The 6th Symposium of the International Society of Root Research
11-15 November 2001. Nagoya, Japan

Root morphology and phosphorus efficiency in wild and cultivated species

Jocelyne Ascencio*[1], Elena Medina[2] and Jorge Ugarte[1]
1:Departamento de Botanica, Universidad Central de Venezuela, Fac. Agronomia, Maracay 2101, Venezuela
2:Actual: INIA, San Felipe, Edo Yaracuy. Venezuela
jocelyne@telcel.net.ve

Introduction

Root morphology and architecture are important traits for P acquisition since the relative immobility of P in soils makes the plant very dependent on efficient soil exploitation in time and space (Barber 1984). In acid soils, phosphates of Fe and Al can be mobilized by the influence of the rizosphere exudation of organic acids and phenols (Bolan et al. 1997; Rao et al. 1999). In alkaline soils, organic acids cause the dissolution of calcium phosphates by lowering the pH and by the chelation of Ca. The objective of the present paper is the study of P-efficiency associated to plant attributes for P acquisition from sparingly soluble sources, in different plant species.

Materials and Methods

Plant materials: Three dicotyledoneous cultivated species : *Phaseolus vulgaris* L., *Vigna unguiculata* (L.) WALP, *Cajanus cajan* (L.) MILLSP, and the three wild species *Desmodium tortuosum* Sw. DC., *Euphorbia heterophylla* L, and *Amaranthus dubius* MART., were grown from seeds planted in 950 ml properly drained pots with sand, every other day irrigated with water and with 100 ml of a nutrient solution with P as soluble potassium dihydrogen phosphate (TO) or the sparingly soluble inorganic phosphates of iron (T1) or di-calcium (T2). Six plants per species and P treatment, were harvested at ages shown under "results" within the early vegetative phase for each species, and the roots of 3 plants carfully washed with distilled water and preserved in ethanol 70% for morphological and architectural studies, using image analysis to assess general patterns of root arquitecture and lateral branching.The remaining 3 plants were used for dry weight and P determinations in the dry matter of roots and shoots, with the phosphomolibdate method after wet digestion with HCl and hidrogen peroxide.

Results and Discussion

There were marked differencies in growth (biomass accumulation) and total root length, when Fe or Ca phosphates were the only source of P in the nutrient solution and, except for the pigeon pea and *Vigna*, plants could uptake more P when supplied with dicalcium phosphate (T2). However, when plants were irrigated with soluble K-phosphate (TO), the root system was better developed.

Marked differences in phosphorus absorption efficiency per unit root length (PAE) were observed when plants were irrigated with K (TO), Fe (T1) or Ca (T2) phosphates that reflected the different strategies for P-acquisition developed by the species. As seen in Table 1, except for *Amaranthus*, lower values of total root length were observed in T1. Efficiency was lower in the two wild species *Amaranthus* and *Euphorbia*, except for the highest value found for *Euphorbia* in T2. Higher values of root length were not directly correlated with higher values of PAE and, except for pigeon pea and *Vigna*, plants could uptake more P when supplied with dicalcium than with iron phosphate. In general, PAE was higher when plants were irrigated with sparingly soluble phosphorus sources and the response appeared to be somewhat species related as PAE was *Euphorbia* > *Desmodium* > *Phaseolus* > *Cajanus* > *Amaranthus* > *Vigna*, in T2 , and *Vigna* > *Cajanus* > *Desmodium* > *Euphorbia* > *Phaseolus* > *Amaranthus* in T1.

Genetic variations in rizosphere acidification is an important trait associated to P acquisition and P-efficient plants exuded significantly larger amounts of both total acids and protons than inefficient ones (Yan 1998). P uptake is related to root surface area, absolute root length, root growth angle, lateral rooting, root hair density and root hair length (Bar-Yosef 1996; Lynch and Brown 1998). In the present study differences in P-utilization efficiency (PUE) and specific root length (SRL) are shown in Table 2: lower PUE found for T2 plants and higher SRL for the wild species in TO and T1. Alterations in the architecture of the root system were found and differences were obvious in lateral root dispersion in single axis of secondary roots: less dispersed laterals were observed in TO followed by T1. The most dispersed pattern was observed in T2.

Table 1. PAE: Phosphorus absorption efficiency (mg P in shoots/root length) and L: Total root length (m)

	DAYS	T0 (KH_2PO_4) PAE	T0 (KH_2PO_4) L	T1 ($FePO_4$) PAE	T1 ($FePO_4$) L	T2 ($Ca(H_2PO_4)_2$) PAE	T2 ($Ca(H_2PO_4)_2$) L
Phaseolus vulgaris	30	34.0	63.4±5.6	6.0	32.9±6.4	27.7	65.0±6.4
Vigna Unguiculata	33	30.9	75.5±19.8	41.3	41.6±11.7	10.4	85.5±12.3
Cajanus Cajan	35	16.8	20.6±13.8	25.2	11.4±1.2	18.9	12.8±3.2
Desmodium Tortuosum	44	44.9	21.8±2.2	12.4	14.2±3.0	40.6	28.3±14.7
Amaranthus Dubius	51	4.4	95.6±7.01	3.9	92.7±1.2	17.0	144±50
Euphorbia heterophylla	38	12.6	43.9±1.4	7.2	21.8±0.9	67.1	22.7±0.6

DAS: Days after sowing

Table 2. PUE: Phosphorus Use Efficiency (Shoot dry weight/mg P in shoot + roots) and SRL : Specific Root Length (root length/g root dry weight)

	DAYS	T0 (KH_2PO_4) PUE	T0 (KH_2PO_4) SRL	T1 ($FePO_4$) PUE	T1 ($FePO_4$) SRL	T2 ($Ca(H_2PO_4)_2$) PUE	T2 ($Ca(H_2PO_4)_2$) SRL
Phaseolus vulgaris	30	131.27	62.31	303.44	52.38	92.25	70.51
Vigna unguiculata	33	157.46	45.28	203.71	49.32	164.16	62.60
Cajanus cajan	35	177.42	81.81	192.34	40.86	117.41	70.86
Desmodium tortuosum	44	221.45	34.44	236.66	34.44	118.44	46.50
Amaranthus dubius	51	254.36	128.08	222.87	92.03	87.29	104.42
Euphorbia heterophylla	38	286.89	114.6	275.35	133.26	107.46	60.17

Acknowledgments: this work was supported by CONICT, Proyecto S1-2764.

References

Ae et al. 1990. Science 248:477-480
Barber S.A. Soil Nutrient Availability.1984. Wiley, N.Y.
Bar-Yosef 1996. Plant Roots. Dekker, N:Y. USA
Bolan et al. 1997. Bio.Fert.Soils 24:169-174
Lynch&Brown 1998. Phosphorus in Plant Biology. ASPP
Rao et al. 1999. J. Plant Nutr. 22:1175-1196
Yan X. 1998. Phosphorus in Plant Biology. ASPP. USA