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Healthy Farms for Future Generations – Methods, Research and Education in Managing Soil Quality

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Introduction and Overview

The soil is the primary resource for almost all agricultural practices, providing the water, nutrients and the anchorage allowing crops to grow. The principles of sustainable soil management have been embedded in traditional farming practices for millennia, but these practices were almost forgotten in the West during the 20th century with the onset of the Green Revolution (GR)[1]. This movement reformed the way in which developed nations produced food, through intensive fertiliser and pesticide application, monoculture farms, mechanised labour and increasingly high yields.

One specific consequence of the GR has been the widespread deterioration of soil quality across agricultural lands[2]. Overall global soil health has worsened in regard to its fertility, biodiversity, oxygen levels and water retention capacity. This has been reflected in a slow-down of yield output and intense fertiliser application to restore nutrients. To address the modern issue of achieving sustainability in agriculture, soil health must become a priority to secure stable yields over generations. Policies are required to implement education in the principles of soil health to farmers. Equally, research funding is required to develop the current knowledge base we have of soil chemical and biological processes.

Improving Soil Health

The issue of nutrient depletion in soils has been approached from many angles. GR practices attempt to replace lost nutrients, using synthetic, inorganic fertilisers. This has been generally ineffective in improving soil quality as the compounds are highly

soluble and leach out of the system in solution. Furthermore, this results in nutrient addition to waterways, which can cause further environmental damage. Organic solutions attempt to use sustainable methods to improve soil health without relying on synthetic compounds, including crop rotation, organic fertilisation and microbial stimulation.

Crop Rotation

Crop rotation utilises the ecological functions of both plants and animals to return nutrients to soils that have removed nutrients during previous seasons. One of the most common crop rotations, both in history and today, involves alternating two fields between a grain and a legume each season. Leguminous plants are beneficial to soil quality as they utilise the symbiotic fungus *rhizobia* in root nodules that fix atmospheric N_2, returning this nutrient to the soil and preparing it for grain cultivation during the following season. Legumes include beans and pulses, which have economic value, and therefore the farmer continues to receive benefit from all land available. Livestock are also commonly incorporated into rotations. Keeping poultry in fields following harvest effectively returns nutrients to soils through excreta.

Crop rotation is nothing new, however, alternative schools of thought argue that monoculture increases productivity through economies of scale when costs are reduced due to bulk purchasing of seed and uniform field management. Initial profits may be greater in the first seasons of monoculture growth, but yields will decrease over time with nutrient depletion[3]. To move towards sustainability, crop rotation techniques will need to be employed more widely, maintaining good yields indefinitely. Furthermore, research needs to be done, by both academics and the farmers themselves, to find the most productive combinations of crop varieties and cultivation times which are tailored to conditions of specific farms.

Organic Soil Fertilisation

Fertiliser provides an external source of nutrient input into soil systems. Synthetic fertilisers are important in conventional agriculture and result in much greater yields as crops grow with more vigour. Synthetic fertilisers are flawed because they are often highly soluble so difficult for plants to absorb them before they are leached out of the soil. The production of synthetic fertiliser is also highly energy intensive, requiring mined raw minerals and high-temperature processing.

Organic fertilisers provide an alternative to synthetic ones. They are sourced primarily from bio-wastes, including animal excreta, animal products and plant matter. The most common forms of organic fertiliser are mulch, which are readily available on site at most farms, and these provide all essential plant macronutrients required for growth. Mulching has been employed in conjunction with agroforestry methods. Trees, which themselves have commercial value, are planted alongside the target crop, so falling tree leaves create a natural mulch which mimics processes occurring in natural systems.

Other sources of bio-fertiliser involve Cow Pat Pits. These ferment cow dung, egg shells and silica together to create a ready-to-use effective end product[4]. By fertilising in this way, soil nutrient levels are not subject to the large variations of intense nutrient input followed by rapid leaching, as seen in conventional fertilisation.

Soil Community Health

Soil is both a substrate for agrarian plants and animals but also a habitat for a range of diverse invertebrate ecosystems. These communities of organisms have a synergistic relationship with the soil they inhabit, relying on nutrients and organic material to support the primary trophic level but also improving soil quality themselves. Soil invertebrates are bioturbators, mixing nutrients evenly through the soil column and aerating the space they live in. This is important in preventing toxic metal compounds from

building up in the soil, and allowing plant roots to penetrate deep into the substrate.

Further to invertebrates, soil fungi and bacteria play an important role in both soil and plant health. Fungi decompose organic matter, breaking down nutrients into accessible forms for plants. They also form symbiotic relationships with plant roots in a space known as the rhizosphere – assisting with the absorption of nutrients by crops.

Bacteria are also the source of much bioavailable nitrogen. For this reason, analysis of soil organism communities is a good way of monitoring soil health and implementing action when necessary. Microbial stimulants have become popular in recent years as a result of this thinking[5]. These supply nutrients to the growth of soil communities, letting soil systems improve their own quality, even without the addition of external nutrients.

Implementing Policy

Good soil quality is one of the prominent features of healthy farms. Sustainable practices such as crop rotation, organic soil fertilisation and soil community maintenance are low-tech approaches to soil management. They are relatively simple to communicate, without reliance on expensive or inaccessible equipment and resources. This makes smallholder farms the most appropriate starting point for implementing new sustainable practices.

Smallholder farms account for 80 per cent of all farms globally and they generally already practice more traditional methods than large agribusinesses[6]. Smallholders are more likely to share information and spread the knowledge they gain with friends and neighbours. They are often family orientated so farmers therefore are much more invested in sustainability, to secure livelihoods for their own children. Education for these farmers is the central feature that policies will have to incorporate in order to shift towards sustainable agriculture. Workshops in

methods of maintaining healthy soils will provide farmers with the skills to implement these new practices to their own benefit.

It is important that it is the autonomous decision of farmers to adopt new techniques to encourage personal responsibility towards the health of the soil. Cooperatives have proven to be successful in the sharing of information and resources between individual farmers and communities[4]. Individual farms are part of an interconnected landscape, and by managing them as a cooperative, the landscape quality as well as yield productivity can be maximised. Government support for cooperatives is required to make sure they remain effective and are not threatened by large agribusiness corporations.

Coupled with farmer education, academic research is required to advance our understanding of how the agricultural and soil systems interact, and how we can use this information to sustainably increase yields. Policy implementation must encompass academic funding, particularly outside Western Europe and the US, where current knowledge is limited and population is greatest.

Ultimately, individual farmers need to recognise the long-term impact that conventional high-intensity agriculture can have on their soils. The health of the soil eventually feeds back on the welfare of the individual. Through education they can incorporate the practices that will sustain high crop yields and secure a more stable income for generations.

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