P module uptake

the demand for P is created by the difference between the current P content of the plant and an Optimum content. This latter decreases as the development of the plant proceeds

Mathematically, the potential P uptake rate is simulated as follows:

The daily rate of P uptake is controlled either by crop demand or by its ability to take up P from the soil. The daily crop demand for P is the difference between the actual plant P content and the optimum P content for that day. This is mathematically expressed as follows:

: The total P demand rate of the plant (in M P/L2/T) = : Potential P uptake rate (in M P/L2/T)

is the accumulated crop dry matter (in M /L2). (practically, it is the sum of accumulated plant dry matter for seed, leaves, stems and roots (i.e. + + ).

the actual P crop content (in M P/L2).

the optimal P concentration dependent on development plant stage (in M P/M dry matter) and could be calculated as follows:

: Heat unit index (-). It is given as follows:

Where:

: potential heat unit of crop (°C)

: actual time (day)

: initial time corresponding to crop emergence (day)

: time step (day)

: average daily temperature (°C)

: crop specific base temperature below which crop growth ceases (°C)

: crop parameters expressing optimal P content dependent on plant development stage.

The potential P uptake rate is further divided in a diffusive and convective fraction. Given the fact that most of P plant demand (> 93 %) is supplied by “Diffusion” and not by “mass flow or convection”.Source: Table 3.2 (page 59) from book Growth and Mineral Nutrition of Field Crops.

The potential diffusive P uptake rate, (in M P/L2/T) from the rooting depth () should then be calculated as follows:

Where:

: the root density at the layer “*i*” (in L/L3)

: mean root radius (L)

: P diffusion coefficient (L2/T) in soil solution :

: labile P concentration (M P/L2)

: the rooting depth at layer i (L)

: volumetric water content in i soil layer ( . (a variable calculated by the water transport module)

: the travel distance resistance between the bulk soil solution and the root (L). it is usually in the range of 0.1-15 mm

Assuming that the amount of P supplied by mass flow () should not exceed a maximum threshold, for example 5% of the total potential uptake rate of P (), the potential P uptake rate by mass flow, (in M P/L2/T), from the whole rooting depth () can then be deduced as follows:

Hence, based on aforementioned equations, the actual rate of P plant uptake, (in M P/L2/T), is calculated as follows:

**Remark:** The principal forms for P uptake by plant are H2PO4-, HPO4-2. The diffusion coefficient “” for H2PO4- in soil solution is 2.4 x10-11 (cm2/sec). Source: Table 3.3 (page 60) from book Growth and Mineral Nutrition of Field Crops.

**Remark:** To meet dimension analysis, the equation **23** was adapted from equations reported in WAVE model (page 108). ( probably need to be verified again!)