

Boron in forestry production

Overview

Boron deficiency is the most common micronutrient³ limitation in forest plantations. It occurs in many countries, particularly in exotic plantations of eucalypts and pines, but also in plantations and natural stands of native species on soils altered by macronutrient fertilization, liming, fire, or erosion.

Deficiency symptoms

Deficiency symptoms are usually characteristic but can be confounded by variable foliar concentrations, erratic occurrence, and possible climatic damages. Boron deficiency symptoms³ on pines vary by species and may be distinctly seasonal in occurrence and are often environmental stress induced. Spring growth from unaffected buds appears normal, and it's not until midsummer or later that leading shoots show clearly recognizable symptoms. Limited supplies or even brief interruptions (such as those caused by drought) in absorption of boron can cause irreversible damage to rapidly growing shoots. A split leader is often the outcome.

Pinus sylvestris (an uninodal species): Exhibits abundant resin flow and various disturbances in apical dominance as the first external evidence of boron deficiency. The terminal bud may be small, malformed, retarded in expansion, or dead. Adjacent lateral buds may or may not be similarly affected. Swelling, cracking, bending, or dying of the leader occurs as in other pine species and so also darkening and formation of cavities in the pith. Needles near the affected tips are often short and deformed, either dark green, or discolored.

Pinus stobus and *Pinus sylvestris*: Dieback of terminal growing points. Tips of the primary needles turn light yellow/orange in color and have light brown edges.

Pinus sylvestris: Seedling are short with thick, succulent, and somewhat fragile roots. The buds—which are small—remain moribund and the young needles chlorotic. Needle malformation is common.

Pinus radiata: Shoot and tip dieback, dead tops and malformation, and brown root tips with extensive surface cork development. The shoot growing point of a seedling not supplied with boron typically dies after five months.

Thuja plicata: Growing shoot wilts readily and the needles on young shoots become bronzed.

Pinus patula, *P. khasya*, and often in *P. caribaea hondurensis*: The leading shoots become very crooked but are otherwise healthy with normal foliage and no resin flow.

Pinus elliottii: Resin flow, bud death, and tip dieback symptoms. Needle malformations often occur before other external symptoms.

Boron and tree physiology

Boron is a relatively immobile nutrient within plants. Unlike many other nutrients (eg nitrogen and magnesium), it is not redistributed to growing points by internal cycling. Current uptake by the roots appears to determine the concentrations that are incorporated into shoots and foliage as they are formed.

Fertilization with boron² increases the total carbohydrate content of mycorrhizal roots. In one study, foliar + soil fertilization yielded a 24% increase in total carbohydrates in mycorrhizal roots, whereas foliar fertilization alone decreased the total carbohydrate content. Significant increases in sugars in response to boron fertilization were observed in both ectomycorrhizal and nonmycorrhizal plants.

Low boron availability limits growth of roots, and deficiency affects mycorrhizal symbiosis more than fine roots alone.

Leaves may have a light mosaic pattern of chlorosis in interveinal areas and red-brown spots interveinally and on the margins. Roots may remain short, thicken, swell into knots and break open longitudinally.

AGRONOMY NOTE: FORESTRY PRODUCTION

Where is boron deficiency most common?

Boron deficiency is most common on:

- Soils from acid igneous rocks and fresh water sediments
- Acid soils from which the original content has been leached
- Sands low in silt, clays, or micas; acid peats; and mucks
- Soils with free lime, including some acid soils after heavy liming³

Overt manifestations of boron deficiency and/or reduced foliar boron may be induced by addition of macronutrients³. Liming and nitrogen fertilization⁴ can cause serious boron deficiency. It is likely that liming affects uptake of boron, whereas nitrogen fertilization causes a dilution due to increased growth.

Environmental stresses—especially drought—often induce⁶ or accentuate boron deficiency on marginally deficient sites. Although trees usually recover with resumption of

normal rainfall, the incidence of multiple leaders in affected stands may be high and this reduces their economic value. Applications of boron have been observed to prevent dieback even when years of drought followed the boron application.

Soil test and plant analysis

Soil tests are most useful to determine pH and establish sufficient nutrient levels before planting, but a foliar sample⁵ is needed to determine how well the tree is utilizing the soil nutrients. North Carolina State University recommends sampling at the completion of each growth flush when shoots have stopped growing and needles are fully elongated.

Studies in Australia⁶ with hot-water soluble boron in the 0-10 cm and 10-20 cm horizons of 0.29 and 0.19 ppm caused severe boron deficiency symptoms in *P. radiata* seedlings. Soil test values are not always well correlated with plant tissue values.

Boron recommendations for forestry

Christmas tree (Fraser fir)¹ boron deficiencies have been treated with foliar application of *Solubor*[®] (1 lbs/100 gal) or ground applied sprays of *Solubor* (3-5 lbs/acre). Do not exceed 0.25 lbs boron per 100 gallons for foliar application to Fraser firs. Applications of 5 lbs boron/acre were adequate to correct boron deficiency in *P. radiata* under drought conditions⁶.

Tissue concentrations

Crop	Leaf boron content, ppm boron				
	Deficient	Low	Normal	High	Excess
Birch	<14		28-33		
Eastern cottonwood	<9		68		
Eucalyptus	<35		40-70		
Holly	<20	20-25	>30		
<i>Pinus radiata</i>	<10			>20	
Rubber			>80		
Scots pine	<10		25-30		
Spruce	*8		25-30		

Chapman HD. 1966. *Diagnostic Criteria for Plants and Soils*. Davis, CA:University of California, Division of Agriculture Science. p793.
Shorrock VM. 1997. *Boron Deficiency and Its Cure*.

AGRONOMY NOTE: FORESTRY PRODUCTION

Soil applications (suggested rates of application)

Crop	Granubor® (15% B) Fertibor® (15% B)	Solubor® (20.5%)	
	lbs/acre	lbs/acre	gals/acre
Birch	0.4 - 1.8	0.2 - 1.2	3 - 24
Eastern cottonwood	0.4 - 1.8	0.2 - 1.2	3 - 24
Eucalyptus	1.1 - 3.5	0.7 - 2.4	14 - 47
Pines	6.3 - 31.2	4.5 - 22.3	10.7 - 53.5
Wattle	12.5 - 37.9	8.9 - 26.8	21.4 - 64.2

References

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9. Will. 1985. *New Zealand Forest Research Bulletin* No 97.
10. Duryea ML and Dougherty PM, eds. 1991. *Forest Regeneration Manual*. Kluwer Academic Publishers.

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U.S. Borax, part of Rio Tinto, is a global leader in the supply and science of borates—naturally-occurring minerals containing boron and other elements. We are 1,000 people serving 650 customers with more than 1,800 delivery locations globally. We supply around 30% of the world's need for refined borates from our worldclass mine in Boron, California, about 100 miles northeast of Los Angeles.

Our local agriculture experts understand the uses and benefits of boron on crops. In addition to a global sales team, we have a number of agronomists on staff to help fertilizer distributors maximize the benefits of borates in agriculture applications. Our ag team can answer individual growers' questions and concerns about their particular crop.

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