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Links between potassium of soil aggregates and pH levels in acidic soils under long-term fertilization regimes

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ABSTRACT

Soil pH adjusted by the application of lime can improve soil potassium (K) availability to meet crop K uptake in acidic red soil. However, the response of aggregated K to pH changes is poorly understood. Objectives of this study was to quantify the relationships between aggregate K content and pH levels in soil with different fertilization patterns from a long-term field experiment Then, an incubation experiment of pH adjustment was conducted over 90 days at different pH levels where HCl and $Ca(OH)_2$ were added to nitrogen and phosphorus fertilizers (NP); NP and K fertilizers (NPK); and NPK with manure (NPKM) soils. Our results showed that double linear equations can fit the relationships between aggregate exchangeable K (EK) with pH levels. However, the slopes and other parameters of fitted equations varied among different fertilization soils. Linear equations indicated that increasing pH value could improve non-exchangeable K (NEK) contents of soil aggregates, especially in NP soil with lower initial pH. However, the proportions of EK and NEK stocks in soil aggregates were significantly changed by soil pH adjustment only in NPKM soil. Additionally, redundancy analysis and partial least squares path mode also suggested that soil pH only affected the NEK contents in soil aggregates, although fertilization had direct effects on the EK and NEK contents in soil aggregates. Therefore, this study demonstrated that the aggregate K distribution of adjusting pH varied among soils with different fertilization regimes, then, improved soil pH could maintain high EK and NEK content of soil aggregates in red soil.

1. Introduction

In general, the highest proportion of potassium (K) in soil is in mineral form, which cannot directly supply K to crops. Moreover, previous research suggests that the content of exchangeable K (EK) and non-exchangeable K (NEK) can be to meet crop K uptake due to lower water-extractable K (WEK) (Pal et al., 1999; Jalali and Zarabi, 2006). For example, the WEK content is 5.3 mg/kg in red soil, which was 0.02% in total K (Das et al., 2019). It is therefore necessary to improve the soil K availability through increasing EK and NEK content in soil.

Soil pH is one of the major factors affecting soil processes and chemical, physical, and biological properties of soil (Brady and Weil, 2002). Soil pH decreases slowly from an initial pH under natural conditions (Tian and Niu, 2015). In recent decades, soil acidification has accelerated due to various anthropogenic activities, including acid deposition and application of excessive nitrogen (N) fertilizers in China and over the world (Guo et al., 2010; Tian and Niu, 2015). Soil acidification is severe for most soil types in tropical and subtropical regions such as red soil, because the red soil itself is acidic with pH lower than 6.0 (Lu et al., 2014; Tate, 2014; Zhao et al., 2014). Moreover, the pH value in red soil can be rapidly decreased due to inappropriate fertilization patterns through long-term fertilization experiments (Meng et al., 2014; Cai et al., 2015; Zhu et al., 2018). Soil acidification also results in the toxicity of aluminum and manganese to plants and deficiency of nutrients such as K, thus reducing crop yields (Brennan et al., 2004; Legesse et al., 2017). It is therefore important to alleviate soil acidification to sustain agricultural production.

Lime application slows soil acidification and is thus a popular technique to improve soil pH (Fageria and Baligar, 2008; Goulding, 2016). Han et al (2019) had proved that lime application could improve K availability in red soil. However, Previous studies have shown that the soil K availability is lower in acidic soils than other soil types

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