Mitigating water pollution by nitrogen fertilizers through amending ammonium sorption in an acid soil using Calciprill and sodium silicate

ABSTRACT

Use of nitrogen (N) fertilizers is gaining popularity to meet crop nutrient requirement for sustaining the food security of the increasing global population. However, improper management of N fertilizers in acid soils causes leaching and surface runoff because of excessive rainfalls and poor N retention in the tropics in particular. This results in N pollution in water bodies (also known as eutrophication), which degrades water quality to the detriment of aquatic ecosystems near farms. Thus, there is a need for using inorganic soil amendments such as Calciprill and sodium silicate to improve soil N adsorption because of the alkalinity and ability of these amendments to retain N for mitigating excessive N contamination in water bodies. To this end, this N sorption study was conducted to determine the effects of Calciprill and sodium silicate on ammonium (NH_4^+) adsorption and desorption in an acid soil (Bekenu series, Typic Paleudults). The soil was co-applied with different rates of Calciprill (80 %, 90 %, and 100 % Ca saturations) and sodium silicate (90, 105, 120, 135, and 150 kg ha^{-1}), followed by the NH_4^+ adsorption capacity determination through the additions of NH_4^+ isonormal solutions at the five concentrations (0, 25, 50, 75, and 100 mg L^{-1}) to establish a linear relationship between the amount of NH_4^+ absorbed (qe) and the amount of NH_4^+ left in the solution (C_e) after 24 h of equilibration. Apart from the soil only without any amendment (C0S0), there were another two additional treatments where the soil was added with Calciprill (100 % Ca saturation) (C3) and sodium silicate only (150 kg ha^{-1}) (S5) to determine their respectively effects on N sorption. The collected data were fitted to the Langmuir and Freundlich isotherms. Thereafter, NH_4^+ desorption was determined using the same soil samples added with 2 mol dm^{-3}. Compared with the soil without any amendment (C0S0), the Calcirpill alone (C3) and the combined use of Calciprill and sodium silicate significantly increased NH_4^+ adsorption at the NH_4^+ addition of 250 mg L-1, suggesting that Calciprill is the amendment which dominantly increases NH_4^+ adsorption and the effects of amendments are more pronounced at the lower soil NH_4^+ concentration. The results also revealed that the NH_4^+ adsorption in the soils following the co-application of Calciprill and sodium silicate followed the assumption of Freundlich isotherm. Regardless of the NH_4^+ concentration used, the effects of Calciprill and sodium silicate on the NH_4^+ desorption remain unclear, which could be because of the ability of sodium silicate to stabilize the soil structure. This stabilization reaction might have impeded the dissolution of Calciprill and temporarily fixed the absorbed NH_4^+. These findings suggest that it is possible to use the amendments to amend

NH_4^+ sorption in Bekenu series for mitigating NH_4^+ leaching and runoff to prevent eutrophication.