# BORON A MINOR PLANT NUTRIENT

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During the past century, soil chemists centered their interest on three critical elements, nitrogen, potassium and phosphorus and a great industry developed to supply these.

During the past two decades replacement of animal power by farm tractors, introduction of pure synthetic fertilizers, and intensive specialized agriculture on leachy, humid-climate soils have contributed to manifestation of numerous deficiency diseases of crop plants. Part of the boron, sulphur, and iodine may have been roasted out of the basaltic lava from whence came the major soil forming material in the Pacific Northwest.

During the past twenty-five years essential nature of very small amounts of several so-called minor or trace elements gradually became apparent. Various obscure types of malnutrition in plants are prevented or corrected by the presence of traces of such elements as boron, manganese, zinc, copper, molybdenum, or other elements for which essentiality is less definitely established.

For twelve years the Oregon Experiment Station, Soils Department has done exploratory work with minor elements on Oregon soils including an intensive study of the need and value of iodine, followed by boron and recently by manganese investigations. Striking improvement in vigor and yield have been secured from use of boron on leached soils. Use of boron as a fertilizer for alfalfa west of the Cascade Mountains promises to be as profitable as sulphur has been on the more arid basaltic soils to the east thereof. In a former report (Powers, 1937, 1940) (Powers and Bouquet, 1939) the earlier studies with boron in relation to soil fertility in the Pacifc Northwest or Columbia basin were reviewed. The purpose herein is to present a progress report covering continued and recent boron experiments, particularly in Oregon and the Pacific Northwest.

**Essentiality:** Evidence of the essentiality of boron as a plant food was reported by Agulhon (1910) and Maze (1919) and confirmed by Warington (1923) and Sommer and Lipman (1926). The latter grew large numbers of plants in solution cultures built up from purified chemicals in re-distilled water, and from successixe generations of seed. According to Purvis (1939) 24 states have reported boron deficient areas, and no other plant nutrient has received so much notice in recent literature. Boron, like most of the trace elements, is helpful only at concentrations of the order of one-fourth part per million, while two parts per million in solution may be toxic; so great care is needed in its use. An excess leads to spotting, discoloration and defoliation of lower leaves while a deficiency causes bronzing, then yellowing or blighting of terminal growth.

**Effects:** A score of plant mal-nutritional symtoms have been related to boron need. Boron has been used in the Columbia drainage area to control "corky core" and "drought spot" in apples; "yellow top" in alfalfa; celery "stem crack" turnip "brown heart"; discoloration of broccoli and asters, and "growth strain" of potatoes. Frequently, marked increase in yield and quality resulted from the treatment.

Boric acid was used by the writer to correct a certain type of chlorosis in water culture experiments as early as 1926. Alfalfa grown in the greenhouse in 2-gallon jars of Springdale and Mission soils from Stevens County, Washington in 1936 developed yellow top before the third cutting. Two hundred cc of solution containing 1 part per million of boric acid corrected this in a few days. The yellow top re-appeared as the plants approached maturity for the fifth cutting. Boron

promoted blooming and branching of alfalfa and should aid longevity. Similar response was obtained the same season in British Columbia by McLarty (1936).

Good control of beet canker was secured with 30 pounds of borax an acre in experiments started by Powers and Bouquet in 1937, perhaps for the first time.

Celery stem crack has been controlled by use of 20 pounds an acre of borax the past 4 years in experiments in cooperation with Professor A. G. B. Bouquet. Little leaf of stone fruits near The Dalles was controlled more completely when borax was included with the zinc spray. Boron is now rather generally used in Hood River Valley to control corky core, following results of McLarty (1936). Potato growth strain and cauliflower discoloration have been corrected in Oregon experiments. Chemical determinations show unfavorably low boron content in soils, waters and vegetation in affected areas. Use of boron in such areas has increased the boron content of plants and raised the chlorophyll and the vitamin A contents as much as 50 per cent. Standards are being developed for boron content of normal leaves.

**Possible Functions:** Boron appears to give elasticity to the plant cell membranes and to aid cell division (Johnson and Dore, 1928); seems to regulate respiration, lessen effect of drought, and has improved keeping quality of apples and prunes (Roberts, 1940) and prevents swelling and blocking of roots (Sommer and Sorokin, 1928) and pollen tubes (Denis and O'Brein, 1937); Boron prevents breakdown of conducting tissues (Warrington, 1923); is important in nitrogen metabolism and aids development of nodules and nodule bacteria (Brenchley and Thornton, 1925; Boron affects carbohydrate translocation (Johnson and Dore, 1928) and pectin formation and amount of calcium in tissues. Eaton (1940) reported boron to be essential to formation of auxin in plants. Goldsmith (1932) reported boron essential in metabolism of brown algae. Boron is a constituent of animal tissues (Bertrand, 1912).

**Results of Field Experiments:** During four years three dozen trials with boron have been conducted on 24 soil types including 236 plots. Also material has been furnished the past 2 years to two dozen County Agents for demonstration tests. Use of boron in the Great Basin and in Southern Oregon has been ineffective and in field trials control of beet canker has not affected total yield very consistently so the data are omitted. Increases in alfalfa yields have been as large as two tons an acre a season. A single application of 40 pounds an acre of boric acid on Willamette loam at Hagg Brothers farm gave a total increase in yield of some 7 tons alfalfa and yellow top has not re-appeared after 4 years. The increased yield occurs particularly with old meadows and dry weather cuttings. Legume crops are relatively good indicators of boron need. Bountiful beans in the greenhouse make quick growth and yield goodly amounts of leaves, stems and pods.

Some very profitable responses have been realized from horticultural and field crops. While there is an indicated loss from use of boron on some small fruit crops the second year after treatment there was some increase in cane size and friut yield. Grass and small grain have relatively low boron contents, yet response to boron has been observed with these crops. Schropp and Aren (1940) found boron essential for formation of barley kernels. The grasses in mixtures may receive indirect benefit from legumes.

**Rate and Duration of Treatment** has been varied with several soils and crops. Slight temporary toxicity without economic loss has been observed with corn where a 30-pound application was made inadvertantly for the second year. Lawn grass was slightly off color for 10 days following an application of 40 pounds an acre of boric acid. Yields of alfalfa have increased

with increasing rates of borax application up to 60 pounds an acre. It appears that 30 pounds an acre of borax can be safely used for most purposes. This 30 to 60 pounds has given commercial but not complete control of beet canker. Placement at the side of the row gave more complete control. A 30-pound treatment appears to be effective for 2 or 3 years. Most prompt results in experimental tests have followed where application was by sprinkling in aqueous solution. The borax may be broadcast with a cyclone type of grass seed hand sower. It has been used successfully by mixing with gypsum or superphosphate. Early application is important.

**Boron in Soils and Crops:** Some data as to boron in soils and plants appears in an earlier report (Powers, 1939). We are now using the quinalizarine method of Berger and Truog (1934) for nearly available boron.

Old soils, leachy soils, peaty soils or those derived from igneous rocks seem most apt to be deficient in boron. Soil reaction or liming, soil moisture content, colloidality and organic matter contents, and perhaps also temperature may affect boron availability. So boric acid may best be used for experimental tests on basic soils. Two pounds of boric acid will supply approximately as much boron as three pounds of borax.

The boron content of plant material tested has ranged from 7 to 50 parts per million and has been markedly lower in plants needing boron than in normal plants or those grown on boron treated soils.

There are now some 50,000 acres of alfalfa in Willamette Valley that will yield one-half ton to one ton more an acre from the borax treatment which costs about $1.00 an acre for a 30-pound application. Loss due to beet canker has been 8 to 10 percent and with celery up to 50 percent.

Twenty tons of borax were used for fertilizer in Oregon in 1939 and over 100 tons in 1940.

A minor amount of boron is a major factor in plant nutrition over wide areas of the Pacific Northwest and nutrition is a factor in natioal security.

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