លក្ខណៈសំរូបកម្មនិងការផ្តាច់ចេញ និង ចលនការរំដោះចេញនៃសារធាតុផូស្វ័រ នៅលើដីស្រូវស្រែទំនាបបីប្រភេទផ្សេងគ្នា នៅក្នុងប្រទេសកម្ពុជា

PHOSPHATE SORPTION-DESORPTION BEHAVIOUR, AND PHOSPHORUS RELEASE CHARACTERISTICS OF THREE CONTRASTING LOWLAND RICE SOILS OF CAMBODIA

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អត្ថបទសង្ខេប

ការយល់ដឹងនូវលក្ខណៈសំរូបកម្ម **(sorption)** និងការរំដោះចេញ **(release)** នៃសាធាតុផូស្វ័រ **(P)** នៃប្រភេទដីផ្សេងៗ ពិតជាអាចជួយសំរួលបានដល់ការកំណត់នូវតំរូវការសារធាតុផូស្វ័រសំរាប់ការលូតលាស់របស់ដំណាំស្រូវ។ ទាំងពិសោធន៏នៅក្នុងលក្ខខណ្ឌផ្ទះកញ្ចក់ និងនៅក្នុងមន្ទីរពិសោធន៏ ត្រូវបានធ្វើឡើងដើម្បីពិនិត្យមើលនូវយន្តការយូរអង្វែងនៃការរំដោះចេញនៃសារធាតុផូស្វ័រពីដី តាមរយៈការប្រើប្រាស់ ដីទៅលើវគ្គលូតលាស់ដំបូងរបស់ដំណាំស្រូវ និងធ្វើការកំណត់ផងដែរនូវលក្ខណៈសំរូបកម្ម និង ការផ្តាច់ចេញ **(desorption)** នៃសារធាតុផូស្វ័រនៅលើដីផ្សេងគ្នាបីប្រភេទនៃប្រទេសកម្ពុជា ជាអាទិ៏រួមមានៈ ក្រុមដីប្រទះឡាង គោកត្រប់ និង ក្រុមដីទួលសំរោង។ ចំពោះពិសោធន៏នៅក្នុងផ្ទះកញ្ចក់ គឺដំណាំស្រូវត្រូវបានដាំដុះ ចំនួន ៥ វដ្តជីវិតជាបន្តបន្ទាប់ ដោយក្នុង១វដ្តជីវិតមានរយៈពេលពី ៦ ទៅ ៨ សប្តាហ៏ ដោយប្រើជីផូស្វ័រចំនួន ៤ កំរិត ០, ៥, ១០, និង ២០ មក្រ/គក្រដី។ ចលនការសំរូបកម្ម និង ការផ្តាច់ចេញ **(sorption-desorption isotherms)** នៃសារធាតុផូស្វ័រ ត្រូវបានប្រព្រឹត្តទៅដោយដំបូងឡើយធ្វើអោយដីមានតុល្យភាព **(equilibrate)** ជាមួយកំរិតផូស្វ័រផ្សេងៗ ដូចជា ០, ១០, ២០, និង ៤០មក្រ/គក្រដី ក្នុងសូលុយស្យុងកាល់ស្យូមក្លរ **($CaCl_2$)** ដែលមានកំហាប់ ០,០១ ម៉ូល នៅសីតុណ្ហភាព ២៥ អង្សាសេ ។

នៅលើប្រភេទដីខ្សាច់ប្រទះឡាង និង ដីឥដ្ឋទួលសំរោង ការដាក់ជីផូស្វ័រក្នុងបរិមាណ ១០មក្រ/កគ្រដី មានលក្ខណៈគ្រប់គ្រាន់សំរាប់ អោយដំណាំស្រូវបង្កើតបាននូវបរិមាណអតិបរិមានៃ ចំនួនដើមបែក កំពស់ដើម ទំងន់សារធាតុស្ងួត កំហាប់សារធាតុផូស្វ័រ និង បរិមាណសំរូបផូស្វ័រសរុប **(total P uptake)** ដោយរុក្ខជាតិ។ ផ្ទុយទៅវិញនៅលើក្រុមដីឥដ្ឋអាស៊ីតគោកត្រប់ ដំណាំស្រូវត្រូវការសារធាតុផូស្វ័ររហូត ដល់បរិមាណ ២០មក្រ/គក្រដី ដើម្បីអោយការលូតលាស់ និងបរិមាណសំរូបផូស្វ័រសរុបរបស់វាមានលក្ខណៈអតិបរិមា។ ជារួមយើងសង្កេត ឃើញថានៅលើគ្រប់ប្រភេទដី បន្ទាប់ពីពីរវដ្តដាំដុះរួចមក ការលូតលាស់របស់ដំណាំស្រូវត្រូវថយចុះយ៉ាងខ្លាំងនៅគ្រប់កំរិតជី ដែលបាន ប្រើប្រាស់នៅក្នុងវដ្តដាំដុះទី១ ក៏ប៉ុន្តែការថយចុះខាងផ្នែកទិន្នផល និង បរិមាណសំរូបផូស្វ័រសរុបរបស់ដំណាំស្រូវ ដែលដាំដុះនៅលើប្រភេទដីឥដ្ឋទួលសំរោង និង គោកត្រប់ មានលក្ខណៈតិចតួចជាងដំណាំស្រូវដែលដាំដុះនៅលើដីខ្សាច់ប្រទះឡាង។

ទំរង់ផូស្វ័រអាចស្រូបបានដោយរុក្ខជាតិ **(Resin-P)** គឺជាទំរង់ **(fraction)** មួយដែលមានបរិមាណតិចជាងគេបំផុត បើប្រៀបធៀបទៅនឹងទំរង់ផូស្វ័រចំបងៗនៅក្នុងដីដូចជា **NaOH-Pi, NaOH-Po** និង **Residual-P** នៅលើគ្រប់ប្រភេទដី ។ ក៏ប៉ុន្តែទំរង់ផូស្វ័រ **Resin-P** នេះត្រូវបានគេពិនិត្យឃើញនៅលើដីខ្សាច់ប្រទះឡាង មានបរិមាណច្រើនជាង នៅក្នុងដីឥដ្ឋទួលសំរោង និង គោកត្រប់។ គេកត់សំគាល់ឃើញ ទៀតថា មានការថយចុះខាងបរិមាណនៃគ្រប់ទំរង់ផូស្វ័រ ជាពិសេស ទំរង់ផូស្វ័រចំបងៗ **(NaOH-Pi, NaOH-Po** និង **Residual-P)** នៅគ្រប់វដ្តដាំដុះដំណាំស្រូវ បញ្ហានេះអាចបណ្តាលមកពីប្រតិកម្មជាបន្តបន្ទាប់នៃជីផូស្វ័រដែលបានប្រើជាមួយដី បន្ថែមទៅលើបរិមាណផូស្វ័រ សរុបដែលដំណាំស្រូវស្រូបយកក្នុងវដ្តដាំដុះនិមួយៗ។

នៅក្នុងលក្ខខណ្ឌដីស្ងួត **(oxidized condition)** ប្រភេទដីឥដ្ឋគោកត្រប់ និង ទួលសំរោង ស្រូបសារធាតុផូស្វ័រ ៥ ដងច្រើនជាង ប្រភេទដីខ្សាច់ប្រទះឡាង នៅពេលកំរិតផូស្វ័រប្រមាណជា

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២០មក្រ/គក្រដី ត្រូវបានប្រើប្រាស់។ ការផ្តាច់ចេញនូវសារធាតុផូស្វ័រពីដី ត្រូវបានសង្កេតឃើញដំបូងឡើយមានបរិមាណច្រើននៅលើដីខ្សាច់ប្រទះឡាង ប៉ុន្តែវាក៏បានថយចុះមកវិញឆាប់រហ័សជាងដីឥដ្ឋ ទួលសំរោង និង គោកត្រប់ នៅពេលគេបង្កើនចំនួននិស្សារណកម្ម **(extraction)** នៃដី។ ហើយគេពិនិត្យឃើញទៀតថា បរិមាណសរុបនៃផូស្វ័រដែលផ្តាច់ចេញពីដីឥដ្ឋគោកត្រប់ និង ទួលសំរោង ច្រើនជាងដីខ្សាច់ប្រទះឡាង។ ការស្រូបសារធាតុផូស្វ័រដ៏ច្រើនលើសលប់របស់ដីប្រភេទឥដ្ឋ ក៏បាននាំអោយសំណល់នៃសារធាតុផូស្វ័រ មានប្រសិទ្ធភាពយូរអង្វែងផងដែរ ទៅលើការដាំដុះដំណាំស្រូវ។

ពាក្យគន្លឹះ: ដីស្រូវស្រែទំនាប សារធាតុផូស្វ័រ លក្ខណៈនៃការរំដោះចេញ ប្រសិទ្ធភាពកាកសំណល់ ទំរង់ផូស្វ័រនៃដី សំរូបកម្ម និងការផ្តាច់ចេញ

ABSTRACT

Understanding the P sorption and release characteristics of different soils can help in determining fertiliser P requirements for the growth of rice (*Oryza sativa* L.). Glasshouse and laboratory experiments were undertaken to observe the long-term release characteristics of P from added fertiliser for the early growth of rice, and also to determine P sorption-desorption behaviour of three contrasting lowland soils from Cambodia: Prateah Lang (Plinthustalf), Koktrap (Plinthaquult) and Toul Samroung (Endoaqualf). In the pot experiment, rice was treated with four P rates (0, 5, 10 and 20 mg/kg soil) and grown over five successive cropping cycles, each of six to eight weeks. Phosphorus sorption-desorption isotherms were constructed by equilibrating with 0, 10, 20 and 40 mg P/l in 0.01 M $CaCl_2$ solution at 25 ^oC.

On the sandy Prateah Lang (PL) and clayey Toul Samroung (TS) soils, addition of 10 mg P/kg soil was adequate in the first crop for maximum tiller number, plant height, total dry matter, P concentration, and total P uptake. By contrast, about 20 mg P/kg was needed for the maximum growth and total P uptake on the clayey acid Koktrap (KT) soil. After two crops, plant growth progressively declined at all P levels, but the decrease in yields and total P uptake on the clayey TS and KT soils was slower than for plants grown on the sandy PL soil.

Resin-P extractable was the smallest P fraction compared to other major soil-P (NaOH-Pi, NaOH-Po and Residual-P) pools in all soil groups, but recovery from the Resin-P pool was higher in the sandy PL soil than in the clayey TS and KT soils. The declining amounts recovered from all the extractable soil P fractions, especially major soil P (NaOH-Pi and Po and Residual-P) pools with succeeding rice crops grown on all the soils could be attributed to continued reactions of the added P fertiliser by soils in addition to plant P uptake during each plant-growing cycle.

The clayey KT and TS soils sorbed five-fold more P than the sandy PL soil in oxidized conditions. Phosphorus desorption was initially greatest from the sandy PL soil: but with increasing numbers of soil extractions, the release of sorbed P declined faster than in the clayey KT and TS soils. The cumulative desorbed P was greater from the clayey KT and TS soil than from the sandy PL soil. The greater P sorbed by the clayey soils should ensure a longer duration of the residual P effect.

Keywords: lowland rice soils, phosphorus, release characteristics, residual effect, soil-phosphorus fractions, sorption-desorption

INTRODUCTION

The cause of limiting phosphorus (P) supply for rice crops may be low total P contents and/or a high P sorption capacity of the soil. In Cambodia, the extent to which soil groups identified by White *et al*. (1997a,b) for rice agronomic management differ in their P sorption-desorption behaviour and P release characteristics has yet to be tested. Some studies have been conducted on the short-term crop responses to P fertiliser application (CIAP, 1995, 1996; White and Seng, 1997), and a recent study examined residual value of applied P fertiliser over 5 successive rice crops on the Prateah Lang soil (Pheav *et al*., 2003). Other studies have also examined the dynamics of P availability under alternating reduced and oxidized conditions (Seng *et al*., 1999). It is crucial to determine the long-term P supplying characteristics of a range of important rainfed lowland rice soils in Cambodia.

Understanding of the P sorption-desorption processes of different soils can help in determining comparative P requirements for plants (Kuo *et al*., 1988). The agronomic efficiency of P fertiliser is strongly dependent on the P sorption-desorption capacity of the soils (Singh and Gilkes, 1991). Hence, data on soil chemical properties, including P sorption-desorption reactions in different soils is critical for managing P fertiliser supply and recommendations. Indeed, for further developing soil P management strategies and recommendations, soils may be grouped together on the basis of their ability to release and retain P from fertiliser added, as well as native soil P.

Phosphate sorption characteristics of the soil are important properties in determining fertiliser requirements of crop growth, because adsorbed P equilibrates with P in the soil solution and this P is, in turn, the immediate source of P for plant uptake (Fox and Searle, 1980). Soil properties and environmental conditions affect the P adsorption capacity (Syers *et al*., 1971; Goldberg and Glaubig, 1988; Cristensen, 1989; Sposito, 1989; Zachara *et al*. 1989; Schuster, 1991; Lee *et al*. 1996).

Adsorption capacities typically vary amongst soil types. Some soils have low sorption capacities and hence hold small reserves of P within the soil. The P sorption of soils developed on materials high in quartz was moderate to low, and these soils have modest fertiliser requirements (Mokwunye, 1977). However, other soils have high sorption capacities, and probably, a high capacity to retain P within the soil for an extended period. Fox and Searle (1980) reported that all soils, in which 2:1 and 1:1 type clays predominate, as a general rule, absorb large amounts of P. Sandy soils may have less sorption per unit soil weight, whereas, soils rich in clay minerals and sesquioxides have the greater sorption (Sanyal *et al*., 1993). In a study of P sorption of two soils of southeast Cambodia, Seng (2000) found that a black clayey acidic soil (Koktrap: White *et al*., 1997a, b) sorbed about five-fold greater P concentration than a sandy acid soil (Prateah Lang: White *et al*., 1997a,b) under oxidised conditions.

In summary, with various soil types in different environments, P sorption-desorption processes have been found to vary with forms of Fe and Al, soil pH, organic carbon, clay and carbonate contents and other soil properties (Saunders, 1965; Hinga, 1973; Ballard and Fiskell, 1974; Holford and Patrick, 1979; Ping and Michaelson, 1986). More details of relevant soil properties and soil-water regimes influencing the P sorption-desorption mechanisms in lowland and upland soils were reviewed by Pheav (2002). However, the factors associated with P sorption-desorption processes in major Cambodian rice soils have not been fully identified. This research was conducted to determine the long-term P release characteristics, and availability of P from fertiliser added to the flooded soils planted to rice over five successive cropping cycles each separated by a 2-week oxidised fallow period. The P sorption-desorption behaviour in three contrasting lowland rainfed rice-growing soils of Cambodia was also examined under the aerobic conditions.

MATERIALS AND METHODS

Soil sampling

Three contrasting soil types were selected for both the pot and P sorption-desorption experiments: Prateah Lang (PL), Koktrap (KT) and Toul Samroung (TS) (White *et al*., 1997a,b); Plinthustalf, Plinthaquult and Endoaqualf (Soil Survey Staff, 1994). Prateah Lang and Koktrap soils both varied from moderately to strongly acidic, whereas, the Toul Samroung soil was closer to neutral. Their main properties are presented in Table 1.

The soils used in both the glasshouse and laboratory experiments originated from farmers' rice paddy fields in Cambodia. Usually, these soils were cultivated with rice during the wet season each year. The top 20-cm layer was collected during the dry season when soil was in fallow. Care was taken to ensure soil samples were collected from fields with no recent history of inorganic P fertiliser application. Soils were sun-dried and crushed, all stones and coarse organic debris removed, and then the soils were sieved to pass through a 2-mm screen.

Table 1. Selected properties of the three major rainfed lowland rice-growing soils of Cambodia used for both pot and laboratory experiments (0-20 cm depth, sieved to < 2.0 mm). Values are means of 249 samples.

Major properties	*Prateah Lang soil*	*Toul Samroung soil*	*Koktrap soil*
pH (1:1 H_2O)	*5.4*	*5.6*	*5.1*
Organic C (g/kg)	*4.0*	*9.0*	*13.0*
Sand (g/kg)	*498*	*355*	*279*
Silt (g/kg)	*370*	*410*	*293*
Clay (g/kg)	*132*	*229*	*416*
CEC [$cmol_c$ (+)/kg]	*3.7*	*15.9*	*8.1*
Exch. Ca [$cmol_c$ (+)/kg]	*1.2*	*7.1*	*1.1*
Exch. Mg [$cmol_c$ (+)/kg]	*0.5*	*3.3*	*0.6*
Exch. K [$cmol_c$ (+)/kg]	*0.1*	*0.2*	*0.1*
Exch. Na [$cmol_c$ (+)/kg]	*0.4*	*0.3*	*0.3*

Data source: Oberthur et al. (2000)