

AGRY 515 2008

- 1 Dimensional Models
- Radial Models
- Cushman-Barber (DOS) Model
 - W drive – AGRY515: copy 3 files
- NPK Model
 - <http://www.qpais.co.uk/npk/>
- New Homework #3 deadline: Due Dec. 9 5pm (no exceptions!!)

Fig. 1. Models: are theory; theory isn't always right ... need data for calibration and verification

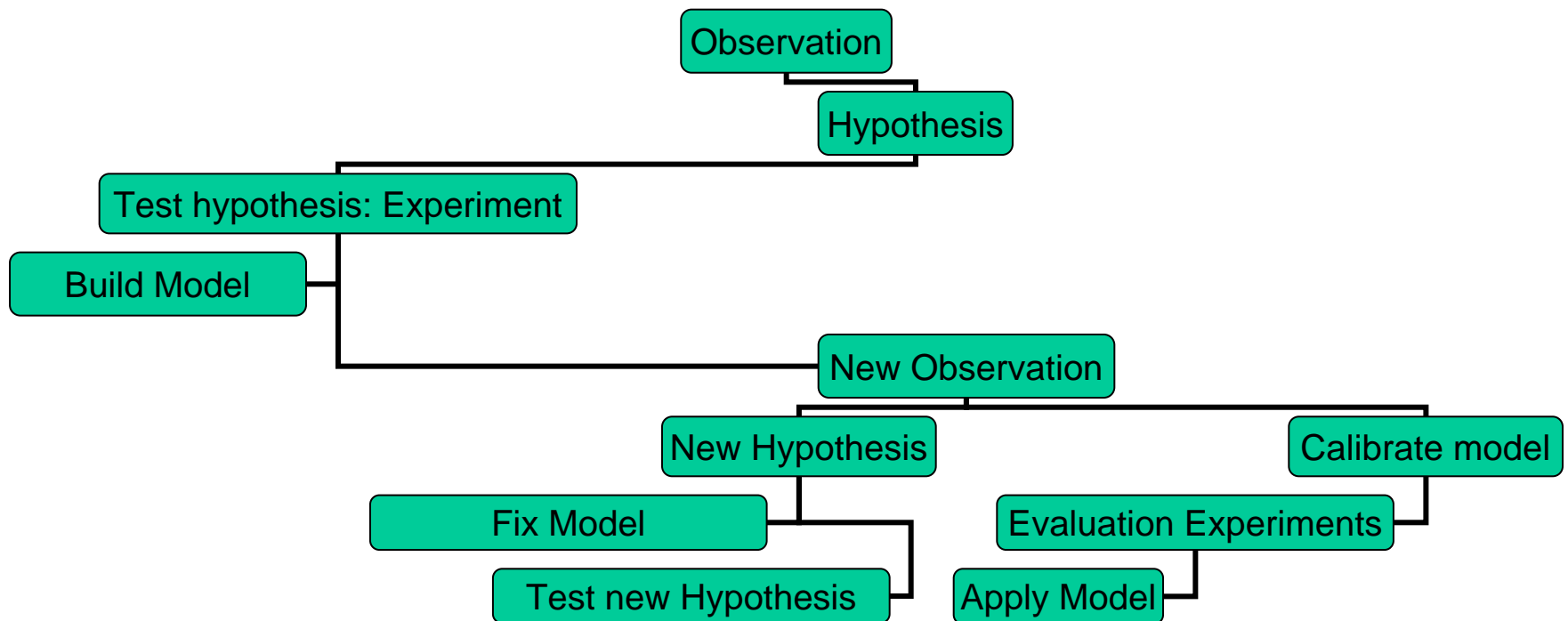


Fig. 2. Schematic of basic elements of soil-root system

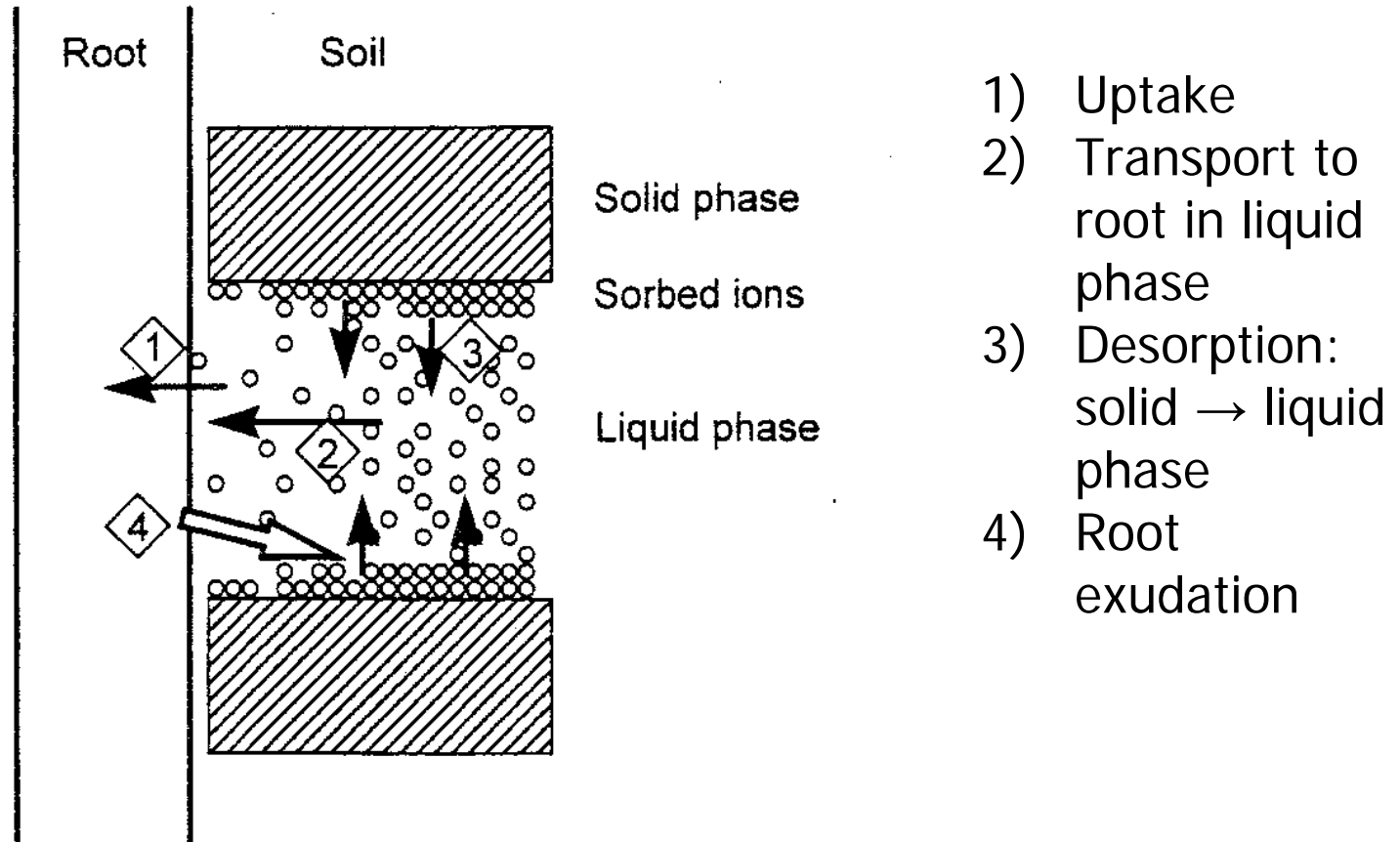


Table 1.

Table 1 Processes Involved in Nutrient Transfer from Soil to Plant and Factors Affecting Them

Processes	Factors
Root development	Root length Root distribution Root morphology (architecture, diameter, hairs)
Nutrient uptake	Concentration at root surface Kinetics of uptake
Transport from soil to root mass flow, diffusion	Transpiration Concentration of soil solution Concentration gradient Diffusion coefficient
Mobilization by roots desorption, dissolution hydrolysis of org. compounds	Depletion of soil solution Root exudates (H^+ / OH^- ions, reducing agents, carboxylates, chelates) Chemical soil composition (pH, humus, minerals) Physical soil properties (texture, density, hardness)
Mobilization by associated organisms	Soil biology Mycorrhizal infection Bacteria

Fig. 3. Schematic of 1 dimensional model for "n" soil layers

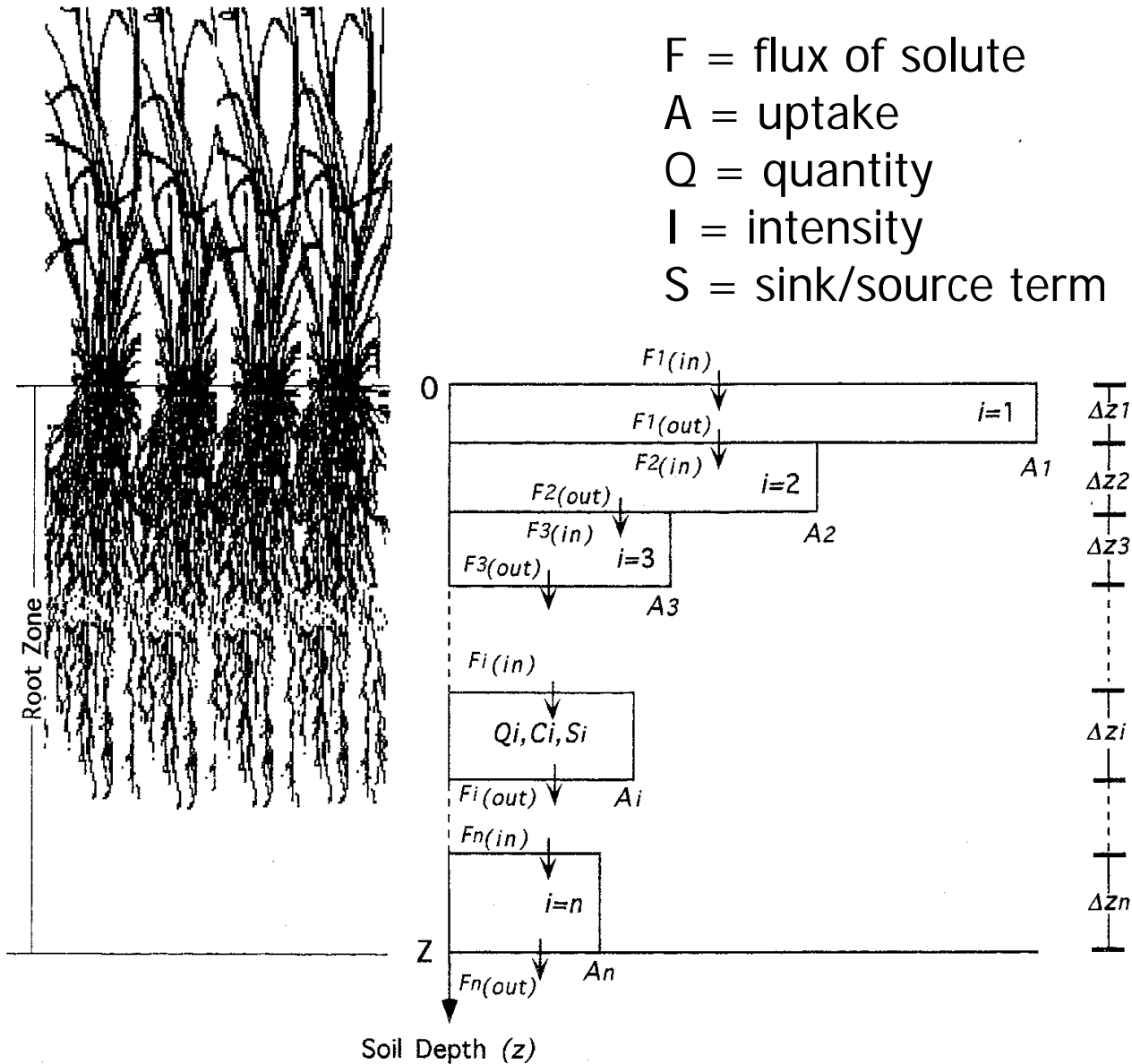


Fig. 4. Radial flux models: Smooth cylinders for roots and root hairs.

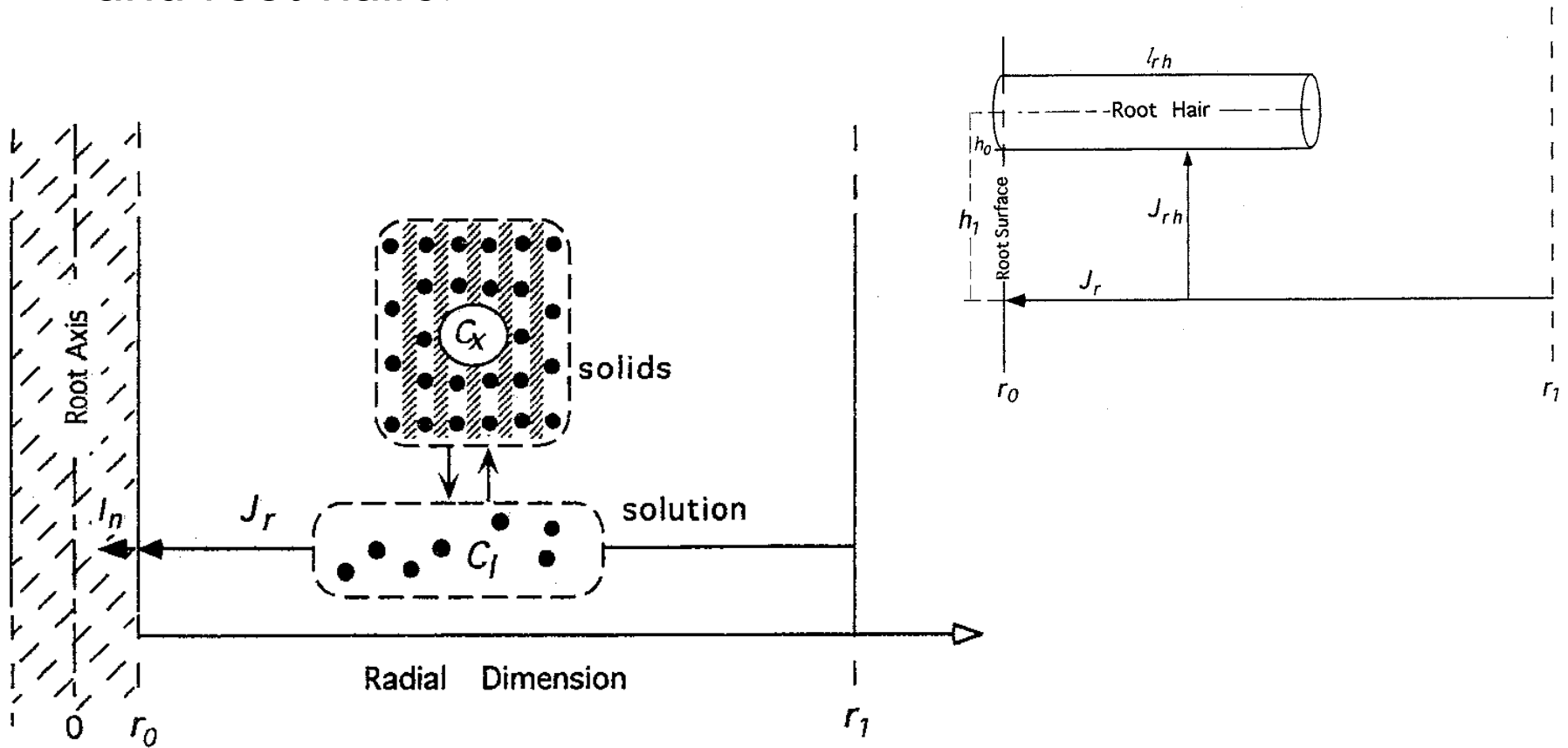


Fig. 5. Schematic of radial flux model such as Cushman-Barber Model

Flux from soil = Influx into plant

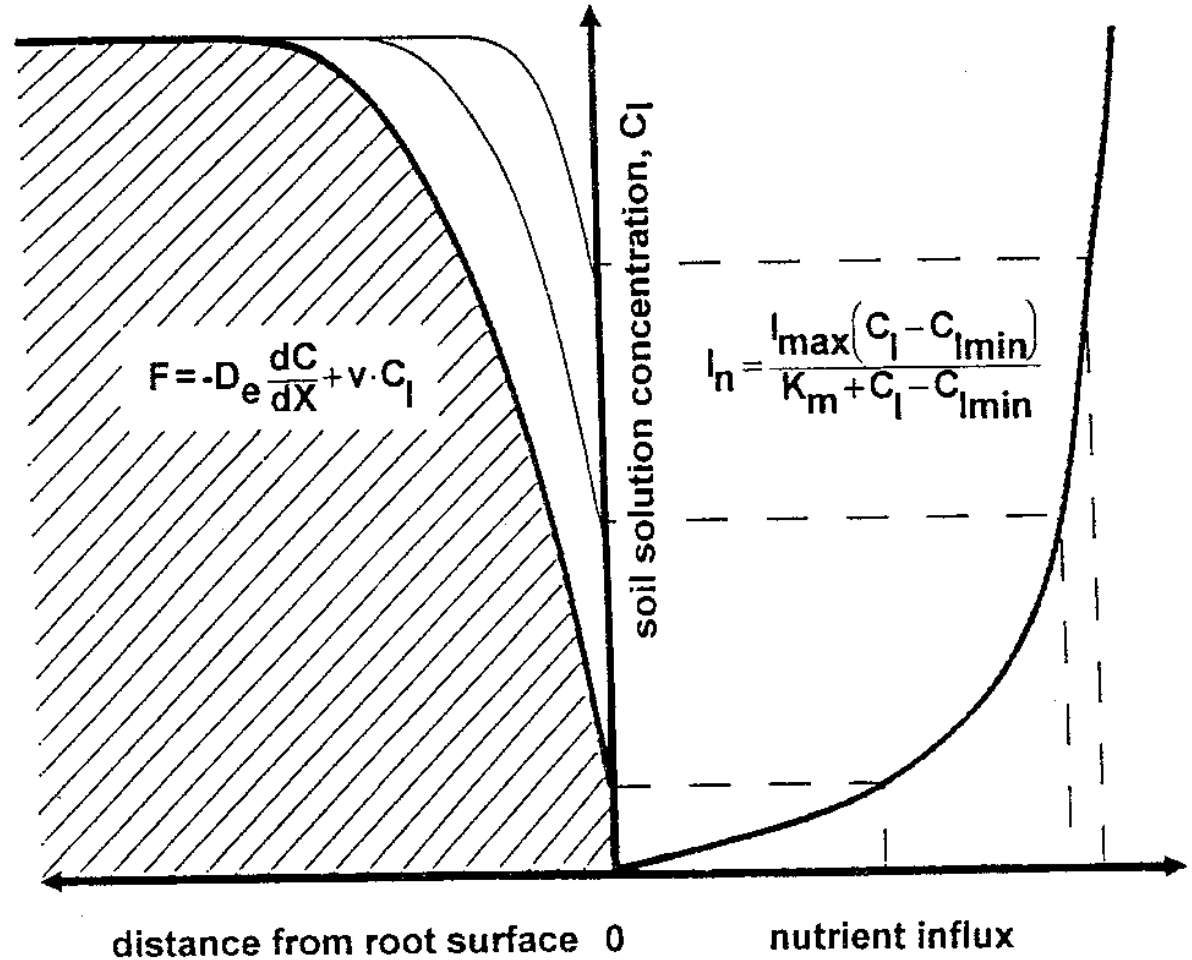


Table 2.
Input
parameters
for the C-B
model

Table 1. Soil and plant parameters and their symbols for the Cushman-Barber model.

Symbol	Parameter	
D_e	Effective diffusion coefficient in bulk soil	Describes nutrient-ion movement to the root surface by diffusion and mass flow
b_1	Soil buffer power	
C_{li}	Initial ion concentration in the soil solution	
v_o	Water influx at root surface	
r_o	Mean root radius	Describes degree of root exploration of a soil volume during the uptake period
r_1	Half distance between roots	
k	Root growth rate	
L_o	Initial root length	
I_{max}	Maximum influx rate	Michaelis-Menten kinetics relate soil solution-phase ion concentration to ion influx per unit root surface area
K_m	Concentration- C_{min} when influx= $0.5(I_{max})$	
C_{min}	Soil solution concentration where net influx=0	

Derived from: Barber, 1995,
Soil Nutrient Bioavailability

Guide 1. Acquiring C-B Input Parameters

- D_e , b , C_{ij} – refer to your notes from early in the class
- v_0 – net water uptake from soil
 - Grow plants in container w/ no plant control
 - Weigh all containers on a daily basis
 - Record all water added
 - Water flux into the plant will be difference between treatments
 - Need to subtract out the weight of the growing plant (How can you do this?)

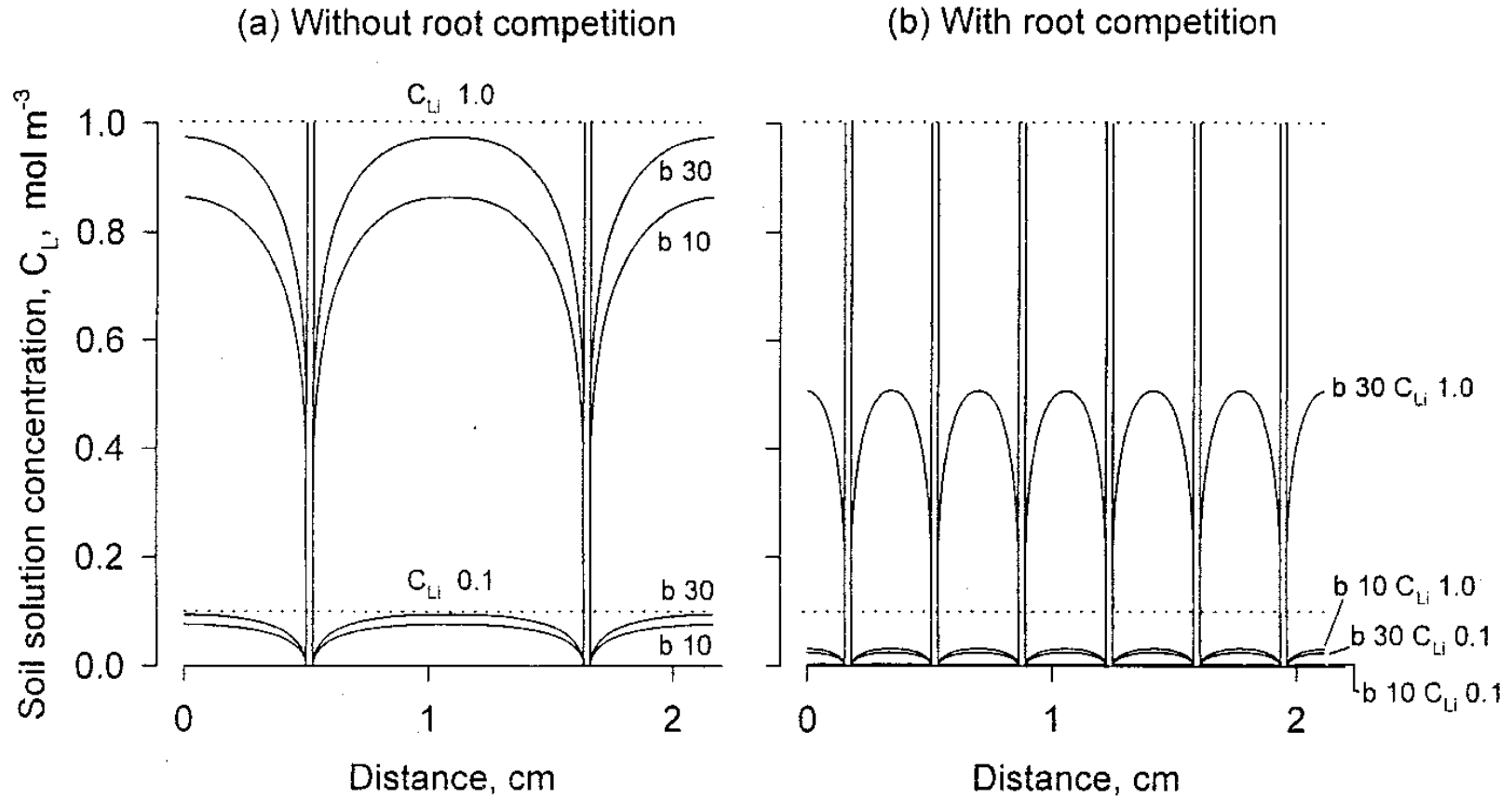
Guide 2. Acquiring C-B Input Parameters

- L_0 – measure length at the start of the experiment (using “0” can be problematic)
- k – Estimated from L_0 and L_{end} . Need to make assumption about how root length develops (linear, exponential, sigmoidal):
 - Linear: $k = (L_{\text{end}} - L_0) / (t_{\text{end}} - t_0)$
 - Exponential: $L_{\text{end}} = L_0 e^{kt}$
 - Exp. Working: $k = (\ln L_{\text{end}} - \ln L_0) / (t_{\text{end}} - t_0)$
note: can't start with initial length of zero if using this equation to solve for k .

Guide 3. Acquiring C-B Input Parameters

- r_1 – half distance between roots
 - $r_1 = [1 / (L_v \pi)]^{1/2}$ where L_v is the root length density (root length per unit soil volume)
 - the greater the root length you have, the greater the inter-root competition
- r_0 – mean root radius
 - This can be a direct measurement but you have to be careful about the value that you choose to use.

Fig. 6. Schematic of the effect of maize root density / root competition on K conc in soil sol'n after 10 d of uptake (shown for 2 initial K conc and 2 buffer values)



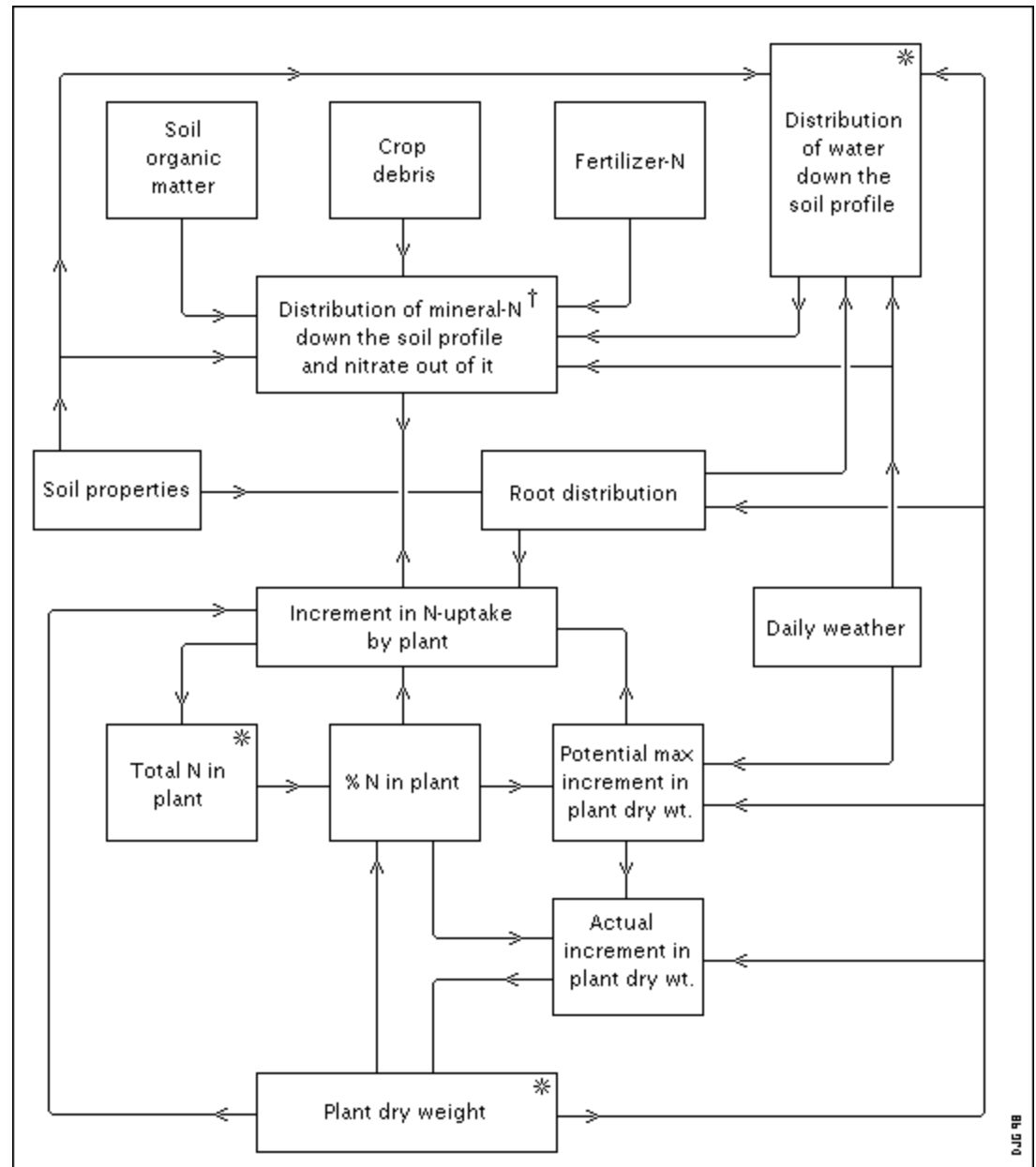
Guide 4. Acquiring C-B Input Parameters

- M-M parameters:
 - Solution depletion technique (hydroponic experiment)
 - Plot nutrient in solution as a function of time for a fairly short period of time
 - Estimate slopes of the figure for uptake rate as a function of concentration
 - Use parabolic or cubic spline equation to fit curves
 - Differentiate equation to find influx as a function of time
 - Plot influx as function of conc. (for each time segment with a slope, plot the slope as a function of the conc. at the beginning of the time segment...
 - Fit M-M equation with non-linear regression

Fig. 7. Flow Diagram of Nitrogen Model

The meanings of the symbols are as follows:

- Boxes.** Variable quantities or in some cases, such as 'Soil properties', groups of quantities.
- Lines and arrows.** The interdependence of the variables.
- Asterisks.** Variables the initial values of which are essential for running the model.
- Dagger.** Mineral-N is (ammonium+nitrate)-N.



Information about the Nitrogen Model:

<http://www.qpais.co.uk/npk/infoindx.htm>

[Authors and
Programmers](#)

Contact details for the authors and programmers of the Model.

[A Description
of the Model](#)

A full illustrated description and a list of published [references](#).

[History of
modifications](#)

A dated list of alterations to the Nitrogen Model installation.

[Horticulture
Research
Int'national](#)

The role of HRI, its address and a link to its Web site.

[Stand-alone
version](#)

How to obtain a copy of the Model's program for your own PC.

[Why should I
care?](#)

A non-technical explanation of some important environmental issues.

[Nitrogen
Model Start
Page](#)

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Table 1 List of Water and Ion Uptake Models

Type of model	Model/authors	Characteristics	Reference	
1-D ^a	Hagin-Amberger Gardner	N transformation and uptake Water uptake	Hagin et al., 1976 Gardner, 1991	
	Rao-Mathur LEACHM	Cd transformation and uptake Chemical reactions and uptake	Rao and Mathur, 1994 Hutson and Wagenet, 1995b Jemison et al., 1994a,b	
	SNAPS	Pesticide uptake	Behrendt et al., 1995	
	TROIKA	Radial water flow to a single root	Lambert and Penning de Vries, 1973	
	Helyar-Munns	Single root with root hairs, P transformation, and uptake	Helyar and Munns, 1975 Nye and Marriott, 1969	
	Nye-Marriott	Radial convection-diffusion flow and uptake by roots, extendible r_1 ^b	Nye and Marriott, 1969	
	Baldwin-Nye-Tinker	Radial convection-diffusion flow	Baldwin et al., 1973	
	Bhat-Nye-Baldwin	Baldwin's model + uptake by root hairs	Bhat et al., 1976	
	Claassen-Barber	Extendible r_1 (without competition)	Claassen and Barber, 1976	
	Barber-Cushman ("Nutrient Uptake")	Constant r_1 (root competition)	Cushman, 1979; Barber and Cushman, 1981; Oates and Barber, 1987	
	Itoh-Barber Bar Yosef-Fishman- Talpaz	As Barber-Cushman, with root hairs Zn uptake, different chemical forms, water depletion	Itoh and Barber, 1983 Bar-Yosef et al., 1980	
	2-D	De Willigen-Van Noordwijk Hoffland et al. COMP8	Constant and zero-sink for high and low concentrations, respectively r_1 adjusted to root density	De Willigen and Van Noordwijk, 1994 Hoffland et al., 1990
Cushman, 1980		As Baldwin-Nye-Tinker; variable buffer power, variable r_1 , competition between plant species hairs or microorganisms)	Smethurst and Comerford, 1993, Ibrikci et al., 1998 Cushman, 1980	
Leadley-Reynolds-Chapin		Barber-Cushman + sink/source (root uptake)	Leadley et al., 1997	
Bouldin		As Barber-Cushman, N components' uptake	Bouldin, 1989	
Reginato et al. NST 3.0		Multi-ions without interaction, linear influx functions	Reginato et al., 1990 Claassen, 1990.	
Silberbush-Sorek- Yakirevich Yanai		Adjusted r_1 , multi-ion uptake, interactions among ions, salinity depletion and steady-state ion influx, root competition	Silberbush et al., 1993 Yanai, 1994; Williams and Yanai, 1996	
2DSOIL		Modular set of models; includes transport, uptake, exchange between phases	Timlin et al., 1996; Acock and Pachepsky, 1996	
3-D		Geelhoed et al.	Exudation of protons and citrate	Geelhoed et al., 1999
		Geelhoed et al.	Uptake by root hairs, zero sink	Geelhoed et al., 1997a,b
		Somma et al.	Solute transport and uptake, and root growth, using finite-element technique	Somma et al., 1998

^aOne-dimensional (vertical) model.^bThe external boundary of the soil rhizocylinder.