Zeilote Effects On Nitrogen and Phosphorus Availability in Soil
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Abstract
Zeilote are naturally occurring aluminosilicate minerals with a large reactive surface area. A field study based on randomized complete block design was established in 2011 to evaluate the effects of Zeilote as a soil amendment to improve the N and P-use efficiency of crops. Mined Ca-Zeilote (Clinoptilolite) was applied at 0, 25, 50, 100 and 200 kg/ha, respectively, in winter-killed Cowpea and radish cover crop plots in April, 2012. Composite soil samples were collected weekly from each replicated plot at 0-15 cm depth, processed, and analyzed for nitrate, ammonium, and available P after extracting the field-moist soil with deionized water and 1-M KCl solution. Results showed that N and P availability to plants was improved. Lesser amount of nitrate was extracted by both water and 1-M KCl solution. Most of the N was extracted as ammonium by 1-M KCl solution. Corn yield was responded to Zeilote application.

Introduction
Zeilote is a nanosporous secondary mineral with large surface contact area making it ideal for adsorption and desorption of nutrients (Photo 1). Zeilote is not susceptible to biological degradation and is expected to have long-term benefits for nutrient recycling. Zeilote is not susceptible to biological degradation. Several researchers have reported that Zeilote (such as Clinoptilolite) incorporation significantly decreased N leaching from sand media (Huang and Petrovic 1994). Ferguson and Pepper (1987) attributed the lower leaching losses to the high NH4 retention of Zeilote. MacKown and Tucker (1985) also reported lower NH4 losses with Zeilote and found that as incorporation rate increased, N loss decreased significantly. Penn et al. (2010) performed batch experiments with zeolite alone, noting that NH4 sorption was mostly exchangeable as 81% to 87% of zeolite-bound NH4 was removed with 1-M KCl. After 6 weeks of corn growth in amended sandy soil, zeolite increased corn yields compared with control. The objectives of the study were to evaluate the effects of Zeilote as a soil amendment to improve the (1) reactive N (NO3 and NH4) and P retention and availability, and (2) growth and yield of corn.

Materials and Methods
The study was conducted at the Ohio State University South Centers at Piketon, Ohio in 2011 and 2012. The soil is a Omulga silt loam (Fine-silty, mixed, mesic Typic Fragudalfs) and has pH 5.3, electrical conductivity 53.2 µS/cm, total carbon 1.51%, total nitrogen 0.13%, bulk density 1.36 g/cm3, and 0-15 cm depth. A randomized complete block design with 5 levels of powdered Clinoptilolite (0, 25, 50, 100 and 200 kg/ha, respectively) was laid-out in 2011. The treatments were replicated 4 times in 20-30 P plots. Prior to establish the experimental design, the field was chisel-plowed in early July, 2011 followed by planting of Cowpea (30 kg/ha) and oilseed radish (kg/ha) together as cover crops (Photo 2). The cover crops were winter-killed and Zeilote was applied surface in the fall. Corn was planted within cover crop residues in the spring. Geo-referenced composite soil samples were collected from each plot March 16, 2012 until July 6, 2012. Field-moist soil samples were processed, extracted with deionized water and 1-M KCl, and analyzed for NH4, NO3 and available P. SPAD meter was used to measure leaf chlorophyll content of the growing corn. At harvest, a random grain sample was collected from each plot, oven-dried and used for calculation of crop yields. Significant differences in reactive N and P concentration, leaf chlorophyll, and crop yields attributed to the effects of Zeilote over time were assessed in a factorial arrangement of the randomized complete block design using analysis of variance procedure of the SAS (SAS 2008). The time and block were considered as random factors. Zeilote and extractant were considered as fixed factors. For all statistical analyses, significant main and interactive effects of predictors on dependent variables were evaluated using the SAS General Linear Model procedure and separated by the F-protected least significant different (LSD) test at p=0.05 unless otherwise mentioned.

Results and Discussion
Results showed that Zeilote as a soil amendment significantly influenced the adsorption and release of NH4, NO3, and available P (Fig. 1). While incorporation of Zeilote significantly decreased NO3 concentration in soil (Fig. 1a), the NH4 concentration significantly increased with Zeilote application (Fig. 1b). The NO3, NH4, and available P concentration have shown a non-linear increase over time when extracted with 1-M KCl or water (Fig. 2a, b and c). On average, the 1-M KCl extracted significantly higher concentration of NO3, NH4, and available P compared with water. The temporal increase in NH4 concentration was for longer time than NO3 and available P.

Conclusions
Results showed that Zeilote significantly adsorb NH4 and P and minimize reactive NO3 formation. Nitrogen released as NH4 after dissolution of applied chemical fertilizers or decomposition of manures and cover crops is adsorbed by Zeilote. Higher concentration of NH4 extracted by 1-M KCl than by water suggested that NH4 is adsorbed by Zeilote and is not removable by water erosion. N mixed with Zeilote could be used as a controlled release fertilizer.

Photo 1: Scanning microscopy of Clinoptilolite

Photo 2: Cowpea and radish as cover crop

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