MANAGEMENT OF NUTRITION TO CONTROL PLANT PATHOGENS

Don M. Huber
Botany & Plant Pathology, Purdue University, West Lafayette, IN 47907

Disease is the expression of the interaction of the plant, the pathogen, and the environment (Figure 1); and disease control is most effectively achieved when the interacting factors of these three primary components are recognized and understood. Mineral nutrients comprise a major factor of the environment involved in disease because the nutrition of the plant determines in large measure plant resistance or susceptibility, and the virulence and ability of pathogens to survive. The immobilization of nutrients which the plant needs to synthesize chemical and physical barriers by pathogens or saprophytic microorganisms in the environment or infection court may result in a plant being susceptible to disease. In contrast, the absence of a specific nutrient required by an organism for pathogenic activity may be manifest as resistance or disease escape. Thus, nutrition, although frequently not recognized, always has been an important factor in disease control.

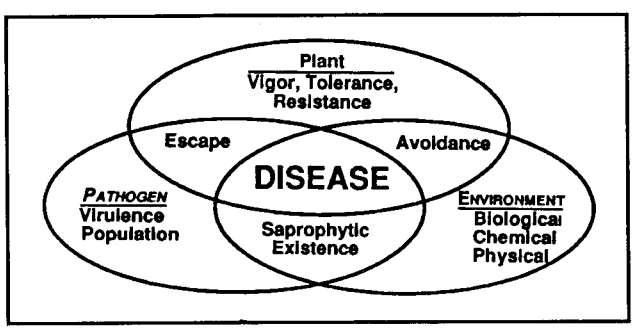

Figure 1. Interactions determining the severity of plant diseases

Cultural tactics for disease control such as crop sequence, organic amendment, liming for pH adjustment, tillage, and irrigation frequently influence disease through increasing or reducing the availability of various nutrients. These practices may supply nutrients directly or influence their solubility or availability through altered microbial activity. Many plant diseases have been effectively controlled by integrating the effects of specific mineral nutrients and the cultural practices which influence them with genetic resistance, sanitation, and chemical controls. Although it is clear from the 1,180 reports of the effects of mineral nutrients on disease (Table 1) that all of the essential mineral elements may influence some disease and that no nutrient controls all diseases or favors disease control on all plants; the severity of most diseases can be greatly reduced by proper nutrition. The chemical, genetic, or biological control of most diseases can be improved by manipulating the availability of specific nutrients directly or through cultural practices.

Table 1. Reported effects of nutrients on disease[1].

	Disease is:		
Mineral Element	Decreased	Increased	Variable Effect
Nitrogen (N/NH4/NO3)	168	233	17
Phosphorus	82	42	2
Potassium	144	52	12
Calcium	66	17	4
Manganese	68	13	2
Copper	49	3	0
Zinc	23	10	3
Boron	25	4	0
Iron	17	7	0
Sulfur	11	3	0
Magnesium	18	12	2
Silicon	15	0	0
Chloride	9	2	8
Other	27	4	0

[1]Based on 1,180 reports in the literature.

Considerations in managing plant diseases by nutrition include: 1) the level of resistance (highly susceptible, tolerant, resistant, or immune) of the cultivar to be grown; 2) whether the nutrient status is deficient, sufficient, or excess; 3) the predominant form and biological stability of a nutrient which is available or applied; 4) the rate, time, and method of nutrient application; 5) the source of an element and associated ions; and 6) integration of nutrient amendment with other cultural practices influencing plant growth, nutrient availability or pathogenic activity. The greatest disease suppression with nutrient amendments generally is with tolerant or resistant cultivars since highly susceptible cultivars may not have the physiological defense regulated by a specific mineral ion, and cultivars immune to a particular disease may be highly efficient in nutrient uptake or function.

Examples can be given where a deficiency or an excess of a particular nutrient will reduce disease severity; however, the greatest differences are generally observed when going from a deficient to a fully sufficient level of nutrition for the plant. Different forms (oxidized or reduced) of a nutrient may have opposite effects on a specific disease because of different metabolic pathways or sustained availability. This is especially true for nitrogen, manganese, and iron. Multiple fertilizer applications to reduce the amount applied at any one time, or application after (or before) the most conducive environmental conditions for disease may permit fertilization for optimum yield and the control of one disease without predisposing to another disease which may be influenced in an opposite manner by the same nutrient element. Integration of nutrient amendment with cultural practices such as tillage, crop rotation, seeding rate, and pH adjustment can accentuate the benefits of the nutrient amendment by modifying the environment for plant growth or microbial activity.

One of the predominant effects of disease is alteration of the nutrition of the plant, and it is sometimes difficult to clearly differentiate between the biotic and abiotic factors which interact to cause a nutrient deficiency or excess. Pathogens such as *Gaeumannomyces graminis* var *tritici* (take-all root and crown rot of cereals) and *Pyricularia grisea* (rice blast) which are able to oxidize manganese to the Mn^{+4} form which is not physiologically available for the plant in the infection court, block the plants defensive reactions to fungal penetration. Resistance to these diseases is associated with increased nutrient uptake efficiency and insensitivity to the fungal oxidative enzymes so that physiological mineral sufficiency is maintained for defensive reactions to block fungal invasion. The increased availability of a nutrients or stimulated root growth following fertilization may off-set the reduced nutrient absorption efficiency caused by root or foot rot fungi. Some nutrients can inhibit virulence of pathogens or reduce their multiplication and survival directly or through induced biological control.

Nutrient management for plant disease control must meet potential crop needs for efficient production, and be economically feasible and environmentally sound. Nutrient availability for the plant will depend on the level of residual nutrient in the soil, rate and time of fertilizer application, specific microbial activity, seasonal losses, efficiency of the plant, and general health of the plant. Nutrient losses can be reduced by applying only the amount required during various growth stages of the plant, avoiding applications during high loss periods, or by modifying the chemical or biological environment influencing nutrient availability.

The severity of most diseases can be reduced by improved management of mineral nutrition. This can be achieved by modifying the availability of particular nutrients or by improving the uptake efficiency and utilization by the plant. Nutrient availability is modified by fertilizer amendment, changing the environment (pH, moisture, etc.), plant density, specific crop sequences, and tillage and seed bed preparation. Nutrient uptake efficiency can be increased by modifying root morphology, kinetics of ion uptake, or rhizosphere biology. When effectively used, this cultural control of plant disease can greatly improve crop production efficiency.

REFERENCES

Engelhard, A.W. (ed). Soilborne Plant Pathogens: Management of Diseases with Macro- and Microelements. American Phytopathological Society, St. Paul, MN.

Epsteim. E. 1994. The anomoly of silicon in plant biology. Proc. Natl. Acad. Sci. USA 91:11-17.

Graham, R.D. 1983. Effect of nutrient stress on susceptibility of plants to disease with particular reference to the trace elements. Adv. Bot. Res. 10:221-276.

Graham, R.D. and M.J. Webb. 1991. Micronutrients and disease resistance and tolerance in plants. pp 329-370. In: R. M. Welch (ed). Micronutrients in Agriculture, 2nd Edition, Soil Sci. Soc. America, Madison, WI.

Hodson, M.J. and E.E. Evans. 1995. Aluminum-silicon interactions in higher plants. J. Expt. Botany 46:161-171.

Huber, D.M. 1980. The role of mineral nutrition in defense. pp 381-406. In: J.G. Horsfall and E.B. Cowling (eds). Plant Disease, An Advanced Treatise, Vol. 5, How Plants Defend Themselves, Academic Press, New York.

Huber, D.M. 1990. Fertilizers and soilborne diseases. Soil Use Manage. 6:168-173.

Huber, D.M. 1991. The use of fertilizers and organic amendments in the control of plant disease. pp 405-494. In: D. Pimentel (ed). Handbook of pest Management in Agriculture, Vol. I, 2nd Edition, CRC Press, Boca Raton, Florida.

Huber, D.M. and D.C. Arny. 1985. Interactions of potassium with plant disease. pp 467-488. In: R.D. Munson (ed). Potassium in Agriculture, American Soc. Agronomy, Madison, WI.

Huber, D.M. and T.S. McCay-Buis. 1993. A multiple component analysis of the take-all disease of cereals. Plant Disease 77:437-447.

Huber, D.M. and R.D. Watson . 1970. Effect of organic amendment on soilborne plant-pathogens. Phytopathology 60:22-26.

Huber, D.M. and R.D. Watson . 1974. Nitrogen form and plant disease. Ann. Rev. Phytopathol. 12:139-165.

Huber, D.M. and N.S. Wilhelm. 1988. The role of manganese in resistance to plant diseases. pp 155-173. In: Graham, R.D., R.J. Hannam, and N.C. Uren (eds). Manganese in Soils and Plants. Kluwer Academic Publishers, Dordrecht, The Netherlands.