

# Phosphorus Fertilization of Soybeans in Clay Soils of Entre Ríos Province

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**Soil texture plays an important role in determining phosphorus (P) availability. This study examined the clay soils of Entre Ríos and determined a specific critical soil test P level for this region.**

Entre Ríos Province in Argentina has a total area of 7 million hectares (M ha) and at present 1.3 M ha are cropped annually. Agricultural production is expected to expand to cover over 4 M ha of the province's potentially arable soils, and the majority will likely be under soybean. In 2000/01, the soybean area was 580,000 ha and grain production was greater than 1.65 million tonnes (M t). This represents a 113 percent increase in cropped area compared to the previous five-year average. Recent changes in agricultural practices, such as no-tillage and glyphosate herbicide-resistant soybean genotypes has simplified crop management, and is a partial explanation for this significant increase.

The dominant soils in the agroecological zone experiencing the fastest agricultural expansion are Vertisols. These soils are characteristically found on long slopes (0.5 to 2.5 percent); they are dark in color, high in clay content, and have a strong tendency to shrink and swell as soil moisture changes. Soil texture is commonly silty-clay-loam in the topsoil horizons...some soils may have up to 45 percent clay...and silty-clay or clay in the subsurface horizons, which are very dense with very little permeability. If not eroded, these soils have relatively high organic matter contents (3.5 to 6 percent). However, they often produce crop symptoms of nitrogen (N) and P deficiency.

Sustainable agriculture relies on maintenance of adequate soil fertility and replenishment of nutrients removed by harvested grain. Phosphorus replenishment is particularly important in these clay soils that have very low native P availability levels (Darwich, 1980; Tasi, 2000). Soil testing is the most precise available tool to: 1) determine whether P deficiencies are the cause of low soybean yields, and 2) prescribe adequate P fertilization rates (Melgar et al., 1995). However, some reports suggest results can be erratic

Visitors are shown during field day at the Paraná experiment site.



**Table 1.** Phosphorus availability, pH, organic matter (OM), total N content, and preceding crop at eight study sites (Entre Ríos Province).

| Sites     | Bray P-1,<br>ppm | pH  | OM,<br>% | Total N,<br>% | Preceding<br>crop |
|-----------|------------------|-----|----------|---------------|-------------------|
| Las Tunas | 6.2              | 7.8 | 4.14     | 0.188         | Sorghum           |
| Viale     | 9.8              | 7.5 | 4.37     | 0.195         | Corn              |
| Tala      | 7.1              | 7.4 | 3.39     | 0.178         | Soybean           |
| M. Grande | 7.2              | 7.0 | 4.69     | 0.223         | Soybean           |
| Paraná    | 9.5              | 7.1 | 3.28     | 0.150         | Corn              |
| Villaguay | 7.6              | 6.4 | 4.25     | 0.213         | Corn              |
| Uruguay   | 8.0              | 7.6 | 4.10     | 0.186         | Wheat             |
| La Paz    | 14.7             | 7.5 | 5.20     | 0.245         | Rice              |

(Gutiérrez Boem et al., 1998).

There is a need to continue research on adjusting and validating soil P testing and P fertilization practices for improved productivity in the region. This study evaluated P fertilization effects on soybean yield and determined a critical

P level for clay soils in Entre Ríos.

### Material and Methods

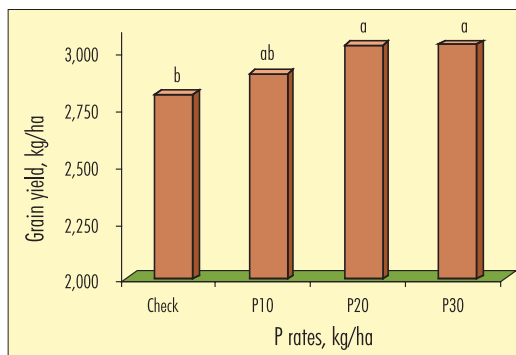
Eight on-farm experiments were carried out on Argillic Pelluderts soils during 1999/00 and 2000/01 in Paraná, La Paz, Villaguay, and Concepción del Uruguay in Entre Ríos Province. Six sites were under no-tillage and two under conventional tillage. Soybean cultivars of maturity groups IV to VII were planted from November 8 to December 23 with row spacing from 0.38 m to 0.52 m. Experimental design was a randomized complete block with three or four replications. Four treatments included a control, and rates of 10 (P10), 20 (P20), and 30 (P30) kg P/ha. Phosphorus was applied at planting and was banded below the seed as triple superphosphate (0-46-0). At maturity, 15 m<sup>2</sup> were hand harvested to determine grain yield. Results were analyzed by ANOVA using procedures of the Statistical Analysis System (SAS, 1999). The critical P level was determined by Cate and Nelson graphic methods (Cate and Nelson, 1965). Relative yield (RY) was determined by dividing the yield observed in the control by the average yield of the most productive treatment. Initial soil conditions of all experimental sites are shown in Table 1.

**Figure 1.** Average soybean grain yield as function of P rates. Different letters indicate statistically significant differences among treatments according to LSD test ( $p < 0.05$ ).

### Results and Discussion

Average soybean yield was 2,940 kg/ha and varied from 1,800 to 4,290 kg/ha. Phosphorus fertilization significantly affected soybean grain yield in all sites, but no differences were determined between P10, P20, and P30, and between P10 and the control (Figure 1). Average yield responses to P varied from 87 kg/ha (P10) to 217 kg/ha (P30).

A critical level of 9.5 parts per million (ppm) was determined from the relationship between P availability (Bray P-1) and RY using the Cate and Nelson graphical method (Figure 2). Only four observations were considered outliers (i.e., data points located in the upper left and lower right quadrants) (14 percent error). Applying this critical soil P level, the average yield response to P fer-



tilization in soils testing within the deficiency range was 249 kg/ha, whereas above this critical level no response was found.

Melgar et al. (1995) reported a similar critical level in a study of 65 experiments in Buenos Aires and Santa Fe Provinces. Other results suggest a higher critical level (Gambaudo and Fontanetto, 1996; Mallarino, 1999; Berardo, 2000). Soils of these previous experiments were silty or silt loam, and as suggested by Cox (1994), the silty-clay-loam texture of this study's Vertisolic topsoils can explain the difference.

Results of these on-farm experiments validate soil P testing as an adequate diagnostic tool to improve soybean P fertilization management in clay soils of Entre Ríos Province. A high probability of soybean yield response to P fertilization is expected when soil P is below 9.5 ppm. **BCI**

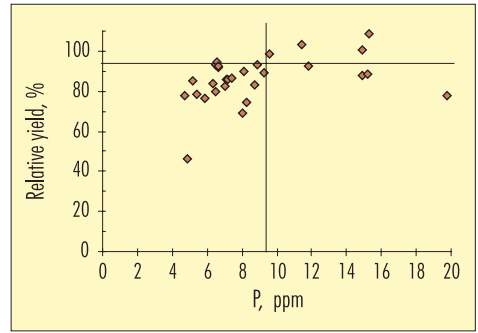
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## References

- Berardo, A. 2000. Jornada de actualización técnica para profesionales. p. 4-10. INPOFOS Cono Sur. Acassuso, Buenos Aires, Argentina.
- Cate, R.B., Jr., and L.A. Nelson. 1965. North Carolina Agric. Exp. Stn., Int. Soil Testing Series Tech. Bull. no 1.
- Cox, F.R. 1994. p. 101-113. *In* Havlin, J.L. and Jacobsen, J.S. (Eds). Soil Testing: Prospects for improving nutrient recommendations. SSSA Special Publication Number 40.
- Darwich, N. 1980. Actas IX Reunión Argentina de la Ciencia del Suelo. Paraná, Entre Ríos. AACs.
- Gambaudo, S., and H. Fontanetto. 1996. Gaceta Agronómica XV (89): 26-31. Buenos Aires, Argentina.
- Gutiérrez Boem, F., J. Scheiner, and R. Lavado. 1998. Fertilidad y uso de fertilizantes. Vol. 6. Cátedra de Fertilidad y Fertilizantes. Facultad de Agronomía. UBA. Buenos Aires, Argentina.
- Mallarino, A.P. 1999. Proceedings of the IV World Soybean Research Conference. Chicago, Illinois, USA. p. 251-257.
- Melgar, R., E. Frutos, M.L. Galetto, and H. Vivas. 1995. 1er Congreso Nacional de Soja y 2da Reunión Nacional de Oleaginosas. Pergamino. Tomo I. p. 167-174. AIANBA. Pergamino, Buenos Aires, Argentina.
- SAS Institute Inc. 1999. SAS OnlineDoc®, Version 8, Cary, NC. SAS Institute Inc.
- Tasi, H. 2000. Rev. Facultad de Agronomía (UBA), 20 (1):1-6. Buenos Aires, Argentina.



**Figure 2.** Soil P (Bray 1) critical level for soybean crops in clay-textured soils of Entre Ríos province.