apple. *Applied Biological Research* 7 (1/2): 37–43.
- Righetti, T., K. Wilder, R. Stebbins, D. Burkhart, and J. Hart. 1998. Apples: Nutrient Management Guide. *Oregon State University Extension Service Publication EM 8712*. Oregon State University.
- Sallato, B. n.d. Washington State University.
- Sallato, B., T. DuPont, and D. Granatstein. 2019. [Tree Fruit Soil Fertility and Plant Nutrition in Cropping Orchards in Central Washington](#). *Washington State University Extension Publication EM119E*. Washington State University.
- Sallato, B., and M.D. Whiting. forthcoming. Early Defoliation Reduced Yield and Bud Nutrient Concentration in ‘Selah’ Sweet Cherry. *Acta Horticulturae*.
- Sánchez, E.E., and T.L. Righetti. 2005. Effect of Postharvest Soil and Foliar Application of Boron Fertilizer on the Partitioning of Boron in Apple Trees. *HortScience* 40 (7): 2115–2117.
- Sánchez, E.E., T.L. Righetti, D. Sugar, and P.B. Lombard. 1990. Responses of ‘Comice’ Pear Tree to a Postharvest Urea Spray. *Journal of Horticultural Science* 65: 541–546.
- Silva, H., and J. Rodríguez. 1995. Fertilización de Plantaciones Frutales. Colección en Agricultura. *Pontificia Universidad Católica* 519.
- Van der Zwet, T., and H.L. Keil. 1979. Fire Blight: A Bacterial Disease of Rosaceous Plants. Handbook 510, United States Department of Agriculture.
- Weinbaum, S.A., I. Klein, F.E. Broadbent, W.C. Micke, and T.T. Muraoka. 1984. Effects of Time of Nitrogen Application and Soil Texture on the Availability of Isotopically Labeled Fertilizer Nitrogen to Reproductive and Vegetative Growth of Mature Almond Trees. *Journal of the American Society for Horticultural Science* 109: 339–343.
- Wójcik, P., and H. Morgaś. 2013. Response of ‘Burlat’ Sweet Cherry Trees to Postharvest Sprays of Nitrogen, Boron and Zinc. *Journal of Plant Nutrition* 36 (3): 503–514. DOI: 10.1080/01904167.2012.748071.
- Wójcik, P., and H. Morgaś. 2015. Impact of Postharvest Sprays of Nitrogen, Boron and Zinc on Nutrition, Reproductive Response and Fruit Quality of ‘Schattenmorelle’ Tart Cherries. *Journal of Plant Nutrition* 38 (9): 1456–1468. DOI: 10.1080/01904167.2015.1009095.
- Wojcik, P., and M. Wojcik. 2006. Effect of Boron Fertilization on Sweet Cherry Tree Yield and Fruit Quality. *Journal of Plant Nutrition* 29: 1755–1766.
- Zhang, Q.L., and P.H. Brown. 1999. Distribution and Transport of Foliar Applied Zinc in Pistachio. *Journal of the American Society for Horticultural Science* 124: 433–436.

By
Bernardita Sallato C., Assistant Professor and Tree Fruit Extension Specialist, Agriculture and
Natural Resources Unit, Washington State University



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