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Total and extractable Phosphorus concentrations at different depths in a soil fertilized with manure

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A number of extraction methods have been proposed to assess soil phosphorus availability. The aim of this study was to evaluate the phosphorus (P) concentration at several depths in a soil using different techniques. The research was carried out in Ribadeo (Lugo Province, NW Spain). The study area was 625 m^2. A total of 36 soil samples were taken in 9 points at the following depths: 0-5; 5-10; 10-20; 20-40 cm. Total P content in soil was determined by microwave digestion with nitric acid, USEPA method 3051. Extractable P was measured by Mehlich-3 extraction followed by two different determination techniques (ICP and colorimetry, M3-ICP and M3-COL, respectively), anion exchange resin (AER) and Olsen (Ol). Data were compared using Tukey's test and Pearson's r coefficient. Extracted amounts of P (Table 1) were much higher than expected and they were also relatively high compared to those measured by other researchers in the same region. Note that thresholds for excess P contents using the Mehlich-3 and Olsen methods have been reported as 31 and 21 mg kg^{-1}, respectively. The results obtained in this study exceeded these thresholds in every depth. However, our results were within the range reported by Sharpley et al. (2004), who observed P values extracted by Mehlich-3 within a range of 64 to 2822 mg kg^{-1} and 407 to 2480 mg kg^{-1} for total P depending on the type of manure used and at a depth of 0-5 cm. Phosphorus accumulation suggests long-term intensive application of organic manures.

Table 1. Soil P concentrations as a function of depth and extraction method.

Depth (cm)	$\mathbf{P}_{Total(mg/kg)}$	$\mathbf{P}_{M3(mg/kg)}$		$\mathbf{P}_{AER(mg/kg)}$	$\mathbf{P}_{Ol(mg/kg)}$
		ICP	COL		
0-5	1793 a	664 a	598 a	583,0 a	154,0 a
5-10	1814 a	669 a	607 a	600,0 a	156,0 a
10-20	1633 ab	652 a	606 a	625,0 a	146,0 a
20-40	1453 b	539 b	538 b	491,0 b	119,0 b

Total: Total P, M3:Mehlich-3 (ICP and COlL: Colorimetry), AER: Resin and Ol: Olsen. On each column, different letters indicate statistically significant differences according to Tukey test ($P \leq 0.05$).

P values obtained by Mehlich-3 showed significant correlations with those from Olsen and resin methods (r values between 0.64 and 0.82). In addition, P measured by Olsen and resin were significantly correlated (r = 0.69). All the methods, except anion exchange resin, provided highest P concentrations were at the 5-10 cm depth, thought they were not significantly different than those measured at the 0.5 and 10-20 cm depths. At 20-40 cm depth, the significantly lower P concentrations were observed independently of the method used (Table 1). The relatively high concentrations of P at the 20-40 cm depth are thought to be caused by soil mixing during deep plowing, whereas more superficial tillage operations would cause maximum values at the 5-10 cm depth. Based on our results it would be advisable to cease manure additions to the study soil until the P level decreases.

Sharpley, A.N., R.W. McDowell, and P.J.A. Kleinman. 2004. Amounts, forms, and solubility of phosphorus in soils receiving manure. Soil Sci. Soc. Am. J. 68:2048–2057.