Pedosphere **24**(3): 367–377, 2014
ISSN 1002-0160/CN 32-1315/P

Published by Elsevier B.V. and Science Press

PEDOSPHERE

www.elsevier.com/locate/pedosphere

Effect of Land Use on Soil Phosphorus Sorption-Desorption Under Intensive Agricultural Practices in Plastic-Film Greenhouses*[1]

YANG Guang-Rong[1,2], HAO Xi-Ying[1], LI Chun-Li[1] and LI Yong-Mei[2,*2]

[1] *Agriculture and Agri-Food Canada, Lethbridge Research Centre, Lethbridge T1J 4B1 (Canada)*
[2] *Yunnan Agricultural University, Kunming 650201 (China)*

(Received July 10, 2013; revised March 27, 2014)

ABSTRACT

With rapid urbanization and economic growth, Chinese traditional rice-legume production is increasingly replaced by vegetable and horticultural flower production, which could affect soil properties. This study was conducted near Kunming City, Yunnan Province, Southwest China to investigate how soil phosphorus (P) sorption and desorption processes respond to land use changes and to relate P sorption and desorption parameters to soil properties. Soil samples (0–20, 20–40, 40–60, 60–80 and 80–100 cm) were collected from five sites representing four land use types: rice-legume production in a two-crop, one-year rotation (Rice), vegetable production in open fields (Vegetable), recent (< 3 years) conversion from open fields to plastic-film greenhouse vegetable and flower production at two sites (VFCS$_1$ and VFCS$_2$), and longer-term (> 10 years) plastic-film greenhouse vegetable and flower production (VFCL). The changes in land use affected soil pH, electrical conductivity, available N and P and organic carbon content in topsoil and subsoil. In turn, these changes of soil properties influenced soil P sorption capacity. The P sorption maximum ($S_{\max}$) was affected by land use types, soil sampling depth and their interactions ($P < 0.0001$). For surface soil, $S_{\max}$ was in the order of Rice (1 380 mg kg^{-1}) > VFCL (1 154 mg kg^{-1}) > VFCS$_2$ (897 mg kg^{-1}) > VFCS$_1$ (845 mg kg^{-1}) > Vegetable (747 mg kg^{-1}). The lowest $S_{\max}$ generally occurred at the surface (except for Rice at 80–100 cm) and increased with depth. The amount of P desorbed during the 8 successive extractions was in the range 23%–44% of sorbed P, and was not affected by land use types or sampling depths. The decreases in $S_{\max}$ suggested that soil P sorption capacity decreased when rice-legume production converted to more intensive vegetation and flower production and caution should be exercised when applying P fertilizer to minimize potential leaching and runoff P loss to the environment.

Key Words: flower production, P sorption maximum, rice-legume production, vegetable production

Citation: Yang, G. R., Hao, X. Y., Li, C. L. and Li, Y. M. 2014. Effect of land use on soil phosphorus sorption-desorption under intensive agricultural practices in plastic-film greenhouses. *Pedosphere*. **24**(3): 367–377.

INTRODUCTION

Excessive application of inorganic fertilizers and/or manures can result in phosphorus (P) enrichment in farmland and lead to the eutrophication of water bodies, deterioration of water quality and reduced aquatic biodiversity (Heredia and Cirelli, 2007). About 10.1% of total P entering recipient waters was caused by surface runoff or leaching from farmland (Chen *et al.*, 2008). Non-point sources pollution in Dianchi Lake basin were strongly related to agricultural activities, with about 30%–60% of total P in water bodies originating from agricultural activities (Chen *et al.*, 2006).

Phosphorus sorption and desorption processes within the soil system are important for both agricultural production and environmental protection. Phosphorus accumulated in soil would join P sorption-desorption processes and/or be lost through runoff or drainage (Zhou *et al.*, 2005). Soil represents a temporary P reservoir in which P mobility depends on P sorption and desorption processes. Lower soil P fixation ability indicates higher soil P availability for plants after P fertilizer application and higher risk for P loss *via* runoff and leaching (McDowell and Sharpley, 2001). Soil P desorption rate is of paramount importance for crop nutrition and fertilizer use efficiency and P loss. Higher P desorption capacity would increase P desorbed from soil for crop growth and indicate greater potential P mobility into water bodies.

Previous studies of soil P sorption and desorption processes have tended to focus on the P sorption potential of different soil types and the effects of soil physicochemical properties (Auxtero *et al.*, 2008; Lair *et al.*, 2009), long-term fertilization (Guo *et al.*, 2008) and ve-

---

*[1] Supported by the Yunnan Provincial Department of Science and Technology, China (No. 2006YX35) and the National Natural Science Foundation of China (No. 31260504).

*[2] Corresponding author. E-mail: youngmaylee@126.com.

getation cover (Nairam *et al.*, 2005). Zhao *et al.* (2008) and Palmer-Felgate *et al.* (2009) reported land use effects on soil P fractions in grassland and forest ecosystems.

With rapid urbanization and economic growth, farmland use has become more diverse and intensive in China. With rapid development of vegetable and flower production in peri-urban areas, plastic-film greenhouses are increasingly used. This practice could potentially affect soil properties and soil nutrient dynamics, with concomitant implications for environmental pollution. Information on how land use (crop rotation) transition, especially under intensive agriculture in plastic-film greenhouses, affects P sorption and desorption is limited. Freese *et al.* (1992) reported intensive crop and pasture production with heavy fertilizer application may affect P sorption. There is little information on soil P desorption under different crop systems. Therefore, our study was conducted near Kunming City, Yunnan Province, Southwest China to determine the soil P sorption and desorption capacities under different farmland uses and to relate P sorption and desorption parameters to soil properties, in order to provide information for developing best management practices to reduce soil P loss under intensive agriculture in plastic-film greenhouses.

MATERIALS AND METHODS

Sampling sites

Soil samples were collected in December 2009 near Kunming City, Yunnan Province, Southwest China. Soil parent materials are lacustrine deposits near Dianchi Lake. The soils belong to red soil according to the Chinese Soil Taxonomy, corresponding to Ultisol in the taxonomic classification of USDA. The mean annual precipitation in this region is 1 031 mm and mean annual temperature is 17–19 °C. There were five soil sampling sites which represented four land use types: 1) rice-legume production in a two-crop, one-year rotation (Rice), 2) vegetable production in open fields (Vegetable), 3) recent (< 3 years) conversion from open field to plastic-covered vegetables and flower production at two sites (VFCS_1 and VFCS_2), and 4) longer-term (> 10 years) plastic-covered vegetables and flower production (VFCL).

The plastic-film greenhouses (‘polytunnels’) were about 20 m long, 4.3–4.6 m wide and 2.2–2.6 m high and supported using split bamboo and reinforced using concrete pilings. The environmental condition and soil texture of the sampling sites are reported in Table I.

Soil sampling and analysis

Soil samples were collected from five depths (0–20, 20–40, 40–60, 60–80, and 80–100 cm) at each site. Five subsamples for each layer were collected to make a composite sample using soil auger. All samples were taken into laboratory within 24 h, air-dried and ground to pass a 2.0-mm sieve. Soil basic properties were determined in triplicate and are summarized in Table II.

Soil pH and electrical conductivity (EC) were determined following the methods of Janzen (1993). This involved shaking the soil-water solution (1:2, w:v) at low speed (180 r min^{-1}) for 30 min and measuring the pH of the slurry using a portable pH meter (Orion, pH/ISE Meter Model 290 Aplus, USA). The slurry was then filtered using Φ 0.45-μm filter paper for the determination of soil EC and water soluble ions. Soil EC was measured with an EC meter (Thermo Orion, Model 125 Aplus, USA). Soluble cation (Na^+, NH_4^+, Mg^{2+}, K^+ and Ca^{2+}) and anion (Cl^-, NO_3^- and SO_4^{2-}) concentrations were determined using a flame atomic absorption spectrometer (Varian Model AA240, Palo Alto, USA).

For soil organic carbon (SOC), total nitrogen (TN) and total phosphorus (TP) determinations, the coarsely ground soil samples (< 2.0 mm) were further fine-ground to pass through a 0.15-mm sieve. The SOC and TN concentrations were determined using a gas chromatography-mass spectrometer-central nervous system (GC-MS CNS) analyzer (Rodano, Italy). Soil TP was determined by digesting with 18 mol L^{-1} $\mathrm{H_2SO_4}$, following the method of Parkinson and Allen (1975), and the P concentration in the digested solution was determined by molybdenum blue colorimetric method using an auto-analyzer (Astorial Clackamas, USA). Soil available N (NO_3^--N and NH_4^+-N) was extracted using 2 mol L^{-1} KCl (1:5, w:v) and NO_3^--N and NH_4^+-N concentrations in the extract were determined using an auto analyzer (Bran + Luebbe III, Germany). Soil available P, including water dissolved P (W-P), Mehlich 3 solution extractable P (M-3-P), and Olsen extractable P (O-P), were extracted by a soil-to-liquid ratio of 1:10 and available P concentration in solution was determined using an auto-analyzer (Astorial Clackamas, USA).

Phosphorus sorption and desorption

The processes of P sorption and desorption were duplicated for each soil sample. Phosphorus sorption and desorption characteristics were determined using the method of Auxtero *et al.* (2008) and Lair *et al.*