Soil life and chemical fertilizers

What is a soil? What are the interrelations between soil life and chemical fertilisers? What determines the Level of low external inputs? How to best use external inputs is also a question of seed conditions. In this article on the living soil, Ana Primavesi shares her extensive insights and practical experiences gained through her research (e.g. on drought resistance by proper soil management) and her work with small farmers in Brazil.

Ana Primavesi

Present-day chemical and mechanical agriculture is skilful planting on biologically inactive and physically deteriorated soils. It is an expensive technology which regards soil only as "support" for fertilizers, plants and irrigation water. However, crops are responding less and less to the chemical inputs (fertilizers and toxic chemicals) and, to be able to afford them, farmers need government aid, e.g. subsidies, which increases the debt of farmers and countries. Can a mixture of chemical and organic agriculture be made to lower costs and maintain high yields?

Complex interactions
Plant nutrition and crop production cannot be understood by focusing on fertilizers or soil life alone. In nature, detached factors do not exist, only interrelated systems. Soil life is not something isolated; it depends greatly on organic substances such as straw, leaves, dead roots, root secretions and animal excretions in complex interaction with the chemical, physical and biological factors of the soil, climate and environment as well as wind protection, shade and other factors (see box). Organic matter is not only a natural form of fertilizer but also the support of soil life, soil structure (pore system), plant metabolism and crop production. Organic matter is the basis of soil productivity. Recently bred crop varieties are high yielding but little adapted to the soil. They need high chemical fertilizer applications. And since fertilization is generally restricted to NPK (nitrogen, phosphorus, potassium), trace elements are frequently lacking in tropical soils. This micronutrient deficiency makes plants weak, less resistant and often highly susceptible to plagues and diseases. Mechanized working of the soil (particularly in large-scale monoculture) always favours the same microbes and insects, thus "breeding" parasites and obliging a farmer to use toxic chemicals intensively. It's "Agriculture of Consumption" -an agriculture which consumes external inputs; it's not there to produce.

Chemical fertilizers and soil life
Chemical fertilizers not only nourish plants and microbes, but also may have harmful effects on the soil and its life, especially when they are very concentrated and water soluble. Acidification as well as neutralization of the soil may be very harmful to microbes, which often depend on a sole enzyme. And enzymes are active only in a very specific pH. Changes in pH slow down enzyme reaction, and microbes have to enter into rest, encysting, or die from hunger. Micronutrients are the activators of enzymes. Ammonium sulphate is a very strong biocide, hindering nitrogen fixation and killing nematodes and earthworms. Superphosphate has a negative effect on free-living nitrogen-fixing bacteria, which may be favoured by "mild" fertilizers such as Thomas slag, thermophosphate or bone meal when added to stubble mulch or straw. Soil microbes and soil animals need mineral nutrients like plants do. Chemical fertilizer may help soil life, and soil life helps fertilizers and their availability for plants and microbes. Thus, cellulose-decomposing bacteria need phosphorus and calcium, but the availability of zinc and phosphorus depends on soil life. The efficiency of chemical fertilizers, however, decreases with decreasing soil life.

Organic treatment
Table 1 shows fertilizer use and yields of maize and field beans of the best small farmer of Sao Paulo State in Brazil, of the corn belt of USA, and of our ecological farm at Itai, Brazil (maize variety ‘Agroceres 401’, field beans 'CA 80') in 1989. The ecological farm is a mixed farm of 90 ha: 25 ha arable land, 12 ha forest

and 53 ha natural grassland for beef cattle; green manure crops are Avena spp, Calopogonium in rice and Mucuna spp. On the ecological farm, fertilizer use was less, plant health much better and no pesticides were used. Thus, costs sank drastically and the gains were considerably higher. With the organic treatment, micro-life was stimulated and soil productivity increased steadily each year. On the nearby chemical farm, soil productivity decreased and pests increased, requiring ever higher inputs to maintain yields.

Remove limiting factors

Ecological recovery of a soil can be achieved through balanced application of organic matter and chemical fertilizers. The soil is an ecosystem in itself, and is part of the environmental ecosystem. Thus, soil conditions are related to those of the location, and crop production is determined by both. In a region of southern Brazil, even very high chemical applications to paddy could not increase crops to more than 2,250 kg/ha. There was a severe attack of rotten-neck (Piricularia oryzae). The low production was due to a strongly anaerobic superficial soil layer. Removing this layer by incorporating all straw and weeds and adding 300 kg/ha of bone meal stimulated cellulose-decomposing bacteria, allowing crumb and pore formation and soil aeration. The only inputs to the paddy were copper sulphate as fertilizer to the seeds and irrigation water. Rotten-neck disappeared in the same year, and the yield was 12,500 kg/ha with seed treatment. This means that, when the limiting factors are removed, high yields may be obtained with very little chemical fertilizer. The most common factors which limit yields are:

- deficiency in trace elements in seeds, resulting in deficient plants with low resistance to heat, cold and pests;
- compacted, anaerobic soil layers with little biological activity, few pores and, therefore, little penetration of water and air, and "reduced" forms of plant-toxic minerals such as SH2, CH4, Mn+2;
- insufficiently protected soils, exposed to rain impact and overheating, fostering crusts, pans and erosion;
- monocultures and the consequent "breeding" of always the same few species of microbes and insects which easily turn into parasites.

If seeds from crops with high NPK applications have to be used, seed enrichment with trace elements and micronutrient fertilization enables plants to be more resistant to parasites and cold.

Balance instead of absence

Periodical return of organic matter to the soil, crop rotation and seed enrichment improves the soil physically and biologically. As it improves the plants physiologically, they need less chemical inputs. In very exhausted decayed soils spoiled by heavy erosion, even hardy green manure plants cannot establish without some chemical Fertilizer (150 kg/ha of a low formula of NPK). On the other hand, intensively fertilized orange plantations (Botucatu area, Brazil), after some years of overcropping, suffered from serious die-back. By adding organic matter and trace elements to the soil and spraying amino acids on the leaves, the trees recovered. Then, 1.5 kg NPK per tree was applied. The yield was 200% higher. With correct use of organic matter, physical and biological properties of the soil recover. Then, chemical inputs can be low to nil, plant health is good, and water problems decrease greatly. Whether the level of external inputs can approach nil depends mainly on the extent to which the plants can be adjusted to the soil conditions. What is important is not the absence but the balance of chemical inputs and organic matter.

Ana Primavesi
CP 26
18730 Itai
Brazil