IMPACTS OF SOIL MANAGEMENT - WHERE IS THE PHOSPHORUS?

Ararso Etana, Mona Mossadeghi Björklund & Tomas Rydberg

Swedish University of Agricultural Sciences, Department of Soil and Environment, P.O. Box 7014, 75007 Uppsala, Sweden

Summary

Four tillage systems in a long-term tillage trial in central Sweden were evaluated with respect to crop yield, soil organic carbon status and phosphorus (P) and potassium content. The tillage systems comprised: mouldboard ploughing (MP); shallow tillage (ST); shallow tillage with occasional ploughing (OP); and chisel ploughing (CP). This poster focuses on the content and stratification of P in the soil. The results showed that reduced tillage can be implemented on Swedish clay soils without impairing crop yield. Both ST and CP caused stratification of P while ST also stratified pH. OP resulted in higher crop yield and P redistribution and conservation. In continuous ploughless tillage (ST and CP), fertiliser recommendations should be based on soil analyses that take account of plant nutrient stratification, rather than the present composite sampling of the whole topsoil. This would allow efficient nutrient utilisation and minimise the risk of P leaching.

Materials and Methods

A long-term tillage trial has been underway since 1974 at Ultuna (59°48′N, 17°39′E), south of Uppsala. The soil is Eutric Cambisol and the textural composition is dominated by clay. The trial is designed as a randomised block with four replicates. We investigated P status in the following treatments:

MP- Mouldboard ploughing to 22-24 cm

OP- Shallow tillage to 10-12 cm with occasional ploughing

ST- Shallow tillage to 10-12 cm with non-inverting implements

CP- Cultivation to 22-24 cm with non-inverting implements

The crop rotation mainly includes cereals, but oilseed rape has been grown three times since the start of the experiment. Soil samples were taken using a steel frame measuring 0.5 m×0.5 m and samples were taken from three layers (approximately in 0-5 cm, 5-25 cm and 25-50 cm) in MP and OP plots and from four layers (0-5 cm, 5-12 cm, 12-25 cm and 25-50 cm) in ST and CP plots. Total P was determined after extraction with 2 M HCl. The concentrations of the element in the extracts were determined using ICP Optima DV. Soil pH was determined in soil-water suspension (1:5, v/v).

Results and Conclusions

The long-term average crop yield (not shown here) in the continuous ploughless tillage systems (ST and CP) was almost equal to that in MP, and OP produced significantly highest yield in 15 out of the 36 experimental years . The good performance of OP is presumably attributable to its weed suppression and loosening of the whole topsoil, allowing better root growth. Another positive impact could be the mixing of the near-surface accumulated plant nutrients into the lower topsoil. We measured distinct stratification of P-HCl and P-AL within the topsoil in treatments ST and CP and the differences between the upper (0-12 cm) and lower topsoil (12-25 cm) were statistically significant (Fig. 1 & Table 1). In the seedbed (0-5 cm), the concentration of P-AL was greater in ST than in MP plots in both spring and autumn samples.

There was a good correlation between P-AL and P-HCl (Fig. 2). P-AL accumulated in surface soil outside the growing season may be lost through run-off and/or preferential transport, posing a risk of surface water eutrophication. As our results show however occasional ploughing can eliminate this problem.

P-HCl stocks in the topsoil was lowest in ST and highest in OP (Fig. 3, left). The low value in ST cannot be attributed to P removal with grain, since the mean differences between yields in different tillage treatments were not statistically significant and the P content of the grain (data not shown) was almost identical for all treatments. The low P-HCl values in ST might be due to particulate P losses through surface runoff or preferential transport through macropores. P -AL stocks were lower in ST and CP than in MP and OP (Fig. 3, right) but ST had highest P-AL concentration in the seedbed (Table 1). This shows that P-Al was well distributed in the whole topsoil when mouldboard or occasional ploughing was implemented. Thus, periodic mouldboard ploughing reduces the risk of plant nutrient depletion. pH was higher in the subsoil than in the topsoil (Table 2), and in the upper topsoil of ST, it was significantly lower than in the layers beneath or in the other treatments. The acidification of the surface soil can be attributed to the increased organic matter and use of ammonium fertilizers. Maximum P availability to plants is obtained when soil pH is in the range of 6.0 -7.0.

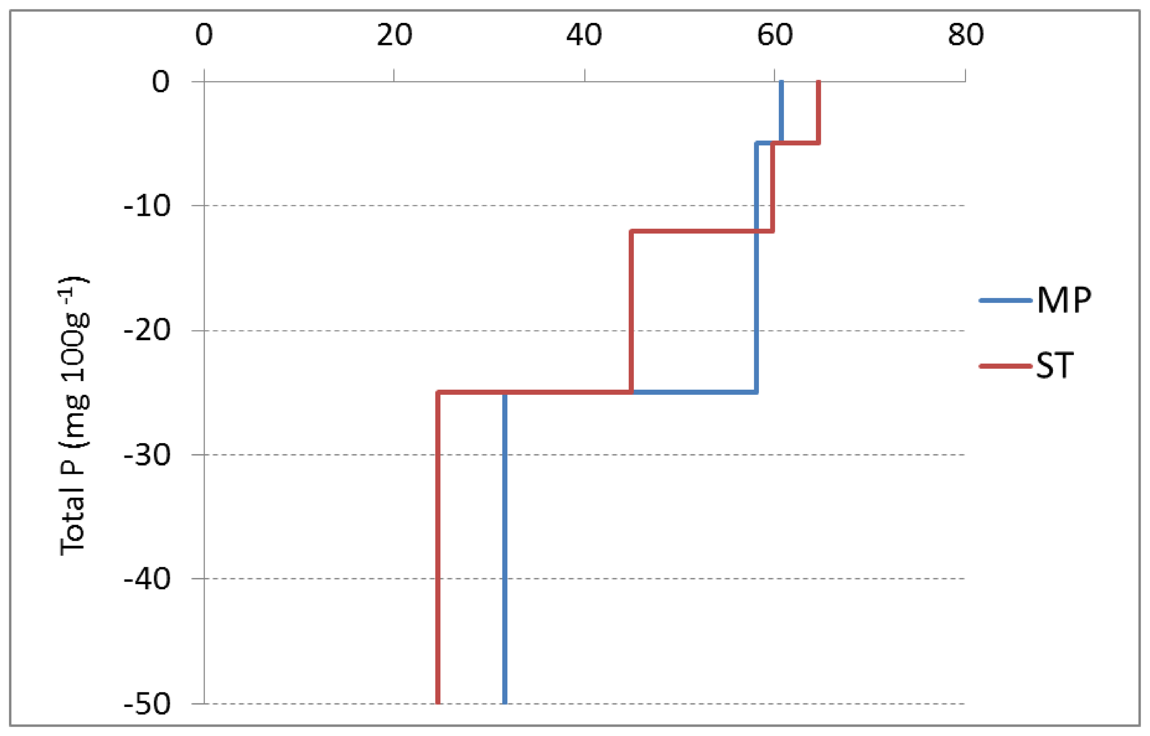

Fig.1.Total phosphorus distribution by depth.

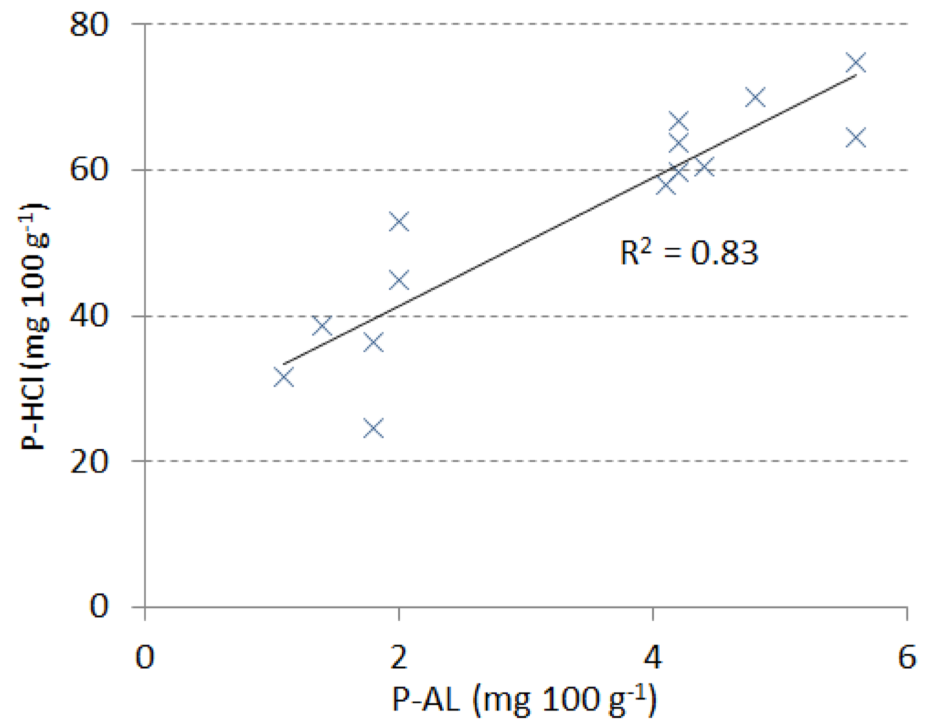

Fig 2. Plant available P as a function of total P.

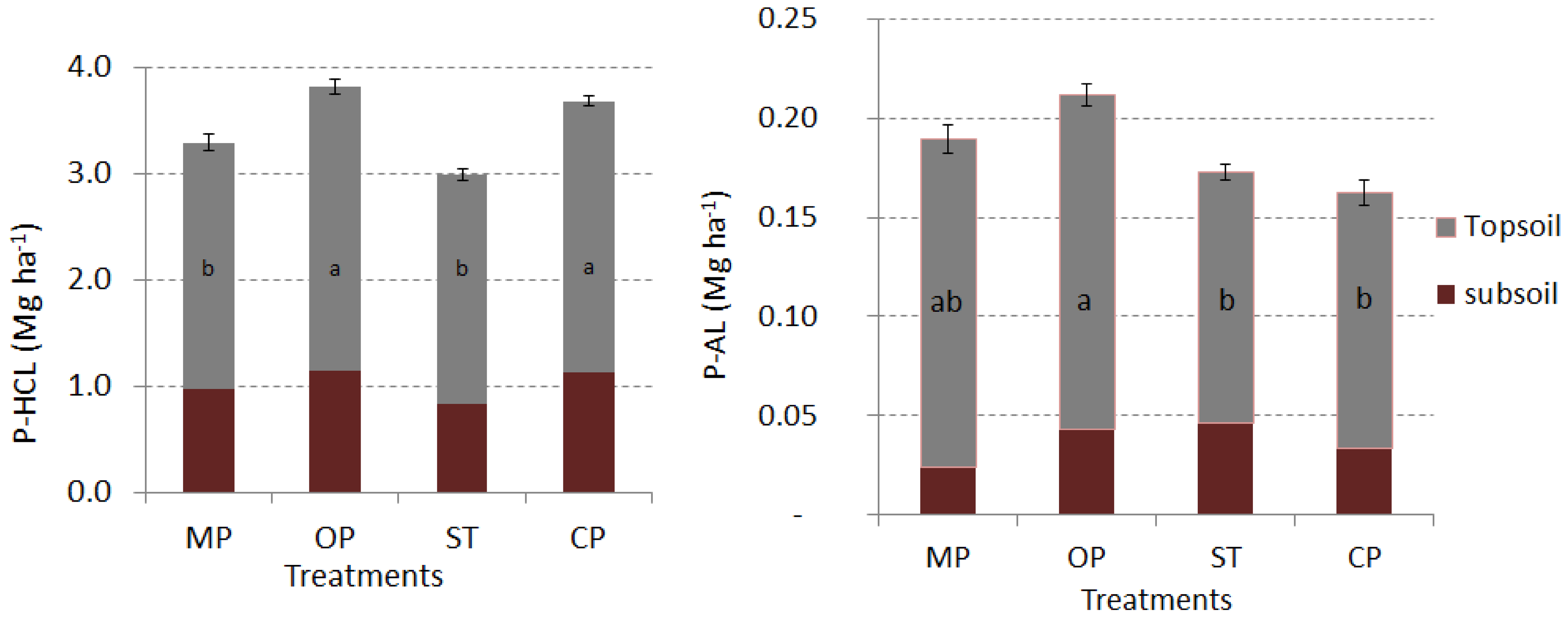

Fig . 3. Total P (left) & plant available P (right) stocks.

Table 1. Mean concentration (mg 100 g^{-1}) of total phosphorus (P) & plant-available P (P-AL)

	Total P				P-AL (spring)				P-AL (autumn)	
Depth, cm	MP	OP	ST	CP	MP	OP	ST	CP	MP	ST
0-5	60.6^{cd}	70.0^{ab}	64.6^{bc}	74.8^{a}	4.4^{cd}	4.8^{abc}	5.6^{ab}	4.8^{bc}	4.0^{cde}	5.8^{a}
5-12	58.0^{cd}	66.8^{abc}	59.8^{cd}	63.7^{bc}	4.1^{cde}	4.2^{cd}	4.2^{cd}	3.1^{ef}	3.6^{de}	4.3^{cd}
12-25	58.0^{cd}	66.8^{abc}	44.9^{ef}	53.0^{de}	4.1^{cde}	4.2^{cd}	2.0^{gh}	1.9^{gh}	3.6	2.3^{fg}
25-50	31.6^{gh}	38.6^{fg}	24.6^{h}	36.5^{fg}	1.1^{h}	1.4^{gh}	1.8^{gh}	1.4^{gh}	1.4^{gh}	1.9^{gh}

Values with different superscripts are significantly different (P<0.05).

Table 2. Soil pH in different layers

Depth, cm	MP	OP	ST	CP
0-5	5.8^{cd}	5.9^{bc}	5.5^{e}	5.8^{cd}
5-12	5.9^{bc}	6.0^{bc}	5.5^{e}	6.0^{bc}
12-25	5.9^{bc}	6.0^{bc}	6.0^{cd}	6.1^{bc}
25-50	6.6^{a}	6.6^{a}	6.7^{a}	6.7^{a}

Acknowledgements: This work was financed by Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning **(Formas).**