Phosphorus acquisition efficiency in maize genotypes

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Low soil phosphorus availability is one the major constraints limiting crop production in weathered soils of the tropics. Due to low P mobility in the soil, P acquisition is generally considered to be proportional to the root surface area involved in P uptake. Genetic differences in the number and length of root hairs have been identified as an important trait governing P acquisition by controlling the absorptive surface area of the root and exploring a greater soil volume. The root of plants can modify significantly the rhizosphere pH. Some studies in calcareous soils have demonstrated that the acidification of rhizosphere pH by plant roots can increase the P availability, probably by increasing the calcium phosphate solubility. However, in acid soils there is little evidence that increases in rhizosphere pH improve P availability. The principal objective of this study was to evaluate the effect of P stress on characteristics as of root hairs, rhizospheric pH and microbial metabolic diversity in maize genotypes contrasting for P efficiency.

The experiment was conducted in a Red Latosol using four maize hybrids, three P efficient (H1, H2 e H3) and one P inefficient (H5), and two levels of P (2 and 174 mg kg^{-1} P). The soil acidity was corrected, raising the base saturation to 50%. The soil (2,2 dm^{-3}) was placed in PVC rhizosphere boxes (20 cm width, 2.5 cm deep; e 50 cm high). Three uniform seedlings were planted in each box and placed at a 45° angle. The experimental design was a completely randomized with the treatment in a factorial arrangement 2 (P levels) x 4 (maize hybrids), replicated three times. At 18 days after planting, density and length of root hairs, rhizospheric pH and microbial metabolic diversity was evaluated. Eight roots segments (2 cm of each type of root; seminal, nodal and lateral) were taken from each rhizobox to measure root hairs length and density. The evaluation of rhizospheric and non-rhizospheric pH was realized using a combined microelectrode according to the methodology of Häussling et al. (1995). Eight pH measurements were taken for each root type (nodal and lateral roots), and in a non-rhizosphere soil. The microbial metabolic diversity in rhizospheric soil, was determined using the methodology of Zak et al (1994).

Significant variations were observed in either length or density of root hairs; however, there was no correlation between P efficiency and this traits in maize genotypes studied. The maize genotype and the root type modified both root hair densities and root hair lengths and the P level influenced root hair density (Tables 1 and 2). The root hairs of nodal roots of H 3 and H 2 (P efficient) were much longer than the other genotypes. The hybrid, H3 had higher root hair density in the high P level. The rhizospheric pH was significantly modified by P levels of the soil and by the root types, but there were no significant differences between the hybrids (Table 3). The rhizosphere pH of all genotypes was higher than non-rhizospheric pH, independently of the P treatment, showing that maize was able to modify soil pH in the rhizosphere. Also, it was observed that the rhizosphere pH of the lateral roots was slightly higher than that of he nodal roots. The microbiological diversity indices were higher at low P levels. The H3 and H5 genotypes showed a tendency of higher indices of microbial activities in the rhizosphere.

At 18 days after planting, our results showed no relationship between P efficiency and the characteristics evaluated (rhizosphere pH, root hair length and root hair density) in the maize hybrids previously classified as P-efficient and P-inefficient, based on grain yield production in contrasting environments.

Table 1. Root hair length and density of seminal, nodal and lateral roots of P efficient (E) and P inefficient (I) maize hybrids, grown at two soil P levels.

	Root hair characteristics			
Hybrids	**Seminal root**	**Nodal root**	**Lateral root**	**Average**
	Root hair length (mm mm^{-1})			
H1 (E)	22.00 a A	21.50 b A	13.83 a B	19.11 ns
H2 (E)	19.40 a B	30.50 a A	19.00 a B	23.17 ns
H3 (E)	21.66 a B	36.66 a A	16.20 a B	25.35 ns
H5 (I)	24.40 a A	25.80 b A	16.20 a B	22.13 ns
Average	22.64 NS	27.82 NS	16.64 NS	
	Root hair density (number mm^{-1})			
H1 (E)	31 a A	33 c A	24 a B	29 ns
H2 (E)	28 a B	36 b A	28 a B	31 ns
H3 (E)	31 a B	41 a A	25 a C	33 ns
H5 (I)	29 a A	32 c A	22 a B	27 ns
Average	30 NS	34 NS	25 Ns	

Averages followed by the same capital letter in a column and the capital letter in a row were not significantly different (5%) by the Scott-Knott test.

Table 2. Root hair density of maize hybrids P efficient (E) and P inefficient (I) hybrids grown at two soil P levels (average of nodal and lateral roots).

	Root hair density	
Hybrids	**Low P**	**High P**
	------------------------------number mm^{-1}	----------------------
H1 (E)	29 aA	29 bA
H2 (E)	30 aA	31 bA
H3 (E)	29 aB	37 aA
H5 (I)	28 aA	27 bA
Average	29 NS	31 NS

Averages followed by the same capital letter in a column and the capital letter in a row were not significantly different (5%) by the Scott-Knott test.

Table3. Rhizospheric pH of P efficient (E) and P inefficient (I) maize hybrids, grown at two soil P levels (average of nodal and lateral roots).

	Rhizospheric pH[(1)]				
Hybrids	**Low P**		**High P**		
	pH	**(Δ pH)[(2)]**	**pH**	**(Δ pH)[(2)]**	**Average**
H1 (E)	5.24 ns	(0.18)	5.47 ns	(0.31)	5.35 ns
H2 (E)	5.49 ns	(0.37)	5.45 ns	(0.36)	5.46 ns
H3 (E)	5.36 ns	(0.13)	5.43 ns	(0.36)	5.39 ns
H5 (I)	5.40 ns	(0.39)	5.52 ns	(0.37)	5.50 ns
	5.37 B		5.47 A		

[(1)] Averages followed by the same capital letter in a column were not significantly different (5%) by the Scott-Knott test. [(2)] Difference between rhizospheric pH and non-rhizospheric pH.

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