ROCKS AND MINERALS FOR PLANT NUTRITION

A O SHIRALE, B P MEENA, PRIYA P GURAV, SANJAY SRIVASTAVA, A K BISWAS, A K PATRA

ICAR- Indian Institute of Soil Science, Bhopal, Madhya Pradesh
*Corresponding author, E-mail: abhayshirale@gmail.com

Any plant for completion of their lifecycle they require 17 elements which are known as essential nutrients. With the exception of primary nutrients C, H and O, which plants obtain from air and water, plants derive the remaining 14 elements from the soil or through organics and chemical fertilizers. The weathered rock mineral portion of the bulk soil solid fraction is the main reserve of many plant nutrients. The same portion of soil exerts significant direct and indirect influences on the supply and availability of most nutrient elements to crop plants.

To increase soil productivity, food production and food security, farmers have to not only increase soil nutrient concentrations but also improve the structure of the soil, and reduce soil losses. The utilization of manures and other local nutrient inputs is one of the strategies of effective resource management. Use of imported water-soluble fertilizers is another management practice that can replenish soil nutrients. However, the use of these externally-produced nutrient inputs by resource-poor farmers is constrained by high costs.

Under these situations the use of crushed rocks and minerals can act as viable option for supplementing the major and micronutrients. The use of whole rock silicate fertilizers is attractive as these types of fertilizers have the potential to supply soils with a large array of macro

and micronutrients in comparison to commercially available soluble fertilizers, which commonly only supply the main macronutrients N, P and K, but not nutrients such as Ca, Mg and micronutrients. Ground rocks can be considered as slow release fertilizer in situations where leaching rates of conventional fertilizers are particularly high, e.g. in sandy soils under wet climatic regimes. In this article we tried to summarize the indigenous nutrient sources, its impact on crop yield, soil properties and techniques to use the ground rock material in agriculture.

ROCKS AND MINERALS: A RESERVOIR OF NUTRIENTS FOR CROPS

There are many mineral sources, for example, K-feldspars, micas, and illite. These are promising sources of potassium, and they also contain other minerals such as Mg, Fe, Ca, Na, Si, and a number of micronutrients (table 1). Mineral sources like amphiboles and pyroxenes are considered as important reservoirs of Mg, Fe, Ca, Si, and most of the micronutrients. Plant-induced weathering of basalt supplies trace amounts of P in the form of calcium phosphate, the primary source of P in most ecosystems and fertilizers, and adds plant-essential trace nutrients. For example, most of tropical soils in developing countries are deficient in K, and crushed silicate rocks applied as slow-release K fertilizers which can help to sustain profitable crop production.

Rock powders act as fertilizers because their small grain size allows the mineral elements they contain to be readily released by the action of water, carbon dioxide, and organic acids released by plant roots and beneficial microorganisms.

Figure 1 Glauconite deposits in Singrauli District of Madhya Pradesh

Figure 2 Mica deposits in Jharkhand (Source: hindustantimes.com)

Figure 3 Plagioclase feldspar deposits in India (Source: https://digitalfire.com)

Finer materials have higher surface area and release their minerals more quickly. The greatest benefits are obtained on the most nutrient deficient soils. Crushed rock powder therefore is a strategy for improving soil fertility of soils.

Table 1. Composition of nutrient elements in different soil minerals

Mineral constituent	Nutrient element Constituent	
	Major element constituent	Minor element constituent
Feldspar	K, Ca, Na	Cu, Mn
Amphiboles & Pyroxene	Mg, Fe, Ca	Ni, Co, Cu, Mn, Zn, Mo
Micas	K, Ca, Na, Mg, Fe	Ni, Mn, Co, Zn, Cu
Titanium minerals	Ti, Fe, Ca	Co, Ni
Apatite	Ca, P	
Clay	K, Mg, Fe, Ca, Na	
Iron oxides	Fe	
Carbonates	Ca, Mg, Fe	

(Source: Klein and Hurlbu, 1999)

CROP PRODUCTIVITY AS INFLUENCED BY USE OF ROCKS AND MINERALS

Amending soils with ground Ca/Mg-rich silicate rocks can improve crop yields and has a long history of being practiced on a small scale, especially in highly weathered soils. The experiences with the application of different rock powder in revealed significant effect on crop performance except the in some cases the of granite rock powder showed inconsistent results. Application of rock powder was found to increase yields in many agricultural crops. Among the various sources glauconite, nephaline, waste mica etc. were found most effective in enhancing uptake and yield of crops.

ROCKS AND MINERALS AS AN AMENDMENT FOR DEGRADED SOILS

By generating alkalinity as they weather, silicate rocks reduce soil acidification caused by overuse of ammonium and elemental sulphur fertilizers, urea, growth of nitrogen-fixing legumes and repeated crop harvesting. Acidification of agricultural soils is a worldwide problem and reversing it improves nutrient uptake, root growth and crop yields. Neutralizing acidic soils also reduces metal toxicity (e.g., aluminium and manganese) and increases P availability, especially in highly weathered acidic tropical soils, where metal oxides strongly bind remaining P reserves.

For example the rocks like glauconite either calcined (heating of mixture of glauconite and $CaCl_2$ or glauconite and lime) can act as amendment for management of soil acidity in highly weathered soils. The rock powder was found to be a good remineralizer in eroded soils, where most of the top fertile soil is lost due to erosion. The use rock powders as source of nutrient or amendment for degraded soil have following proven benefits;

- Improving nutrient content (major and micro nutrients) needed by crop plants
- The Ca and Mg elements present in the rock powder will help in the amelioration of acidic soils
- The rock powder can bring the changes in important physical soil parameters like bulk density, water holding capacity, soil texture etc
- The improvement in chemical properties of highly weathered soil like improvement in pH, cation exchange capacity, exchangeable ions (cation and anions), availability of nutrients etc.
- The rock powder enhance the biological properties of soils
- Enhance the crop yield and quality of the produce
- The finely ground silicate rock powder can act as slow nutrient release fertilizer

TECHNIQUES FOR USE OF INDIGENOUS POTASSIUM SOURCES AS FERTILIZER

i. Use of K solubilizing microorganism: The bacteria and fungi which can solubilize the potassium from K bearing rocks are numerous for example the microorganisms like *Pseudomonas* spp., *Burkholderia* spp., *Acidothiobacillicus ferrooxidans*, *Bacillus mucilaginosus*, *Bacillus edaphicus*, *Bacillus megaterium*, *Bacillus circulans*, *Paenibacillus* spp.,

Pseudomonas and *Burkholderia* can release K from K-bearing minerals by secreting organic acids or by chelating the primary mineral's silicon ions which brings the K into solution.

ii. Use of organic matter: In India huge quantities of crop residues are generated, which are generally burnt in the field by the farmers. This residue can effectively be used by converting them into K enriched manure through composting with the K rich rock and minerals like glauconite, mica, feldspar.

iii. Acidulation treatment: The acidulation of rock powder with organic acids weather rocks by changing the dissolution rate through decreasing solution pH or forming complexes with cations at the mineral surface; by affecting the saturation state of the solution with respect to the mineral; and by affecting the speciation in solution of ions such as Al^{3+} that themselves affect mineral dissolution rate. Various organic acids can effectively dissolve minerals and chelate metallic cations. Generally, the effect of organic acid on dissolution rocks and minerals is attributed to the presence of hydrogen ions and the formation of cation complexes. The acidulation of rocks by using mineral acids like H_2SO_4 was also found effective for supplying nutrients to crop plants.

iv. Heat treatment: For nutrients demanded in larger quantities by crops, such as K, there are still restrictions on the use of these materials due to the low solubility of the rocks. The process of calcinations of glauconite and heat treatment to glauconite enhance the solubility of rock minerals by bringing structural changes.

REFERENCES

Klein, C. & Hurlbut Jr., C. S. *Manual of mineralogy (After James D. Dana),* 21st revised ed. New York, NY: Wiley, 1999.

***