7-1968

Visual Diagnosis of Mineral Deficiency in Western Larch

Mark J. Behan
University of Montana, Missoula

Visual Diagnosis

of Mineral Deficiency in Western Larch

by Mark J. Behan

Bulletin 34 July 1968

Montana Forest and Conservation Experiment Station
School of Forestry University of Montana, Missoula

Visual Diagnosis of Mineral Deficiency in Western Larch

(*Larix occidentalis,* Nutt.)[1]

By Mark J. Behan
Department of Botany
University of Montana, Missoula

Several techniques have been developed for the diagnosis of mineral deficiencies in plants, and four of these are particularly common in diagnosing deficiencies in trees: soil analysis, chemical analysis of the foliage, field fertilizer trials, and visual symptoms of deficiency (7). This report describes the method of identifying mineral deficiencies in western larch (*Larix occidentalis,* Nutt.) by visual symptoms, the advantages and limitations of this method, and the current status of the development of alternate methods of diagnosis.

Diagnosis of Mineral Deficiency

When plants grow in unsuitable environments they react in specific ways. If light is insufficient, the green color of the leaf may be lacking or reduced and the leaves may be more yellowish or whitish than is normal. If water is insufficient, growth may be restricted, and on extreme desication the leaves often demonstrate a characteristic pattern as zones or portions are killed by drought. Insect damage and diseases may produce characteristic symptoms in the foilage. A deficiency or excess of an individual mineral nutrient also may cause characteristic effects on the various organs of the plant. The ability to recognize these symptoms forms the basis of the diagnosis of plant deficiency by visual symptoms (9).

Not all species demonstrate visual symptoms of mineral deficiency. Symptoms also vary from species to species. Thus, before the visual method can be used, visual symptoms of deficiency in the species of interest must be determined.

The principal advantages of the method of diagnosis by visual symptoms are its speed and that no apparatus is necessary where the symptoms do not require confirmation (9). However, this method does have disadvantages. Even though a deficiency is known to exist, many species of conifers fail to exhibit

[1]This research was supported in part by a cooperative research grant from the Intermountain Forest and Range Experiment Station, United States Forest Service, Ogden, Utah, and in part by McIntire-Stennis Funds administered by the School of Forestry, University of Montana, Missoula.

a specific and characteristic visual symptom to some nutrients. Symptoms may be complicated or suppressed by other factors such as weather conditions, pests or disease. A further disadvantage is that the symptoms must appear before they can be diagnosed, delaying the time in which remedial action can be taken. The latter disadvantge is probably more important in the culture of annual agricultural crops than in forestry.

Mineral deficiencies often can be demonstrated by an increased growth rate following fertilization, even though the deficiency is not severe enough to produce visual symptoms. This degree of deficiency can often be detected by foliar analysis (9). A technique for diagnosis of deficiency by foliar analysis has been developed for western larch by growing the plant under controlled conditions which provided optimum, deficient, and very deficient amounts of nitrogen, potassium, phosphorus, calcium, or magnesium to the roots. A correlation between the amount of mineral supplied, the concentration of that mineral in the foliage, and growth was observed for most of these minerals (1).

In an effort to correlate the diagnosis of deficiency with growth response following fertilization, 175 experimental fertilizer plots were established in 13 western larch stands in western Montana during the summer of 1966. The locations, specific treatments, and objectives of this study have been described (2). Visual symptoms of nitrogen deficiency were observed in several of these plots at the time of application of the fertilizer treatments, and symptoms of potassium deficiency were seen at one location. The symptoms were found in comparatively young stands (under 30 feet in height) of second growth timber following clearcut logging. Although the symptoms were clearly present in these stands, they were not observed in older stands, even in adjacent uncut areas. The absence of deficiency symptoms in these adjacent older stands may have been due to several factors. The factors include the absence of a deficiency, the loss of the ability of older trees to demonstrate symptoms, an improved nutrient status of the stand as it ages either by reduction in requirements or accretion of minerals on the site, or a deterioration of the fertility of the site associated with logging and regeneration. Some of the fertilizer plots were established to test these possibilities.

Symptoms of deficiency for other conifers have been cited by Mustanoja and Leaf (1965), and a table of references of colored pictures of nutrient deficiencies has been prepared by Tamm (1964).

Methods

Visual symptoms of nutrient deficiency were induced by growing the plants in the greenhouse in four gallon "pyrex" pots containing washed silica sand. Minerals were supplied by irrigating the pots with nutrient solutions of known composition. The seeds used were obtained from Sec. 23, T28N, R17W, Flathead National Forest, at an altitude of 4,200 feet. The seeds were stratified for 30 days at 40° F., and then placed in washed river sand in the greenhouse for 35 days. The most vigorous seedlings that had germinated during this period were selected, and 254 of these placed in the sand cultures (May 5, 1965). The sand culture system was similar in design to that described by Swan (1960), except that provisions were made to permit rapid renewal of the nutrient solutions. Six seedlings were placed in each pot, but the poorest seedling in each pot was discarded 70 days later. The photoperiod was extended to 19 hours with incandescent lamps in order to promote rapid shoot growth (4). The minimum temperature was 55° F. On November 6, 1965, (6 months following placement in sand cultures) initial observations were made of visual symptoms. No spur shoots had formed on any of the plants by this date, even though some of the plants had grown over a meter in height. Three of the five plants were harvested at this time, the minimum temperature lowered to 45° F, and the artifical photoperiod extension discontinued. Most of the needles abscissed during the next 40 days, and by December 20 the plants appeared dormant. Sixty-five days (January 20, 1966) after it had been discontinued, the photoperiod was re-extended to 19 hours. The minimum temperature was raised to 60° F, and all of the plants broke dormancy within 30 days. The plants remained under the extended photoperiod until July 1 and were harvested in late August 1966 following the final observations for visual symptoms.

The full-strength nutrient solution was the same used by Walker (1963) for the successful culture of several species of conifers. This solution has the following composition of

Normal

Magnesium Deficiency

Nitrogen Deficiency

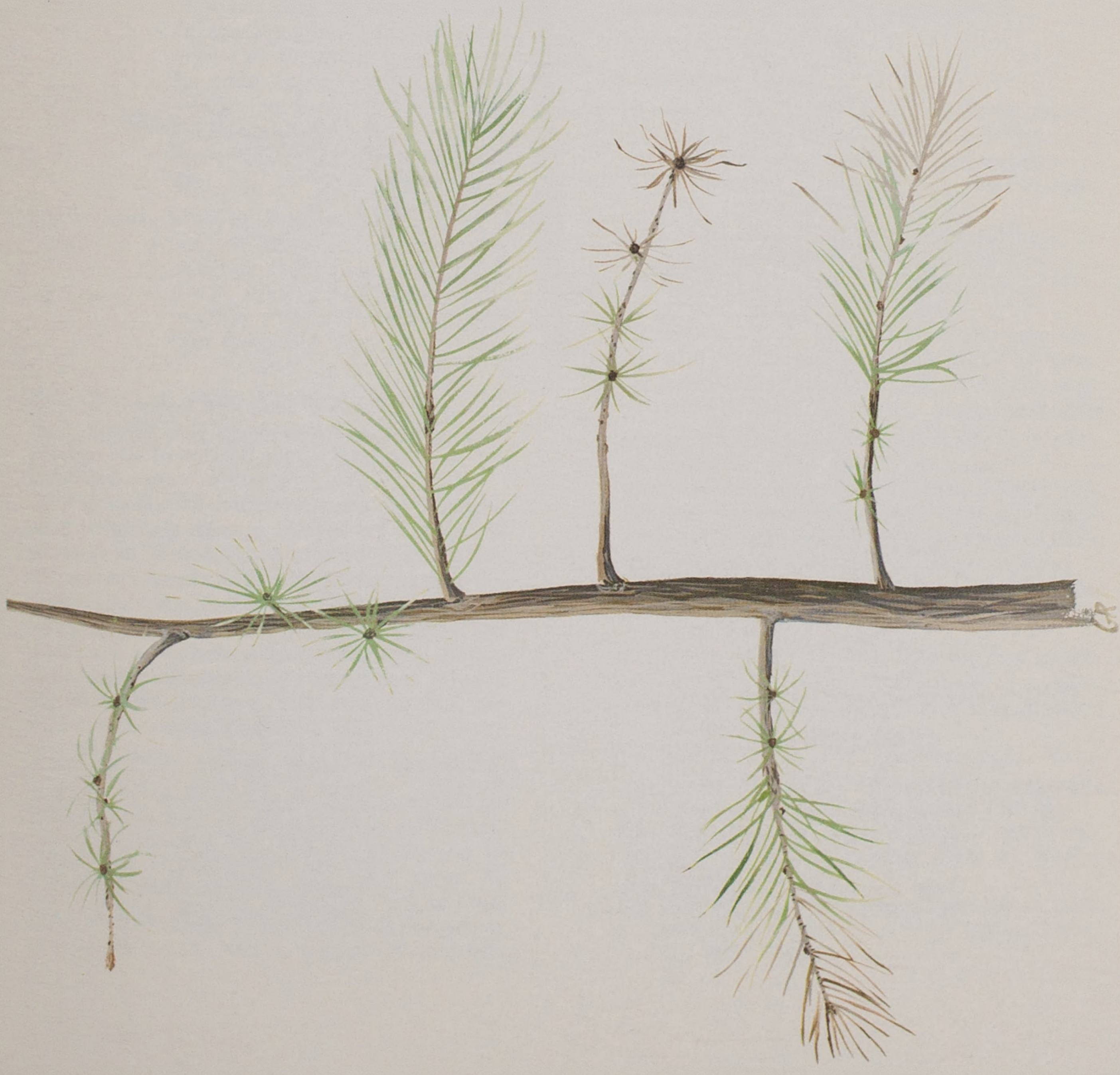

GRU 65

macronutrients: 1.4 ppm (parts per million) ammonium nitrogen, 105 ppm nitrate nitrogen; 15.5 ppm phosphorus, 97.8 ppm potassium, 100 ppm calcium, 24 ppm magnesium, and 32 ppm sulpur. Micronutrients were supplied at half the strength of Arnon's A-5 micronutrient supplement (Hewitt, 1966). Iron was supplied as Sequestrene 138 Fe (sodium ferric ethylenediamine di-(O-hydroxyphenylacetate) at a concentration of 1 ppm iron.* The full-strength nutrient solution also contained 11 ppm sodium and 3.6 ppm chloride.

Visual symptoms were developed by irrigating the sand cultures with either 1/10th or 1/50th the amount of N, P, Ca, or Mg contained in the full-strength solution. The concentrations of all minerals other than those for which deficiency symptoms were being induced were maintained at full strength. Potassium was supplied at either 1/20 or 1/50 the concentration of the full strength solution in the potassium deficient cultures. Except during the period of dormancy, solutions were replaced twice a month.

*The chelate was made available through the courtesy of the Geigy Chemical Corporation, and is often abbreviated Fe-EDDHA.

Potassium Deficiency



Calcium Deficiency

Illustrations

A series of needles or branches were selected for illustration. They were arranged to show the variations of symptoms as they might appear on examination of several branches and the typical gradation of severity of branch tip to base. The symptoms are exaggerated in some illustrations for easier recognition in the field.

DESCRIPTION OF DEFICIENCY SYMPTOMS

Nitrogen (N)

Chlorosis extends from the needle tip toward the base. In cases of severe deficiency the tip is often necrotic, needles near the base of branches and in the lower portion of the crown are more severely affected than those at branch tips and upper portion of the crown. The transition zone between green portion of needle and chlorotic zone is abrupt and is without extension of cholorosis down the midvein of the needle into the green portion. The needles of a few young seedlings had a cherry red anthocyanin pigmentation, but this was not seen in all seedlings nor in older plants.

Phosphorus (P)

Needles formed on the main stem of seedlings often have a bluish cast, although this symptom was not present in older plants. Some plants may have needles with purplish anthocyanin pigmentation. Needles on many plants have spotty zones of necrosis. Visual symptoms of P deficiency are not as distinctive as the other elements studied and deficiencies should be determined by foliar analysis.

Potassium (K)	Needles at the tips of lower branches are tan to light yellow or pale green. Transition between colors on needles is diffuse and not abrupt. Symptoms are more severe in lower branches of the crown.
Calcium (Ca)	Symptoms are restricted to the terminal bud, or to buds and branches near the terminal bud. Terminal buds or lateral buds near the terminal bud fail to elongate, some needles in spur shoots are necrotic, needles often are twisted and deformed. Symptoms resemble insect damage.
Magnesium (Mg)	Tips of needles are chlorotic, but the transition between the chlorotic zone and the green tissue is diffuse. Chlorosis of the midvein generally extends well into the green tissue.

Special Comments on the Visual Diagnosis of Mineral Deficiency in Larch

Needles retained over the winter on young larch seedlings growing in the field often develop a reddish pigmentation, which should not be confused with the pigmentation described for phosphorus and nitrogen deficiencies. Although some degree of chlorosis develops in deficiencies of nitrogen, potassium, and magnesium, the symptoms of each of these elements are distinctive in that the zone of transition between chlorotic tissue and the green portion of the leaf is quite abrupt in nitrogen deficiency, whereas it is diffuse in both potassium and magnesium deficiencies. The midvein is generally chlorotic well into the green portion of the leaf in magnesium deficiency. The pale green to light yellow, and in particular the tannish color of the foliage in potassium deficiency is in contrast to the deeper yellow of chlorosis in magnesium and nitrogen deficiencies. Foliage should be examined for symptoms of deficiency following the completion of needle growth in July and before the onset of autumn dormancy in early September. Symptoms observed outside this period may be reflections of mineral redistribution, which occurs before needle abscission in autumn. Also, the symptoms may or may not develop during the early part of the growing season before needles have attained their full size and activity.

Acknowledgements

The illustrations were prepared by Edward Groenhout, art student, University of Montana, whose efforts are appreciated.

Literature Cited

1.) Behan, M. J., 1968 (a). The effect of mineral supply, season, crown position, and needle type on the foliar mineral content of western larch. *(Larix occidentalis,* Nutt.). Manuscript.

2.) ———— 1968 (b). Fertilization in western larch forests. Montana Forest & Conservation Station Note Six, University of Montana, Missoula.

3.) Hewitt, E. J., 1966. Sand and water culture methods used in the study of plant nutrition. Tech. Comm No. 22, Commonwealth Bur. of Hort. and Plantation Crops. East Malling, Maidstone, Kent, England.

4.) Ingestad, T., 1962. Macro element nutrition in pine, spruce, and birch seedlings, in nutrient solutions. Medd. Skogsforskn-Inst., Stockh. *51* (7): 1-150.

5.) Mustanoja, K. J. and A. L. Leaf, 1965. Forest fertilization research, 1957-1964. Bot. Rev. *31*:151-246.

6.) Swan, H. S. D., 1960. The mineral nutrition of Canadian pulpwood species. Tech. Report 168, Pulp and Paper Res. Inst. of Canada, Montreal. 66 pp.

7.) Tamm, C. O., 1964. Determination of the nutrient requirements of forest stands. Internat'l Rev. Forest Res. *1*:115-170.

8.) Walker, R. B., 1963. Personal communication. Dept. of Botany, Univ. of Wash., Seattle.

9.) Wallace, T., 1961. The diagnosis of mineral deficiencies in plants. Chem. Publ. Co. New York.