Morphological characteristics of the root system of contrasting maize genotypes in relation to phosphorus efficiency under phosphorus stress

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Phosphate deficiency is a global problem, which is particularly acute in the acid soils of the tropics. The root systems of many species are able to respond to low phosphate availability by proliferating or elongating root branches, increasing root dry matter/shoot dry matter rate, increasing root length, and reducing the root diameter. These characteristics increase the absorptive surface area of the root, exploring a greater soil volume and increasing the acquisition of low mobility nutrients such as phosphorus. The inherent difficulty of analyzing and manipulating root systems is root system plasticity, i.e. the capacity to alter is configuration as a function of physical, chemical and biological soil components, and the interaction of specific root morphological traits all contribute in explaining why P acquisition efficiency is still poorly understood.

The objective of this work was to evaluate root morphological characteristics of contrasting maize genotypes under P stress. An experiment with seven contrasting genotypes for P efficiency, three inbred lines (L22, L228 and L3) and four hybrids (H1, H2, H3, H5), and two P levels (2.3 mM and 129 mM) in nutrient solution was carried out in the greenhouse at Embrapa Maize and Sorghum, Sete Lagoas, Brazil. A completely randomized block experimental 7 x 2 factorial design with three replications was used. The genotypes used were previously classified based on their grain yields as P-efficient (L228, L3, H1, H2 and H3) and P-inefficient (L22 and H5). The seedlings were grown in a 140 L plastic container with complete nutrient solution. Four seedlings of each genotype were placed in an acrylic hanging file covered with a sheet of germination paper, and placed at a 45° angle inside the container for 14 days. The recipients were filled with nutrient solution (Clark nutrient solution, modified by Magnavaca, 1982) with 2.3 mM and 129 mM P at pH 5.5, for a 60 min period during the day and a 90 min period during the nights. Root morphology evaluations, root volume, total root length, root diameter, number of seminal, nodal and lateral roots were made 4, 7, 9, 11 and 14 days following the initiation of the P treatments. The number of intersections between the roots and horizontal and parallels lines at 2 cm intervals was recorded.

The results showed that there were differences between genotypes for root morphology attributes and between P levels. The genotypes under low P, in general, had higher root/shoot ratios than the genotypes grown in solution with high P. The root total volume did not differ between the hybrids and P levels. The P efficient inbred line, L 3, had higher root volume at both P levels. The P efficient hybrids (H1, H2 and H3) and inbred lines (L 2 and L 3) had longer and thinner roots than the inefficient genotypes (H 5 and L 1) (Table 1). Genotypes grown at the low P nutrient solution had thinner roots (0.59 mm) than those grown in high P solution (0.61 mm), indicating that there was an alteration in the root system morphology, favoring the formation of thinner roots under P stress. The modifications in root system development were more intense after seven days of P treatments. The P efficient genotypes had a higher number of root intersections between 0-10 cm and 10-20 cm and a deeper root system than the inefficient genotypes, independent of the P level (Figure 1). The inbred line, L3 was superior to the other lines for the root parameters observed. These results demonstrated a differential genotype response in root morphology to phosphorus stress, being consistent with the concept of root morphology traits affecting P efficiency in maize.

Table 1. Root morphological characteristics (total length and diameter) of four maize hybrids at two P levels. (H1, H2, H3 – P efficient, H5 – P inefficient) and three maize inbred lines (L283, L3 – P efficient, L22 – P inefficient).

Genotype	Root morphological characteristics					
	Total length (m)			Diameter (mm)		
	Low P	High P	Average	Low P	High P	Average
	Maize Hybrids					
H1 (E)	8.62 ns	7.90 ns	8.26 a	0.58 ns	0.58 ns	0.58 b
H2(E)	8.23 ns	7.99 ns	8.11 a	0.53 ns	0.58 ns	0.55 b
H3 (E)	7.47 ns	7.37 ns	7.42 a	0.59 ns	0.59 ns	0.59 b
H5 (I)	5.81 ns	4.76 ns	5.29 b	0.64 ns	0.66 ns	0.65 a
Average	7.93 NS	7.19 NS		0.56 NS	0.58 NS	
	Maize Inbred Lines					
L22 (I)	1.97 ns	1.92 ns	1.94 c	0.75 ns	0.76 ns	0.75 a
L283 (E)	3.59 ns	4.37 ns	3.98 b	0.57 ns	0.66 ns	0.61 b
L3 (E)	6.68 ns	6.41 ns	6.55 a	0.54 ns	0.54 ns	0.54 c
Average	4.08 NS	4.23 NS		0.62 NS	0.65 NS	

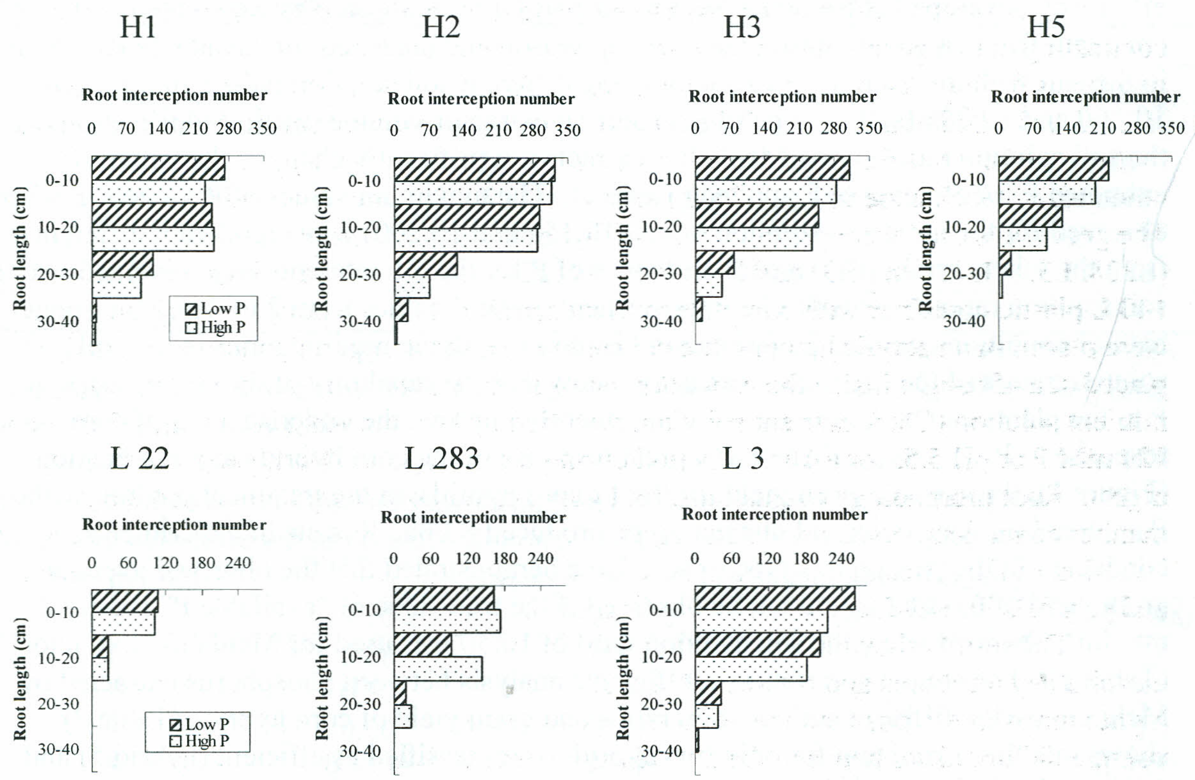

Figure 1. Number of root intersections at four root deeps (0-10, 10-20, 20-30 and 30-40 cm) at two P levels (low P – 2,9μM and high P - 129μM) for four maize hybrids (H1, H2 and H3 – P efficient; H5 – P inefficient) and three maize inbred lines (L 228 and L3 – P efficient; L 22 – P inefficient).

R. Magnavaca (1982). *Genetic variability and the inheritance of aluminum tolerance in maize (Zea mays L.). Thesis (PhD) – Lincoln, Nebraska.*