Part 1. Rocks for Crops

1. Introduction.

A productive and sustainable agricultural system is fundamental to the well being of a nation and a cornerstone of its development. In most of sub-Saharan Africa, more than 50% of the population rely on agriculture for their livelihood, which generally contributes more than 30% of the Gross Domestic Product (GDP). Agriculture is the major source of income, employment, food security and survival for the majority of the population. While agricultural production is steadily increasing in sub-Saharan Africa, the population is growing faster than food production. The result is a net decline in per-capita food production, which contributes to increased food deficits and poverty. A high proportion of African farmers are resource-poor in terms of capital, land, labour and livestock and about one-half of the population is classified as 'absolute poor' with per capita incomes of less than US $1 per day. Life expectancy in parts of Africa is very low. For example, in Guinea-Bissau, Madagascar, Malawi, Rwanda, Sierra Leone, Uganda, and Zambia, life expectancies at birth are less than 42 years. As well, sub-Saharan Africa has the highest proportion of undernourished children in the world.

The rural population in most of sub-Saharan Africa relies on soils and rain for life-supporting agricultural production. Soils are the basis for survival, food security, and employment, but in much of Africa the soils are over-exploited. For soil fertility to be sustainable, exported soil nutrients must equal imported soil nutrients. But in large areas of Africa more soil nutrients are exported than replenished. As a consequence, soils are 'mined' (Van der Pol 1993). In addition, large areas have not been protected from erosion and soils have been washed away from farmers' fields. Over the last few decades, soil productivity has steadily declined. The annual soil depletion rate in sub-Saharan Africa, 22 kg of nitrogen (N), 2.5 kg of phosphorus (P) and 15 kg of potassium (K) per hectare of cultivated land per year, is equivalent to US $4 billion in fertilizer (Sanchez 2002). This decreasing soil quality is regarded by many scientists as the fundamental biophysical cause for the downward trend of food production in sub-Saharan Africa (Sanchez *et al.* 1997; Sanchez 2002).

The need for sustaining agricultural productivity over a long period of time calls for effective resource management practices including sound soil, water and nutrient management. To meet the food challenges that face sub-Saharan Africa, major efforts must to be made at all levels of society; individual, communal, national and international. The well-being of future generations is increasingly linked with sustainable development and food security, and access for all to sufficient and nutritious food is the key to poverty reduction.

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 (Sanchez 2002), and poor availability. In addition, macro-economic policy changes in the 1990s resulted in 'structural adjustment programs' with subsequent liberalization of crop and input prices, abolition of commercial fertilizer subsidies and other measures. In reality, these policies resulted in reduced use of imported water-soluble fertilizers. Regional fertilizer use per hectare is extremely low in sub-Saharan Africa. On average less than 5 kg of water-soluble mineral fertilizers per hectare are applied to food crops in sub-Saharan Africa (Quiñones *et al.* 1997), which are the lowest application rates in the world.

The need to reduce poverty, increase food security and protect the environment requires substantially more and broader efforts and innovation than simply the improvement of soil quality and food production. Sanchez and Leakey (1997) point out three important requirements to increase per capita agricultural production for smallholder farmers, including enabling policies and improved infrastructural environment

(including access to education and health facilities, credits, inputs, markets and extension services), reversal of soil fertility depletion, as well as intensification and diversification of land use with high-value products.

Most soils related research and development efforts (including this one) focus on technical issues. But non-technical factors (mainly social, economic and political) are important as well. The situation on farms is complex and simple resource-based 'fixes' are rare to find and apply. The addition of soil nutrients should be seen as only one of the building blocks of integrated locally adapted soil fertility management.

Agricultural nutrient inputs include manures, fertilizers, and geological resources ('agrominerals') with the potential to enhance soil productivity. Agrominerals are naturally occurring geological materials in both unprocessed and processed forms that can be used in crop production systems to enhance soil productivity. Agrominerals include geological materials that contain one or more recognized plant nutrients and so-called 'rock fertilizers' (Benetti 1983; Appleton 1990), sometimes called 'petrofertilizers' (Mathers 1994; Leonardos *et al.* 1987, 2000), which are ground rocks of different compositions.

The term 'agromineral' is used here in a very broad sense. It includes naturally occurring nutrient-providing rocks and minerals such as phosphate rocks, nitrogen and potassium salts, as well as other nutrient-providing rocks. It also includes 'soil amendments' including agricultural limestone and dolomite, and various ground silicate rocks. Some of these natural geological resources are only moderately soluble in the short term but can release their nutrient content into the soil over long periods of time as 'slow-release' nutrient inputs. Agrominerals also include rocks and minerals that improve the physical status of soils. For example, perlite is used to enhance aeration in artificial growth media in greenhouses, vermiculite and zeolite are minerals able to store and release nutrients and moisture slowly, and volcanic scoria and pumice and other rocks are used as 'rock mulch' to reduce evaporation.

Conventional, chemically processed 'industrial' fertilizers are largely water-soluble and contain high and immediately available nutrient concentrations. Except for some nitrogen-based fertilizers, almost all of them are chemically processed rocks. They are derived from geological materials and have been chemically modified. In contrast, agrominerals are commonly only physically modified, by crushing and grinding. There are however some 'hybrid' rock and mineral modification techniques that use various amounts of chemicals in combination with agrominerals; for example, partially acidulated phosphate rocks (PAPR) or phosphate rocks mixed with acidulating triple superphosphates (TSP).

To date, national and international earth science institutions have mainly compiled mineral resource data for metals, with less emphasis being extended to industrial minerals. One exception is the internationally supported program to compile geological data on the phosphate resources of the world (Notholt *et al.* 1989). Another is the account of limestone resources in Africa, compiled by Bosse *et al.* (1996). In general, however, data on agromineral resources are scattered, and a comprehensive overview of all geological nutrient assets that could enhance crop production in sub-Saharan Africa is necessary.

The purpose of this book is twofold: firstly, to summarize the potential role that rocks and minerals can play in sustaining and enhancing soil productivity and biomass production, and secondly to provide an inventory of known agromineral resources, on a country-by-country basis, for 48 countries in Africa south of the Sahara.