Release of Native and Non-Exchangeable Soil Potassium and Adsorption in Selected Soils of North China

By Cheng Mingfang, Jin Ji-yun, and Huang Shaowen

Research indicates that soils of northern China can have considerably different potassium (K) release rates and K adsorption capacities. This study shows a general increase in the release rate of non-exchangeable K (NE-K) and a decrease in fertilizer K adsorption as one moves from east to west in northern China.

It was once believed most soils in northern China had abundant supplies of available K (native soil K) for crop production. In recent years, with development of new crop cultivars and improved crop management practices, crop yields increased considerably, and native soil K has become severely depleted. Evidence of yield responses to K in northern China continues to accumulate. However, the exact kinetics of native soil K and NE-K release and soil adsorption of fertilizer K are still unclear.

Materials and Methods

Twenty-five soil samples were collected from northern China, including many locally classified soil types such as gray desert soil, anthropogenic alluvial soil, cinnamon soil, chestnut soil, fluvo-aquic soil, brown earth, meadow soil, black soil, and chernozemic soil. The kinetics of native soil K release were determined by extracting with 0.375 mol/L calcium chloride ($CaCl_2$) solution, NE-K release with 0.1 mol/L hydrochloric acid (HCl) solution, and K adsorption with 40 mg/L K solution using the miscible displacement technique. Temperature and flow rate during the experiment were set at 25° C and 1 ml/min, respectively. The K concentration in solution was analyzed by an atomic absorption spectrophotometer.

Cheng Mingfang and Huang Shaowen examining K depletion pot experiments in greenhouse.

Soil K depletion was conducted in pot experiments with successive planting of corn for eight to 10 harvests. Plant uptake of K was determined after each harvest.

Minimum and Maximum Values for Soil K Release and K Adsorption

For the 25 test soils, the amount of native soil K released ranged from 71 to 279 mg/kg while the amount of NE-K ranged from 39 to 672 mg/kg. The maximum release rate of native soil K varied from 2.6 to 21.4 mg/kg/min. Over a 10-hour extraction period, the average release rate of NE-K ranged from 0.07 to 1.1 mg/kg/min. The total amount of K fertilizer adsorbed by these soils varied from 139 to 2,550 mg/kg.

Regional Differences in Soil K Release and K Adsorption

Results (**Table 1)** indicate soils from northwestern China (Xinjiang, Qinghai, Gansu, Ningxia, and Shaanxi provinces) have higher release rates for both native soil K and NE-K and, therefore, higher K supplying power than soils from north central (Beijing, Hebei, Henan, Shandong, Tianjin, and Shanxi provinces) or northeastern China (Heilongjiang, Jilin, and Liaoning provinces). Differences in K release and adsorption were smaller between soils from north central and northeastern China. However, the measured parameters indicate average long-term K supplying power of north central soils is higher than northeastern soils.

The degree of K fertilizer adsorption in northern China increased in a west to east direction (**Table 1**). The respective average K adsorption capacities for seven northwestern, 10 north central, and eight northeastern soils were 608, 1,276, and 1,818 mg/kg. This trend is the reverse of regional differences in soil-K release and the resulting K supplying power.

It should be pointed out that the distribution of soils in northern China is inherently complex. As an example, loessial soils located in the northwestern province of Shaanxi are known to have lower K release rates and higher K adsorption capacities. In addition, chernozemic soils located in north central and northeastern China (Heilongjiang province) have higher K release rates and lower K adsorption capacities.

Table 1. Parameters of native soil K and NE-K release and adsorption to applied K.

Region	Total native K released, mg/kg	Maximum native K release rate, mg/kg/min	Total NE-K released, mg/kg	Average NE-K release rate, mg/kg/min	Total K adsorbed, mg/kg	Average K adsorption rate, mg/kg/min
Northwest (n=7)	171	9.4	314	0.52	608	1.46
North central (n=10)	144	5.1	87	0.14	1,276	2.07
Northeast (n=8)	164	4.8	60	0.10	1,818	2.75

In K depletion pot experiments, K uptake by corn was closely correlated with soil K release rates (**Figure 1**). Correlation coefficients between the maximum native soil K release rate and K uptake during the first planting and total plantings were 0.66 and 0.54, respectively. In turn, correlation coefficients between the average release rate of NE-K and K uptake during the first planting and total plantings were 0.78 and 0.78, respectively. These correlation coefficients were significant at the one percent significance level, which confirms the importance of native soil K and NE-K release rates in influencing the K supplying power for soils of northern China.

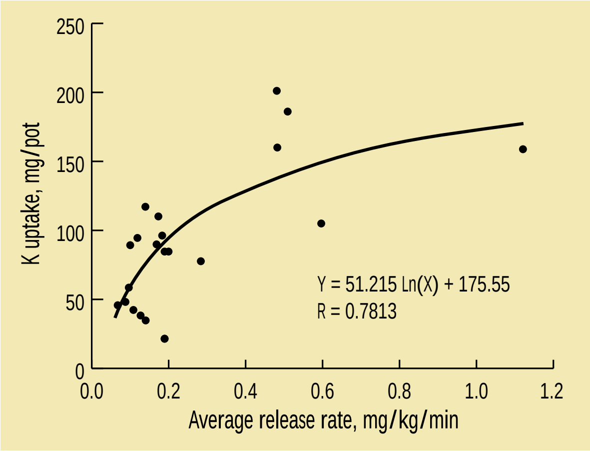

Figure 1. Correlation between non-exchangeable K release rate and K uptake in the first planting of K depletion pot experiments.

Conclusion

Release rate of soil K, especially NE-K, is one of the most important factors governing soil K supplying power. Results of this research are consistent with those of field trials in recent years. Reports of crop responses to K in northeastern and north central China are much more common than in northwestern regions. Reported responses in northwestern China are mainly in specific regions such as those with sandy soils or in high K demanding crops such as cotton, vegetables, and fruits. It is apparent that China's limited supply of K could be better distributed in the K deficient soils of northeastern and north central China. Smaller K quantities are required in northwestern China. Potash supplies are needed for high value crops, high K demanding crops, and localized K deficient soils. For all soils of northern China presently rich in native K, a monitoring system should be established to observe changes in K supplying power. This can be achieved through determination of readily available K, slowly available K, and NE-K release rate. **BCI**

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