Applied Geochemistry, Vol. 2, pp. 243–246, 1987.
Printed in Great Britain

0883-2927/87 $3.00 + .00
Pergamon Journals Ltd.

Rocks as fertilizers: preliminary studies on potassium availability of some common rocks in Sri Lanka

J. M. NIWAS and C. B. DISSANAYAKE
Department of Geology, University of Peradeniya, Sri Lanka

and

G. KEERTHISINGHE
Department of Soil Science, University of Peradeniya, Sri Lanka

(*Received* 2 *December* 1986; *accepted in revised form* 12 *March* 1987)

Abstract—Preliminary investigations of the K availability of some commonly occurring rocks of Sri Lanka showed that granulitic gneiss, pink granite, migmatitic gneiss and microcline granite release relatively high amounts of K indicating the capability of using these to provide K in plant nutrition. The finer crushed sizes are more effective in releasing K, and the availability of the K-reserves under appropriate soil conditions makes them possible substitutes for synthetic K fertilizers.

INTRODUCTION

THE COUNTRIES (mostly third world) that lie in the tropical equatorial belt very often face major problems in agriculture and food production due to the extreme impoverishment of nutrients in the soils. The nature of tropical soils differs from that of younger soils of temperate lands and presents serious problems to the agriculturist for the following reasons:

1. High temperature and rainfall accelerate the progress towards the residua system of weathering (CHESWORTH, 1973) by leaching the more mobile elements, resulting in infertile lateritic soils.
2. As cultivation is intensified, the laterite becomes more barren. Conventional NPK fertilizers are generally not held by Fe_2O_3–Al_2O_3–SiO_2–H_2O laterite systems (LEONARDOS *et al.*, 1985).

Further, the inability of the NPK type fertilizers to add all-important micronutrients to the already "micronutrient-poor" tropical soils, is another reason for the search for an alternative fertilizer. Recently, CHESWORTH (1975), KRONBERG *et al.* (1979, 1985), FYFE and KRONBERG (1980), CHESWORTH *et al.* (1983) and LEONARDOS *et al.* (1985) focussed attention on the replenishment of nutrients in tropical soils by native rocks.

Sri Lanka, a developing country in the tropical equatorial belt, comprises 90% metamorphic rocks and this study has been aimed at investigating the potential of metamorphic rocks to supplement the K budget in leached soils.

MATERIALS AND METHODS

Table 1 shows the rock types that were investigated and their mineralogy. Each rock sample was crushed and sieved to 3 different sizes, i.e. (1) 0.25–0.35 mm (coarse), (2) 0.14–0.06 mm (medium) and (3) 0.06 mm (fine).

The exchangeable K was determined by shaking 10 g of the crushed rock with 100 ml of 1N ammonium acetate buffered at a pH of 7, for 1 h. Acid soluble K was determined by leaching 10 g of sample with 50 ml of 0.1N HCl for approximately 1 h. In order to observe the K-release characteristics, samples were reacted with 50 ml of deionized water for a total period of 6 weeks. At the end of each week, the liquids were centrifuged and the supernatant solution tested for K. A further 50 ml of deionized water was then added to the sample and the procedure continued up to 6 weeks. The K measurements in all extracts were carried out by atomic absorption spectrophotometry.

Table 1. The mineralogy of the rocks investigated

Rock	Minerals
Marble	calcite, dolomite
Quartzite	quartz
Granulitic gneiss	orthoclase, plagioclase, quartz, biotite
Microcline granite	microcline, plagioclase, quartz
Pink granite	microcline, quartz, plagioclase, biotite
Migmatitic gneiss	microcline, plagioclase, quartz, biotite
Hornblende biotite gneiss	orthoclase, plagioclase, quartz
Intermediate charnockite	orthoclase, plagioclase, hornblende, biotite, quartz
Basic charnockite	plagioclase, hornblende, biotite, quartz
Dolerite	diopside, plagioclase, biotite, hornblende

RESULTS AND DISCUSSION

Figure 1 illustrates the release of K from the rocks for the three grain sizes investigated. Pink granite, migmatitic gneiss and granulitic gneiss had the highest exchangeable K contents, in that order, for the coarse and medium fractions. In the finer fraction, however, granulitic gneiss had the highest exchangeable K content, followed by pink granite and migmatitic gneiss. In soil, when cations are removed by cropping or through leaching they are replenished mainly by exchangeable cations. The exchangeable K values of the rocks investigated indicate the degree to which these rocks could be used to enhance soil fertility. In low-K soils the application of 40 kg/ha of K will be needed for enhanced plant growth (TISDALE, 1985). Approximate calculations based on the exchangeable K contents of the rocks studied indicate

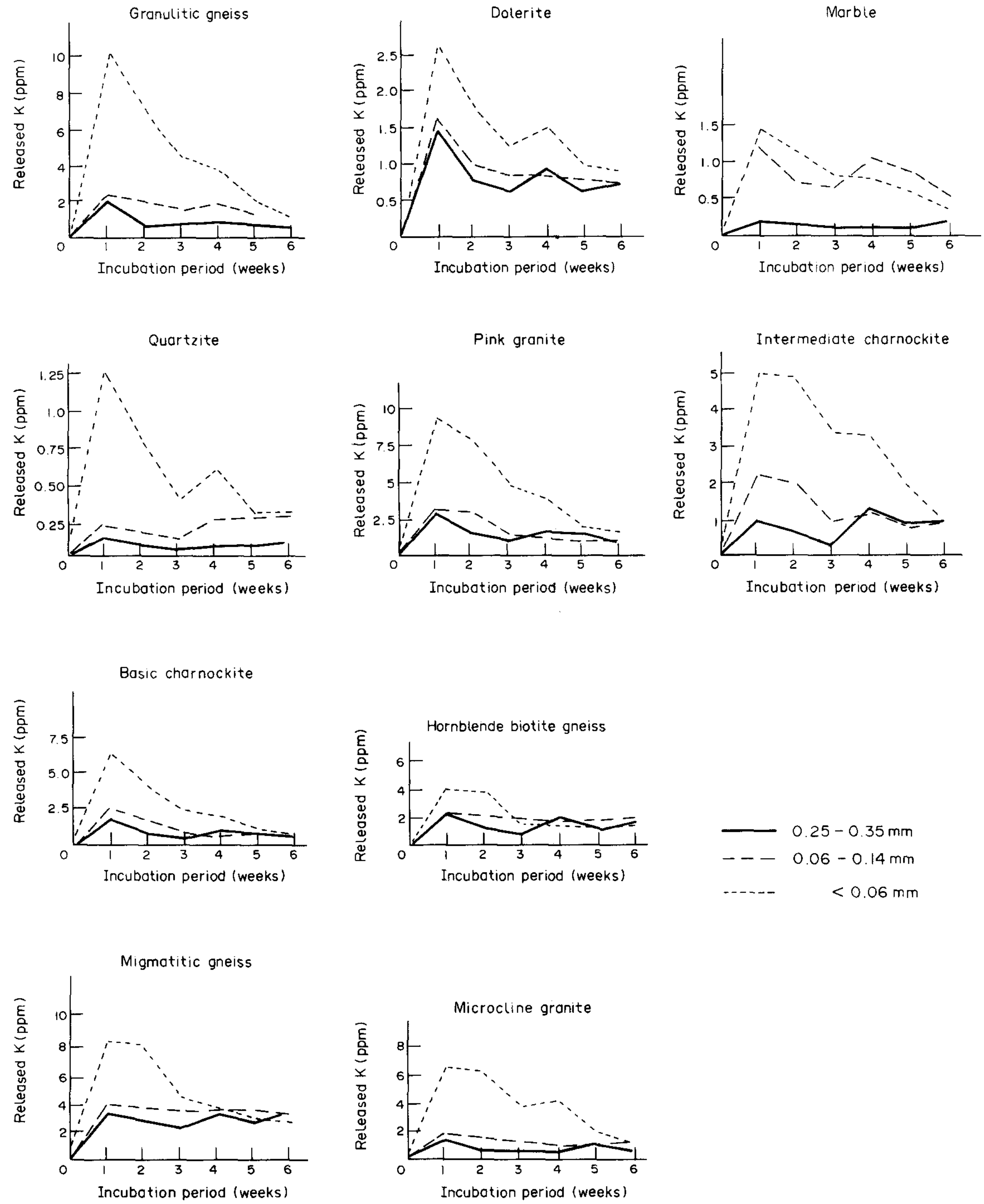

FIG. 1. Release of K from rocks for different grain sizes.

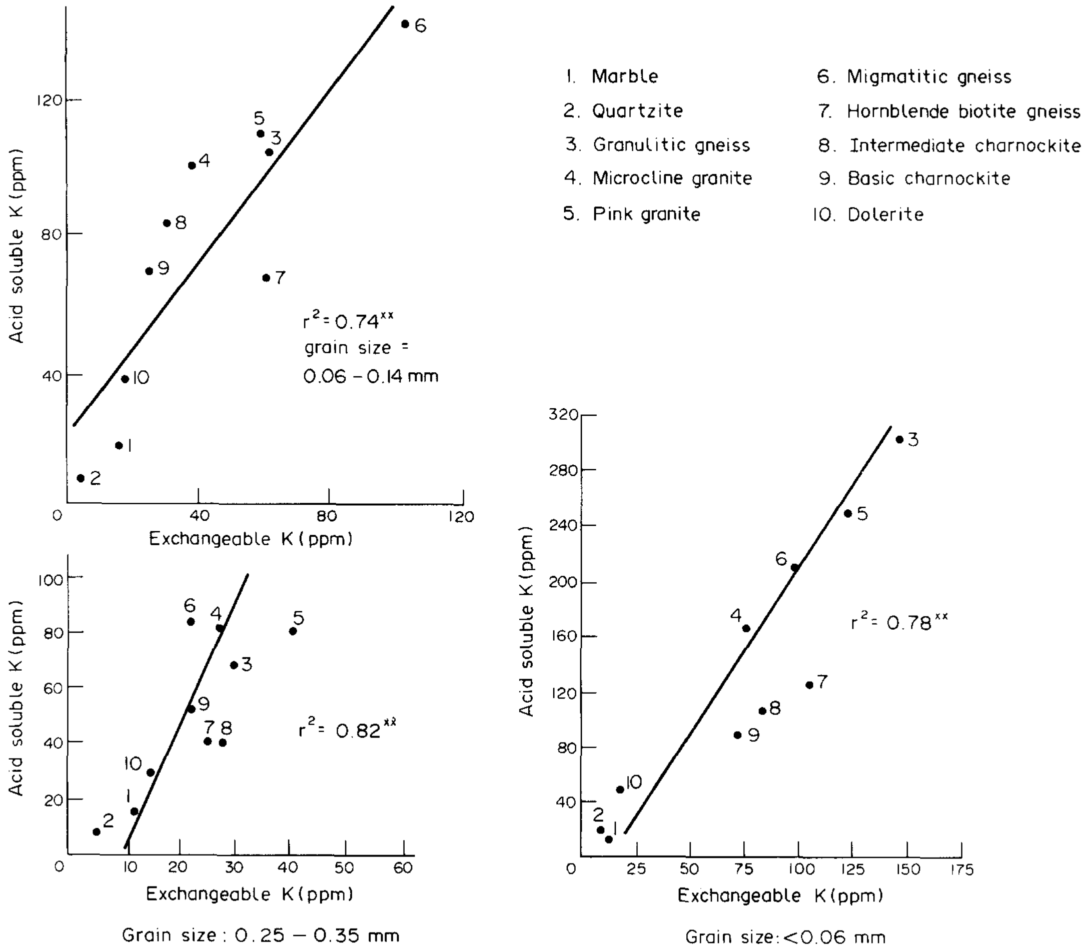

FIG. 2. Relation between acid soluble and exchangeable K of the different rock types for the three grain sizes.

that the application of 250 kg/ha of appropriately crushed pink granite, granulitic gneiss and migmatitic gneiss would meet the K requirements. The application of 40 kg/ha of K has been recommended for new varieties of paddy in Sri Lanka. Even though the exchangeable K contents of the rocks are relatively high, they should have a good replenishing ability so as to maintain a regular K input. Certain rock types such as pink granite, granulitic gneiss, migmatic gneiss and microcline granite showed high acid soluble K contents. Generally, the acid soluble K values were higher than the exchangeable K indicating that a part of the K reserves could be mobilized by acid extractants. However, the significant positive correlation observed between the exchangeable and acid soluble K contents for the three grain sizes of all rocks studied shows that the ammonium acetate extractant is capable of indicating the potential of acid soluble K fraction (Fig. 2).

The concentration of K that should ideally be present in the soil solution for plant uptake varies considerably depending on the type of crop and required growth. A K concentration of about 9 ppm in solution would enhance the growth of crops such as tomatoes and beans (SINGH and JONES, 1976). RUSSEL (1974) has noted, however, that a K concentration of 4 ppm in solution would be sufficient for certain crops for good growth. The results obtained from this study therefore indicate that some of the crushed rocks give sufficiently high K concentrations to sustain good plant growth. It was also observed that, in the fine fraction, these rocks maintained a high K concentration up to a few weeks of extraction. Pink granite, migmatite, microcline granite and granulitic gneiss all maintained a K concentration above 4 ppm up to 3 weeks. The actual value may be much higher in the case of acid soils. In the presence of organic matter and clay, however, it may be lower. The rate of cation release in the soil, however, is likely to be changed due to conditions of acidity, groundwater percolation, presence of CO_2 and humic acid, temperature, other cations present and particle size. Several authors (KELLER *et al.*, 1963; HUANG and KELLER, 1970; VANDOR, 1975; FYFE *et al.*, 1983) have demonstrated the release of cations with water and weak organic acid. In the experiments conducted by

CHESWORTH *et al.* (1983) crushed acid to basic igneous rocks were allowed to react with water and the resulting solution had a K content of 6–10 ppm in 10 days.

Even though a fraction of the K present in minerals exists in an exchangeable form, which in fact supplies the K to the labile pool for plant growth, the larger fraction of K is in a structural form which is not easily available. It would therefore appear possible, with proper selection of soil type and optimum grain size of crushed rocks, to build up a natural nutrient reserve within the soil body which will release the nutrients at an optimum rate for a prolonged period. The many risks inherent in the use of synthetic fertilizers such as rapid solubility and groundwater pollution can be avoided.

CONCLUSIONS

This investigation on the K availability of some crushed rocks from Sri Lanka shows that certain rocks such as pink granite, granulitic gneiss, migmatitic gneiss and microcline granite may be used as a K replenishing source in plant nutrition. Their use as a K donor is based on the relatively high exchangeable K contents and the K release characteristics observed. Preliminary calculations showed that the application of a few hundred kilogrammes per hectare of the appropriate crushed rocks possess the potential of providing K to meet crop demand. The effect of the grain size on the K release characteristics was clearly observed, the finer fractions being more effective. Acid leaching makes the K reserves available to the labile pool and hence by adding appropriate amount of crushed rocks a long-term K source could be established.

Further investigations are clearly needed before the crushed rocks as investigated in this study can be used as K fertilizers on a large scale. Further work should include studies on rates of dissolution of different rock types in accordance to these grain sizes, their K release patterns in different soil types and effect of incorporation of these substances on soil properties.

Editorial handling: Brian Hitchon

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