A role for nickel in the resistance of plants to rust

Robin D. Graham, Ross M. Welch' and Colin D. Walker

Department of Agronomy, Waite Agricultural Research Institute,
Glen Osmond, South Australia 5064.
'U.S. Nutrition Laboratory, Tower Road, Ithaca, N.Y. 14853, U.S.A.

Eskew *et al.,* (1) have recently described a physiological disease, leaf tip necrosis (LTN), of cowpeas and soybeans due to nickel deficiency. The necrosis is due to accumulation of high concentrations of urea in Ni deficient plants owing to low levels of the Ni enzyme, urease. Previously, Forsyth and Peturson (2) had described the eradicative and prophylactic effects of topical applications of Ni on leaf and stem rusts of wheat. Such effects may have been due to the direct toxicity of high concentrations of Ni on the fungus. The new capability (1) of lowering plant Ni concentrations so low as to cause physiological disease prompted us to challenge such plants with rust spores to see if the effects of Ni could be expressed at physiologically meaninful concentrations attained through absorption by roots.

Methods

Cowpeas were cultured in specially purified solutions in a dust-free growth cabinet following the methods of Eskew *et al.,* (1). Ni was supplied to control plants at 3.3 uM as NiEDTA or omitted. When LTN was widespread at 55 days, indicating Ni stress in no-Ni treatments, three leaflets on each of two plants in each of three replicate pots of both treatments were painted to saturation with a 0.1% suspension uredospores of *Uromyces phaseoli* var. *vignae.* Numbers of necrotic lesions were counted 8 days later. At harvests prior to inoculation, leaf urea (56 days) and Ni concentrations (42 days) were determined by standard techniques (1).

Results and Discussion

Ni Supplied	LTN	No. of rust lesions/leaflet	Leaf urea (umole g^{-1} d.m.)	Leaf Ni. Concn. (ug g^{-1})
0	+	904 ± 112 ***	4.0 ± 0.6	0.03
3.3	-	422 ± 70	0 (n.d.)	1.04

Standard errors follow ± ; n.d., not detectable.

The results in the table above show that a high rate of fungal germination and penetration was associated with recognised physiological features of Ni-deprived plants: low tissue Ni concentration, high urea concentration, and LTN. This leads to the hypothesis that Ni at physiological concentrations is acting on host plant resistance, that is, Ni is involved in a biochemical pathway leading to resistance to the pathogen. The implications of such an hypothesis for rust control on crop plants in southern Australia are considerable since large tracts of trace element deficient country potentially low in Ni are sown to cereals on which rusts are serious pathogens.

1. Eskew, D.L., Welch, R.M. and Cary, E.E. 1983. *Science 222,* 621-3.

2. Forsyth, F.F. and Peturson B. 1959. *Phytopathology* 49, 1-3.