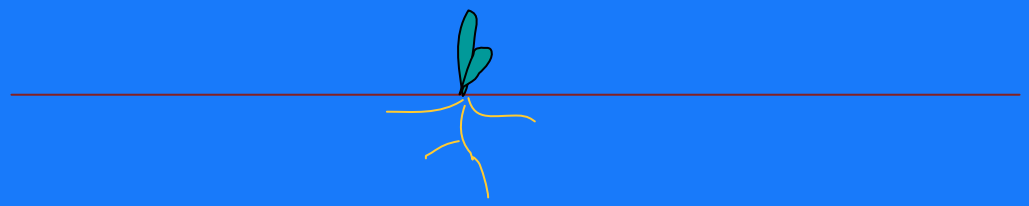
Fine Root (<0.5 mm diameter) Adaptation to Stress



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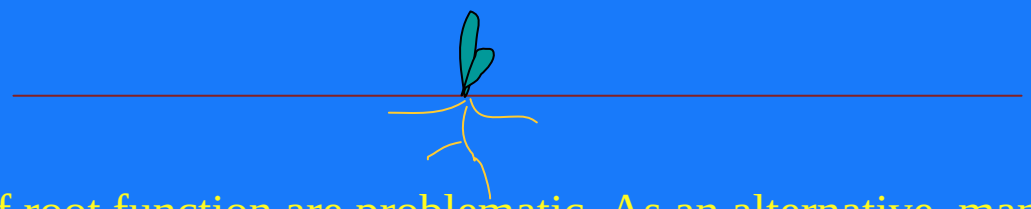
Fine Root (< 0.5 mm diameter) Adaptation to Nutrient Stress



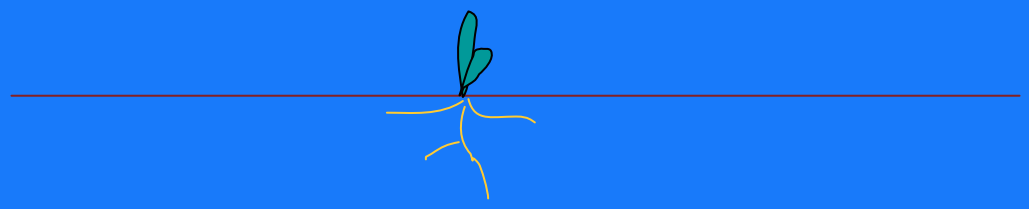
In-Situ studies of root function are problematic. As an alternative, many studies attempt to relate observable and measurable root morphologies and anatomies to root function. One of the most successful relationships has been Specific Root Length (SRL - length of root per unit root biomass). To be efficacious, SRL requires that two basic assumptions be met:

a) Root mass density (mass of root per unit root volume), is not affected by the treatments or environmental perturbations.

b) Root diameter does not change in response to treatments or environmental perturbations.

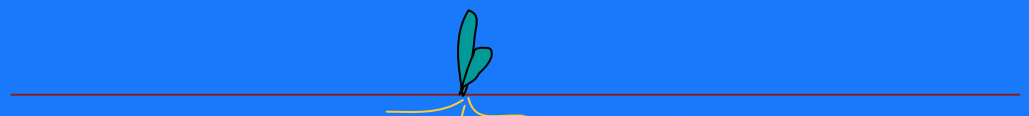
Data sets from experiments with a number of species will be presented. These two critical assumptions will be shown to be invalid, and alternatives discussed.

First Assumption Stated as an Hypothesis



H0: Root mass density (mass of root per unit root volume), is not affected by treatments or environmental perturbations.

In Chicory (*Cichorium intybus* L.), phosphorus status can induce different root mass densities.

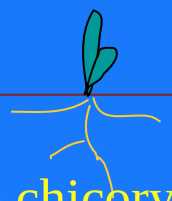


		Total length	SRL	Average Diameter	Dry-mass volume^{-1}
Cultivar	P Treatment	cm	cm gm^{-1}	mm	gm cm^{-3}
GP	-P	1913	13.57	0.316	0.955
GP	+P	1345	7.36	0.372	1.288
LC	-P	1690	13.35	0.311	1.007
LC	+P	1810	10.61	0.313	1.276
FF	-P	1142	8.10	0.379	1.124
FF	+P	1567	10.85	0.337	1.118
	LSD_{05}	433	3.74	0.053	0.215
ANOVA	Cultivar	*	**ns**	*	**ns**
	P Treatment	**ns**	**ns**	**ns**	**
	Interaction	**	**	*	*

ns = Not Significant; * = Significant at P<0.05; ** = Significant at P<0.01
GP = cv. Grasslands Puna; LC = cv. La Certa; FF = cv. Forage Feast

Adapted from: Zobel, R.W., Alloush, G.A. and Belesky, D.P. 2006 Differential root morphology response to no versus high phosphorus, in three hydroponically grown forage chicory cultivars Env. Exp. Bot (In Press)

Meso-Diameter Class



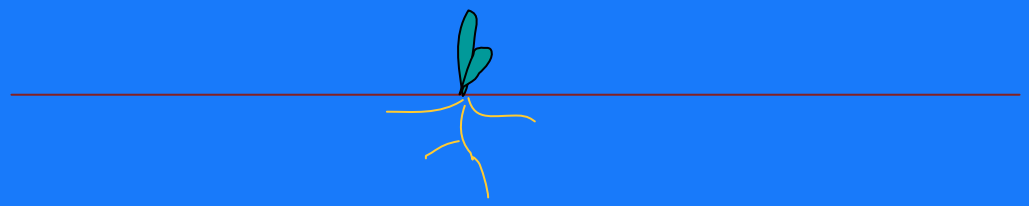
The Zobel et al. (2006 - Table 3) chicory data for diameters less than 1.0 mm, fall into three meso-diameter classes (mDC). [0.26 mm (0.18 - 0.42 mm); 0.55 mm (0.50 - 0.58 mm); & 0.82 mm (0.66 - 0.90 mm)]

Meso-Diameter Class Length (cm)

	mDC		
	0.26 mm	0.55 mm	0.82 mm
G. Puna -P	1473	243	25.3
G. Puna +P	914	263	57.9
La Certa -P	1244	203	34.3
La Certa +P	1292	258	33.4
LSD_{05}	372	87	18.5

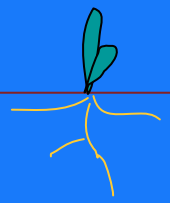
Adapted from: Zobel, R.W., Alloush, G.A. and Belesky, D.P. 2006 Differential root morphology response to no versus high phosphorus, in three hydroponically grown forage chicory cultivars Env. Exp. Bot (In Press)

Second Assumption Stated as an Hypothesis



H0: Root diameter does not change in response to treatments or environmental perturbations.

Experiments



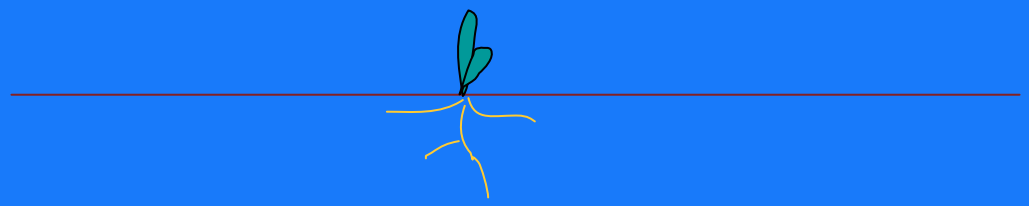
- *Theobroma cacao* L. (Cacao), grown in hydroponics at five nitrate concentrations (1.5, 3, 6, 9, 12 mM).

- *Triticum aestivum* L. cv Scout. (Wheat), seedlings grown in aerated 1 mM $CaCl_2$ solution at 4 aluminum concentrations (0, 3, 6, & 9 μM) or at 6 tannic acid concentrations (0, 1.2, 3.6, 10.8, 32.4, 97.2 mg l^{-1}).

- *Aeschynomene indica* L. (Jointvetch) and *Vigna juruana* (Harms) Verdc. (Tropical Cowpea), grown in hydroponics with three phosphorus concentrations (0.1, 1.6, 3.6 mM)).

These experiments, as presented, are subsets of larger experiments.

Materials and Methods



- Roots were washed, spread out in a layer of water on a scanner, and scanned at 47.2 p mm^{-1} (1200 dpi), unless otherwise stated.

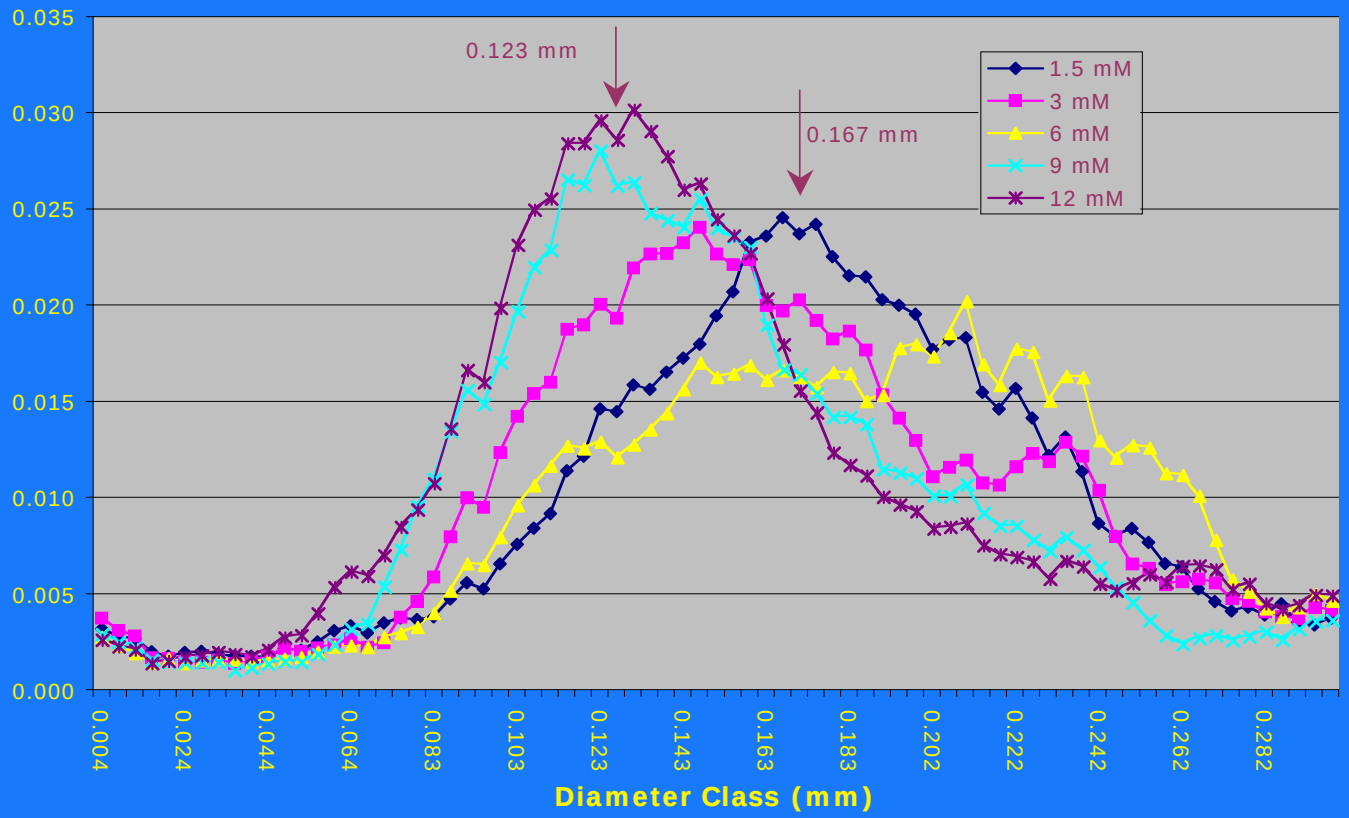
  (1 p mm^{-1} = 25.4 dpi).

- Reported Diameter Class Lengths (DCL) were normalized as a fraction of total root length.

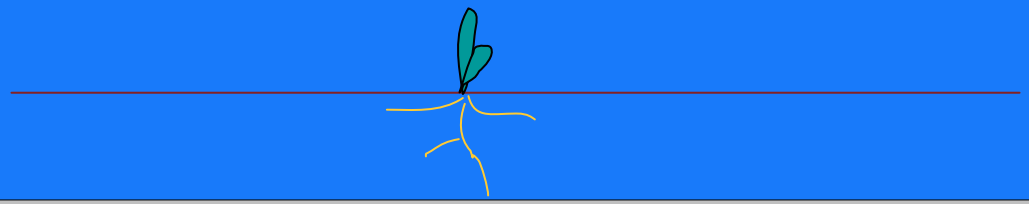
- The results were smoothed with a 5 mean traveling mean algorithm.

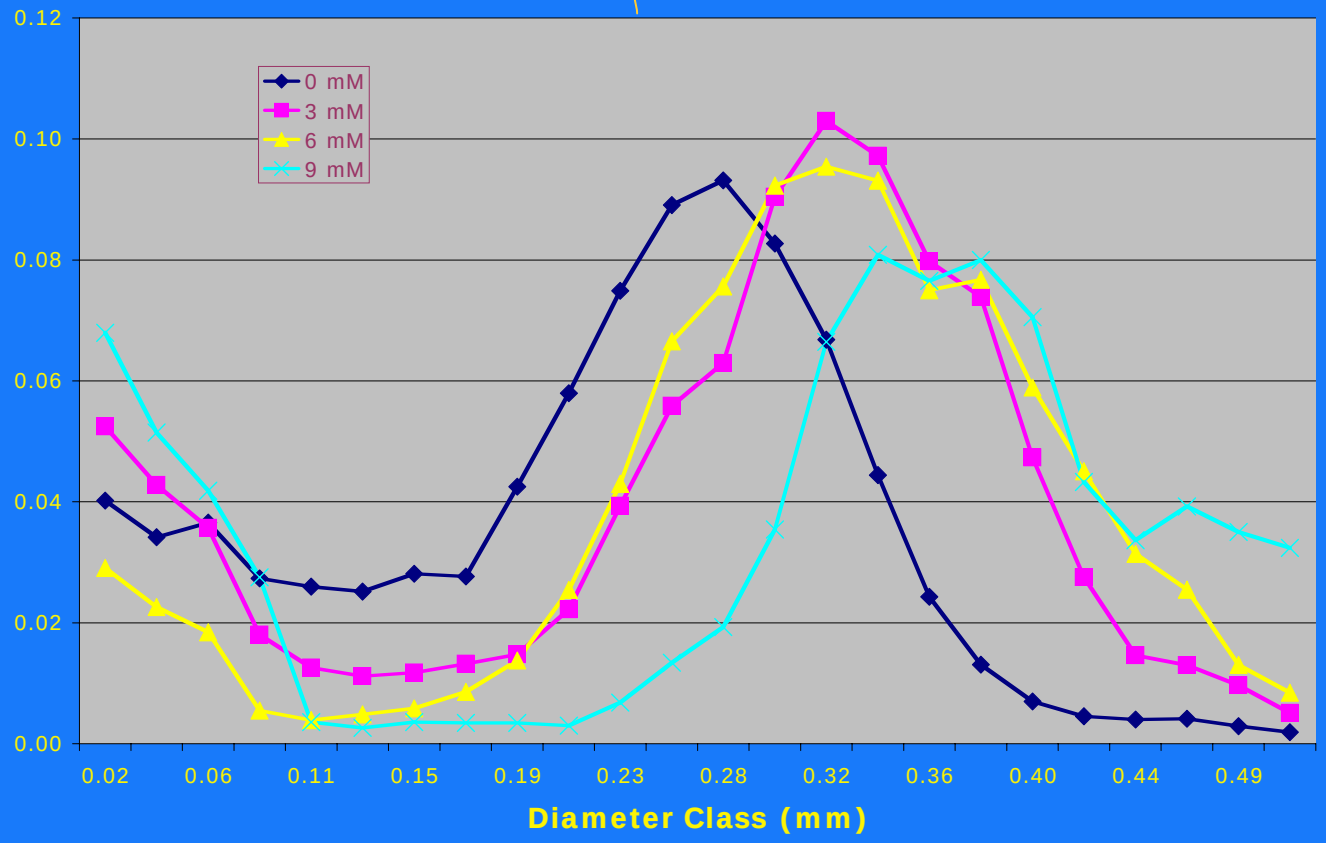
Theobroma cacao L. (Cacao), grown at five nitrate concentrations.

(Scanner Resolution = 252 p mm^{-1} - 6400 dpi)

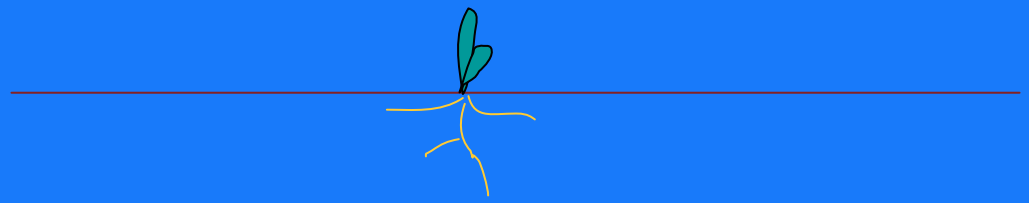


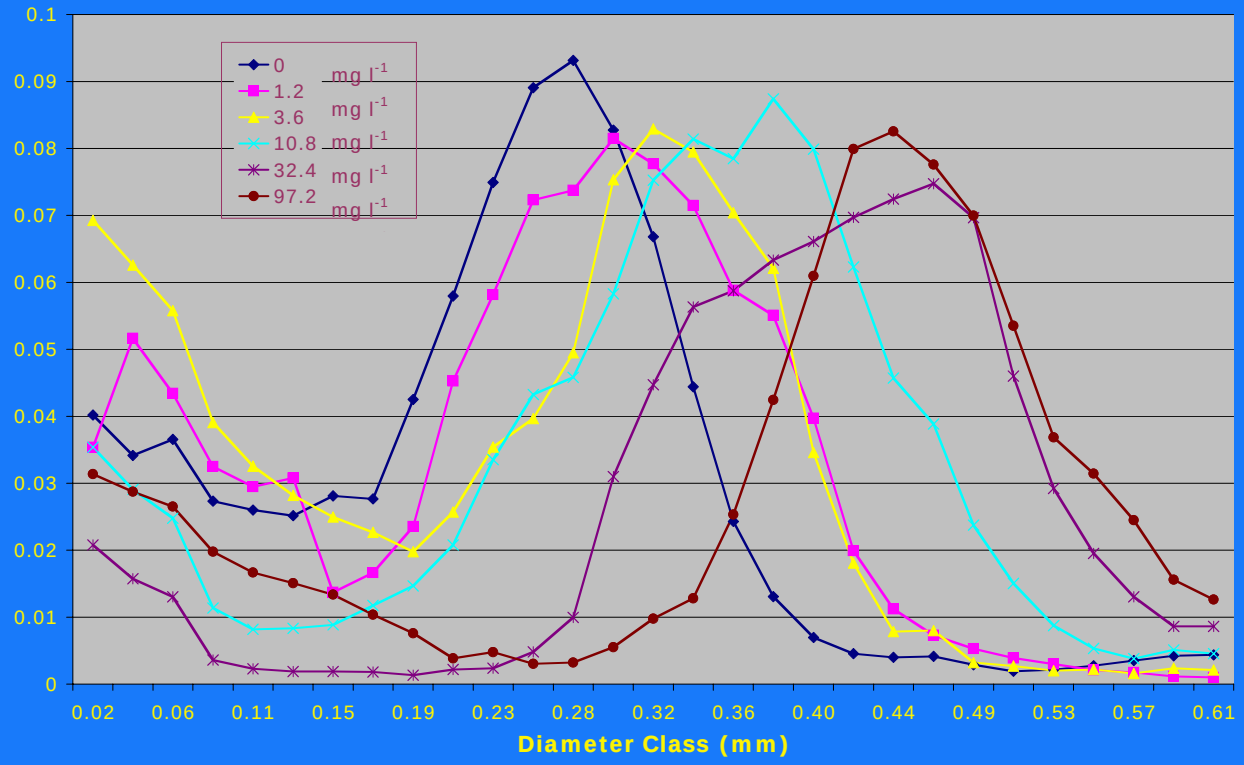
Triticum aestivum L. cv Scout. (Wheat), grown in 4 aluminum concentrations.



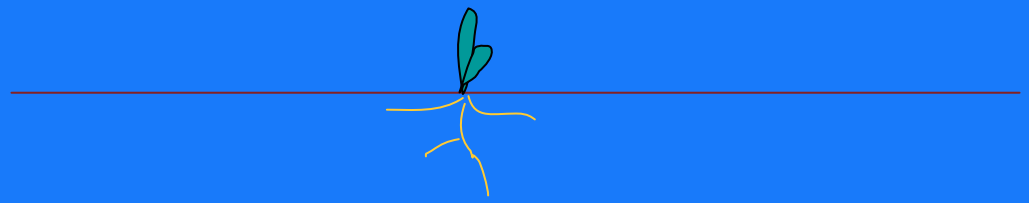


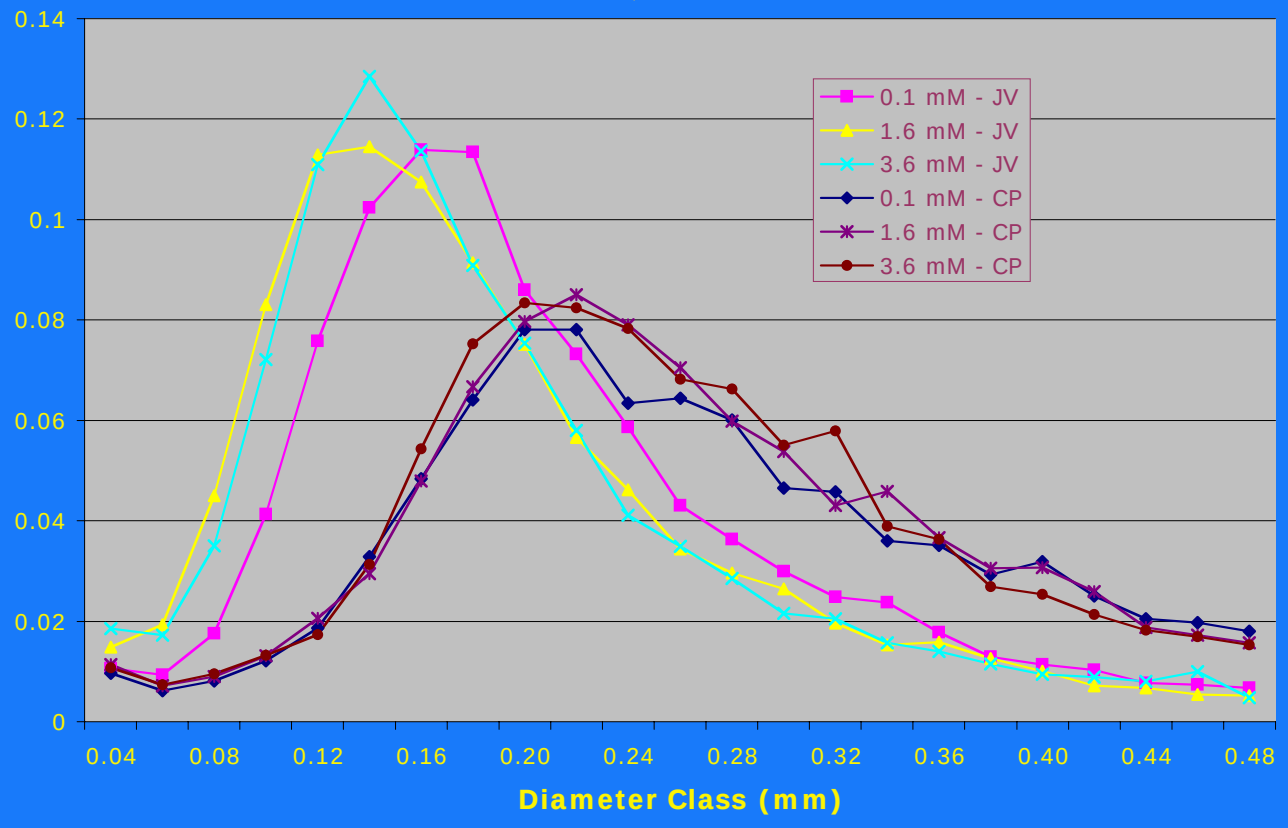
Triticum aestivum L. cv Scout. (Wheat), grown in 6 tannic acid concentrations.



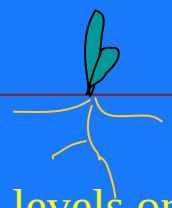


Aeschynomene indica L. (Jointvetch) and *Vigna juruana* (Harms) Verdc. (Tropical Cowpea), grown in three phosphorus concentrations.





Conclusions



In response to changes in nutrient levels or to environmental perturbations, roots of a given species/cultivar demonstrate one or more of 4 morphological response patterns:

- Increase/decrease length of one or more meso-classes of root relative to total root length
- Change diameter (increase or decrease) of one or more meso-classes of root.
- Change the mass density (increase or decrease) of one or more meso-classes of root.
- No morphological change.

(This does not exclude increasing/decreasing root hair length and number, proteoid root development, increased/decreased mycorrhizal or rhizobial infection…….)

Changes in root diameter and mass density (measured at the meso-diameter class level) must be documented in studies of root - environment and, by extension, root - microbe interactions.