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Effects of Phosphorus Accumulation in Soil with the Utilization Ages of the Vegetable Greenhouses in the Suburb of Shenyang

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Abstract

The accumulation of phosphorus in different utilization age (0, 1, 2, 3, 5, 13-year) vegetable greenhouses soil with multi-point mixed samples was examined in Damintun Town of Shenyang. The results showed that the content of P of all samples was increased with the utilization ages of the vegetable greenhouses. For all the samples, the concentration of TP and Olsen-P in the 0-40 cm layer was higher than that in the 40-120 cm. Compared with other samples, the content of TP and Olsen-P of 13 years of vegetable greenhouse soil is the highest throughout the 0-120 cm. In the 0-20cm layer, the TP concentrations in 13-year vegetable greenhouse soil is 4 times higher than that in the open vegetable land, and the concentration of Olsen-P range from 23.87 mg kg^{-1} in bare land soil to 102.13 mg kg^{-1} in 13-year vegetable greenhouse soil. These results demonstrated that long-term continuous P input from chemical fertilizers and manure can cause P accumulation in soils and enrich in topsoil.

Keywords: greenhouse soil; total phosphorus (TP); Olsen-P

1. Introduction

Phosphorus (P) is an essential nutrient for crop growth and yield. In pursuit of high yield and high efficiency, lots of organic fertilizer and chemical fertilizer have applied in farming, especially in

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greenhouse cultivation in China. Compared to chemical fertilizer application, manure application can increase soil organic matter [1], and reduce soil erosion [2], so it has been widely used for croplands. According to an investigation, the amount of manure input of northern china for greenhouse cultivation was at a high level. Generally, manure input applied to meet crop N need that may result in the buildup of P in soil [3-5]. According to a research, the average annual input of manure in the greenhouses Shouguang county (Shandong Province, China) is 177 t hm^{-2}, the maximum is 240 t hm^{-2} and the maximum of residual P in soil is 2053 kg P hm^{-2}. Although that may bring about environmental disturbances, considering about the economic benefit from increasing crops yield, manure has been heavy even excessive used. That may result in P and N enrichments and cause the risk of P and N losses from soils [6, 7].

Because of low use efficiency of the fertilizer (10%~25%), P accumulation in soil has been increasing with long-term continuous P input from chemical fertilizers and manure [8]. Many research showed that long-term continuous application of P fertilizers and organic manures in amounts exceeding the need of crops significantly increase the levels of all P forms in soils [9-12]. After 23 years long-term phosphorus application experiment in black soil, the result showed that phosphorus fertilization remarkably increased total P content and available P which was 6~15 times higher than that of no fertilization treatment [13]. A 16-yr study by Whalen and Chang [14] shows TP concentration (15-cm depth) range from 920 mg P kg^{-1} without P application to 3750 mg P kg^{-1} with cattle manure applications. Although phosphorus is strongly absorbed by soil, continuous P accumulation may bring about P loss. According to Lü's [15] research, phosphorus loss can contribute to the eutrophication of fresh waters.

The objectives of our study presented in this paper are to determine the relationship between soil P content with different utilization ages of the vegetable greenhouses of Shenyang suburb and analyze P accumulation in soil.

2. Materials and Methods

2.1. Study Site

The study was conducted at a vegetable production base of Shenyang suburb, Liaoning province, China (41°55.256'N and 122°58.548'E). After more than ten years development, the vegetable production base has became the largest greenhouse vegetable production of Liaoning province. According to a report, by 2010, Liaoning province greenhouse area will reach 270,000 hectares. The base is located in Liao River alluvial plain, and the topography is relatively flat. The soil is gley meadow soil. According to a research, before the base established, chemical analysis showed that TOC and pH in this soil were 7~11 g kg^{-1}, 6.5~8.5 [16]. Cultivars of vegetables in greenhouses are tomato, cucumber (winter and spring), beans and a variety of leafy vegetables (summer and autumn).

According to investigation, the manures used in the greenhouses include cow and poultry manures. The usage of the organic manure is about 80~110 t hm^{-2} each year. Other fertilizers used in there are urea (500 kg hm^{-2}) or $(NH_4)_2SO_4$ (1000 kg hm^{-2}), $(NH_4)_2HPO_4$ (1000~1500 kg hm^{-2}), K_2SO_4 (1000 kg hm-^{2}) and compound fertilizer (1200 kg hm^{-2}).

2.2. Sampling and Analysis

The tested soil was collected from different utilization ages of the vegetable greenhouses and at the depth of 0~120 cm with multi-point mixed sampling in 2008. After sampling, soil samples were air-dried and ground to pass through a 2-mm nylon sieve. The available P was extracted using the procedure of Olsen et al. (1954) [17]. TP and Olsen-P concentration were determined colorimetrically according to

method of Murphy and Riley (1962) after a Kjeldahl digestion (Taylor 2000) [18, 19], using visible-infrared spectrometer.

The data obtained from the experiment was analyzed by Microsoft Office Excel 2003.

3. Results and Discussion

3.1. Change of total P (TP) in the soil profile

The change with different utilization ages of the vegetable greenhouses in the concentration of TP in soil is shown in Fig.1. The concentration of TP of other samples was drop suddenly in the 0-40 cm. In the 0-20 cm soil profile, the concentration of TP of 13 years of vegetable greenhouse soil was 4 times higher than that of the bare land, and TP of all samples were increased with the utilization ages of the vegetable greenhouses. For the open vegetable land, the concentration of TP was low with little change throughout the 40-120 cm soil profile. For all the samples, the concentration of TP in the 0-40 cm layer was higher than that in the 40-120 cm. This implies that the accumulation of P was most pronounced in 0-40 cm layer. Compare to all samples, TP of 13 years of vegetable greenhouse soil is the highest throughout the 0-120 cm.

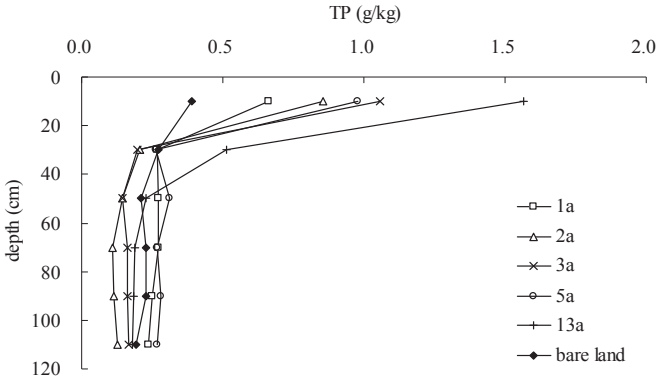

Fig.1 Trend of change in TP in the soil profile with the utilization ages of the vegetable greenhouses

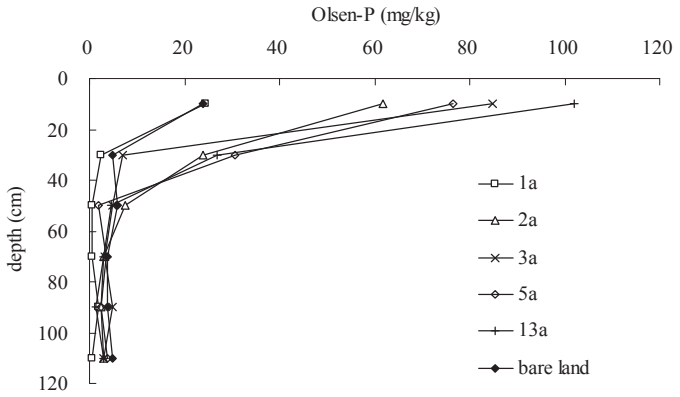

Fig.2 Trend of change in Olsen-P in the soil profile with the utilization ages of the vegetable greenhouses.

3.2. Change of Olsen-P in the soil profile.

The content of Olsen-P in soil is a main factor to estimate the ability of P supply from cropland. P is the main crop dry substance nutrient sources and the guarantee food production base [20]. The trend of Olsen-P is similar to that of TP. The concentration of Olsen-P of all samples was higher than in the bare land in the 0-120 cm soil profile in Fig.2. In the 0-20 cm layer, Olsen-P was increased with the utilization ages of the vegetable greenhouses. Accumulation of P was most pronounced in 0-40 cm layer. In the 40-120 cm layer, Olsen- P of all the greenhouse soil was higher than the bare land, which implies that long-term continuous P input from chemical fertilizers and manure can cause P translocation in soils.

3.3. Relationship between soil P and different utilization ages.

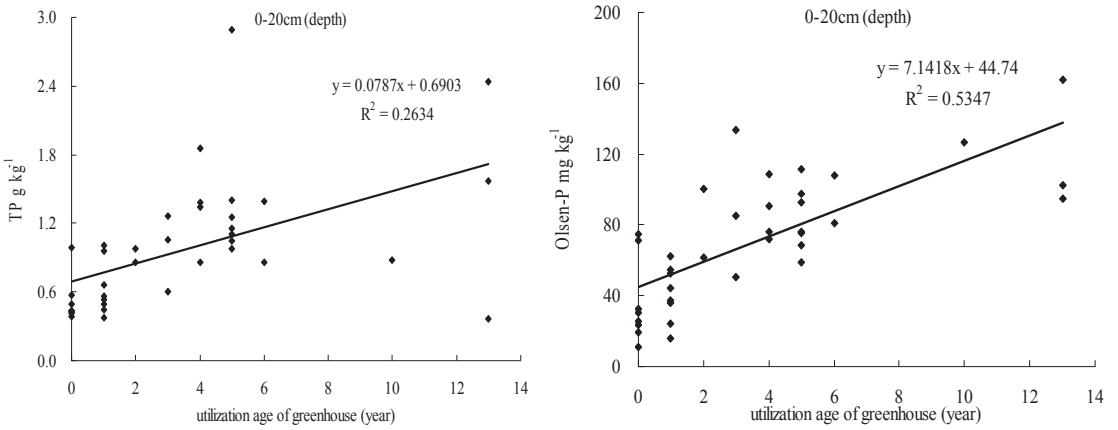

Fig.3 Changes of soil P content in vegetable greenhouses with different utilization ages.

Fig.3 shows the relationship between soil P (content of TP and Olsen-P) and utilization ages of the vegetable greenhouses in the 0-20 cm layer. After analysis 38 vegetable greenhouses soil samples of different utilization ages, the results showed that the content of P was increased significantly with the utilization ages of the vegetable greenhouses. It implied that continuous addition of fertilizer P in years increased the concentration of TP and Olsen-P over those in the bare land. Long-term P input can result in P accumulation in the top soil.

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