Phosphorus use efficiency of Medicago polymorpha in the "secano interior" of central Chile

Del Pozo A.

Systèmes sylvopastoraux. Pour un environnement, une agriculture et une économie durables

Zaragoza : CIHEAM
Cahiers Options Méditerranéennes; n. 12

1995
pages 83-86

Phosphorus use efficiency of *Medicago polymorpha* in the "secano interior" of central Chile.

A. Del Pozo
Centro Regional Quilamapu, INIA, Casilla 426, Chillán, Chile.

Summary: The responses of burr medic (*Medicago polymorpha*) to phosphorus (P) was studied on field conditions. The available P-Olsen increased linearly after the application of increasing amounts of P, and approximatly 7 kg.ha^{-1} of P was needed to change the available P in 1 mg.kg^{-1}. The percentage of P in shoots of *M. polymorpha* increased with increasing P supply, and ranged between 0.18% and 0.25%. Shoot dry weight reached 2682 kg.ha^{-1} in 1987, and 3050 kg.ha^{-1} in 1988, both at the highest P application rate. Seed yield ranged between 305 and 681 kg.ha^{-1} in 1987, and between 300 and 387 kg.ha^{-1} in 1988. Phosphorus utilization efficiency, measured as shoot dry weight per unit of P content, ranged between 391 and 566 kg DW/kg P. Phosphorus use efficiency, measured as shoot dry weight per unit P applied, was 73, 36 and 27 kg DW/kg P, with the application of 24, 62 and 97 kg P.ha^{-1}, respectively. Shoot dry weight increased curvilinearly with increasing P available in the soil at the top 5 cm.

Key-words: annual medic, *Medicago polymorpha*, phosphorus

INTRODUCTION

The "secano interior" of central Chile is a large dryland area of more than 2 million ha, located at the East side of the coastal montains (32°-37°S). As a result of the prevailing landuse systems, about two thirds of secano soils are badly eroded, and soil organic matter, fertility, microbial biomass and pasture productivity are extremely low in many places.

Medicago polymorpha is a self-regenerating annual legume that can be used for improving degraded pastures in silvopastoral systems or in rotation with cereals in ley farming systems, in the "secano interior" (Del Pozo et al, 1989b; Ovalle et al, in review). It is widely distributed in the region (Del Pozo et al, 1989a; Ovalle et al, 1993), however the abundance of M. polymorpha and others annual legumes in volunteer pastures is very low (Acuña et al, 1983). Soil phosphorus (P) is the main nutrient limiting nodulation and growth of M. polymorpha in the "secano interior" (Del Pozo et al, 1989c). In this paper changes in soil P availavility with phosphate fertiliser, and its effect on P uptake and utilization, under field conditions, are reported.

MATERIAL AND METHODS

The experiment was conducted at Cauquenes Research Center (35°58'S, 72°17'W; elev. 177m) in the subhumid mediterranean region. The soil was granitic (Maule Series) of pH 6.6 (1: 5 soil:water), organic matter 1.7%, and low in available P-Olsen (mean 6 mg kg^{-1}) and calcium (2.5 cmol(+) kg^{-1}). The area was cultivated and four rates of P (0, 24, 62 and 97 kg.ha^{-1}) as triple superphosphate and two rates of lime (500 and 1000 kg.ha^{-1}) were broadcast and incorporated into the soil. In addition, all the plots received 100 kg.ha^{-1} K_2SO_4 (43% potasium and 17% sulphur), and 10 kg.ha^{-1} Boronatrocalcita (11% borum). There were 3 replicates of each P fertiliser treatment in a randomised block design with each plot (lime)

split for the four levels of P. subplots measured 3 x 5 m. Annual rainfall was 908 and 698 mm in 1987 and 1988, respectively.

Seeds of a local ecotype (Cauquenes) of M. polymorpha were inoculated with a local strain of *Rhizobium meliloti* and sown in rows (at 20 cm) at the rate of 27 kg.ha^{-1}, in May 25, 1987. Subplots were sampled (1 m^2) for shoot dry weight (October 29 87 and November 10 88) and seed yield (December in both years). Plant material was dried at 70 °C, weighed, ground and analysed for total P by photometric determination.

Soil samples (0-5 and 5-20 cm) were taken sixty days after sowing in 1987 and at the begining of the next growing season in 1988, for P-Olsen determination.

Differences between treatments were analysed by using split splot ANOVA and means were compared through Duncan test. Linear regression was fitted to the relationship between P-Olsen and applied P, and Mitscherlich functions were fitted to the relationship between shoot dry weight and P-Olsen, using no-linear regression.

RESULTS AND DISCUSSION

Changes on soil P availability with applied P

P-Olsen (0-5 cm) increased linearly with the applied P at the rate of 0.14 mg.kg^{-1} of phophorus applied per ha. This means that for granitic soils, 7.2 kg.ha^{-1} P are needed to increase the available P of the first 5 cm in 1 mg.kg^{-1}. Between 5 and 20 cm the available P did not increase with the phosphate fertiliser. Therefore, moderate rates of phosphate fertiliser are needed to increase the available P-Olsen of the top 5 cm of granitic soils of the "secano interior", compared with volcanic soils of the Andes foothills.

Plant growth and phosphorus uptake and utilization

There were no significant differences in shoot dry weight or seed yield between the two rates of lime, therefore means of both levels of lime were considered in further analysis. Shoot dry weight increased with the application of P fertiliser in both years, but seed yield increased only in the first year (Table 1). P concentrations in shoots and P uptake increased but the calculated efficiencies for P uptake, P utilization and P use decreased with increasing P fertiliser application (Table 1). Values for P uptake efficiency were similar to those reported by Paynter and Bolland (1993) in the same species.

Maximum shoot dry weight and seed yield were reached when shoot P concentration was on average 0.25%. In the annual medic M. murex grown in the field, the critical P concentration to get 90% of the maximum shoot dry weight was 0.32% during vegetative phase and 0.16-0.18 on full flowering (Pinkerton and Randall, 1994).

There was a curvilinear relationship between shoot dry weight and the residual P-Olsen in the top 5 cm, in 1988 (Fig. 1). The P-Olsen level to reach 90% of the maximum dry weight, estimated by Mitscherlich function, was 22.4 mg.kg^{-1}.

Table 1. *Shoot dry weight, seed yield, shoot P concentration (% DW), P uptake, P uptake efficiency (P content/P applied), P utilization efficiency (shoot dry matter/P content) and P use efficiency (shoot dry matter/P supplied), of burr medic (*M. polymorpha*) grown at four levels of P supply. Values are means of two levels of lime and three replicates.*

	Applied Phosphorus (kg.ha^{-1})			
	0	24	62	97
Shoot dry weight (kg ha^{-1})				
1987	1360b	1699b	2229a	2682a
1988	1535c	1870bc	2520ab	3050a
Seed yield (kg ha^{-1})				
1987	305b	681a	514a	666a
1988	300a	356a	387a	351a
Shoot P (%)*	0,18b	0,21b	0,25a	0,25a
P uptake (kg.ha^{-1})	2,4b	3,5b	5,5a	6,7a
P uptake efficiency*	—	0,15	0,09	0,07
P utilization efficiency*	566	485	405	691
P use efficiency*	—	73	36	27

* Data from 1987 values having the same letter on the line are not significantly different of P = 0,05

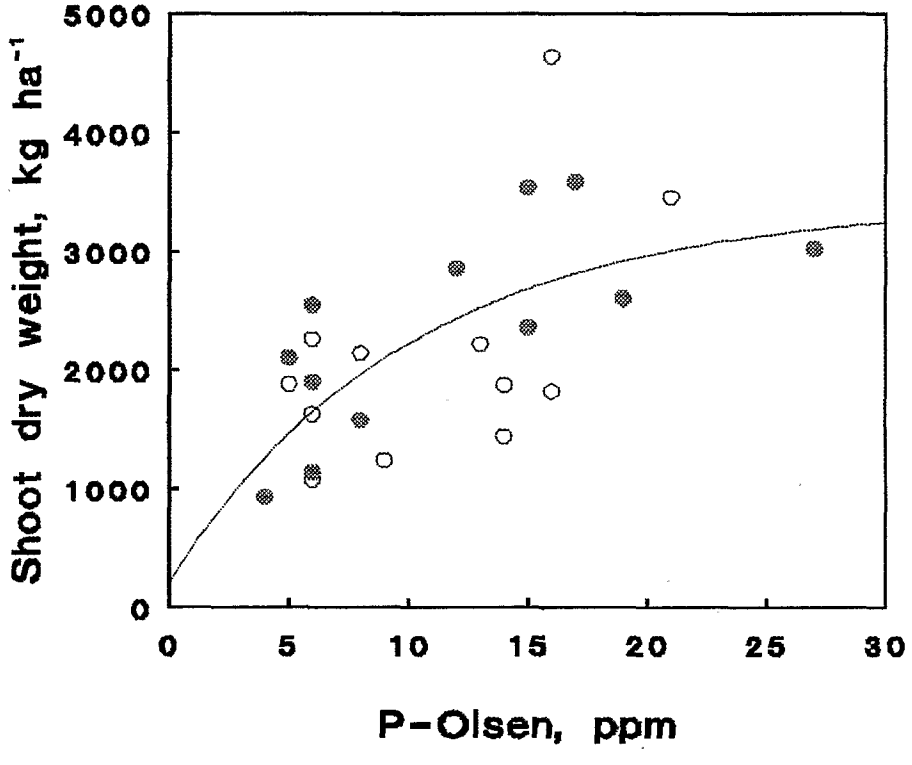

*Figure 1. Relationship between shoot dry weight and the residual available phosphorus (P-Olsen) in the soil at the first 5 cm, at two levels of applied lime, 500 (open circles) and 1000 kg ha^{-1} (closed circles), in 1988. Fitted model was: Y = 3399 - 3200*exp(-0,1*X).*

REFERENCES

Acuña H., Avendaño J., Ovalle C., 1983. Caracterización y variabilidad de la pradera natural del secano interior de la zona mediterránea subhúmeda. *Agricultura Técnica (Chile) 43(1): 27 - 38.*

Del Pozo A., Ovalle C., Avendaño J., 1989a. Los medicagos anuales. I. Distribución y abundancia en Chile y Australia. *Agricultura Técnica 49(3):260-267.*

Del Pozo A., Ovalle C., Avendaño J., Del Canto P., 1989b. Adaptation of *Medicago polymorpha* to the subhumid Mediterranean zone of Chile. *Proc. XVI International Grassland Congress, Nice, France: 1139-1540.*

Del Pozo A., Rodriguez N, Lobos C., 1989c. Nutrientes que limitan el crecimiento y producción de medicagos anuales en el secano interior de la zona Mediterranea subhúmeda de Chile. *Agricultura Técnica 49(1):36-40.*

Ewing, M.A., Howieson J.G., 1989. The development of *Medicago polymorpha* L. as an important pasture species for southern Australia. *Proc. XVI International Grasslands Congress, Nice, France: 197-198.*

Ovalle C., Aronson J., Del Pozo A., Avendaño J., 1990. The espinal: Agroforestry systems of the mediterranean-type climate region of Chile. *Agroforestry Systems 10:213-239.*

Ovalle C., Aronson J., Avendaño J., Del Pozo A., in review. Rehabilitation of degraded ecosystem and outmoded farming systems in central Chile. I. Historical overview and early results with the annual medic *Medicago polymorpha. (Submitted to Agriculture, Ecosystem and Environment).*

Ovalle C., Avendaño J., Del Pozo A., Crespo D., 1993. Germoplasm collection, evaluation and selection of naturalized *Medicago polymorpha* in the mediterranean zone of Chile. *XVII International Grassland Congress, New Zealand: 222-223.*

Paynter B.H., Bolland M.D.A., 1993. Comparison of the phosphate requirements of burr medic and yellow serradela with that of wheat in the low rainfall wheatbelt of Western Australia. *Australian Journal Experimental Agriculture 33:145-157.*

Pinkerton A., Randall P.J., 1994. Internal phosphorus requirements of six legumes and two grasses. *Australian Journal of Experimental Agriculture 34:373-379.*