Healthy Soils with Conservation Agriculture Systems

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About the book

This book was written to help create an awareness of the need and the opportunity for Iran to join the agricultural revolution toward conseration agriculture (CA) practices to enhance the resilience of the farming systems, using less water and other inputs, lowering costs of sustainable production, while creating healthier soils, the natural resource that all people depend on.

Soil is the network of interacting living organisms within the earth's surface layer, which support life above ground – plants and animals, including humans. Soil form the skin of the Earth. Soil consists of a variable, and often complex, mixture of organic matter, sand, silt and clay particles. Less often soil is composed dominantly of organic debris. Soil is our life support system. Soils provide anchorage for plant roots, while holding water and nutrients. Soils are home to myriad microorganisms that fix nitrogen and decompose organic matter, and armies of microscopic animals as well as earthworms and termites. Earthworms as macro fauna are considered as soil engineers because of their effects on soil properties and their influence on the availability of resources for other organisms, including microorganisms and plants. Soil plays a vital role in the Earth's ecosystem. Without soil human life would be very difficult. We would not have evolved from 'hunting and gathering' cultures. Soil filters the rainwater and regulates the discharge of excess rainwater, preventing flooding; it is capable of storing large amounts of organic carbon; it buffers against pollutants, including CO_2. Soil protects groundwater quality.

Many people don't realize that soil, especially healthy soil, is full of life. Millions of species and billions of organisms make up a complex and diverse mix of microscopic and acroscopic life that represents the greatest concentration of biomass anywhere on the planet. Bacteria, algae, microscopic insects, earthworms, beetles, ants, mites, and fungi are among them. All together, their value has been estimated at $1.5 trillion a year worldwide.

What these low-lying creatures lack in size, they make up for in numbers. Consider bacteria, the soil microbes with the highest numbers. For example, you can fit 40 million of them on the end of one pin. In fact, there are more soil microorganisms (microbes for short) in a teaspoonful of soil than there are people on the earth. These microbes, which make up only one-half of one percent of the total soil mass, are the yeasts, algae, protozoa, bacteria, nematodes, and fungi that process soil into rich, dark, stable humus. The healthiest soils are those with a diversity and abundance of life. Farmers who adapted CA approach understand that tillage, the turning of the soil that has been the standard for growing crops for years and years, is disruptive to soil microbes and destructive to the soil system and its very structure. Instead, they disturb the soil as little as possible, generally using specially designed planters that can sow seed into unplowed soils, even though crop residues. CA farmers grow a diversity of living plants in the soil as much of the time as practical, covering the soil and offering food to soil microbes through living roots. Those soil organisms, in turn, cycle nutrients back to the plant, allowing it to grow and flourish. It's a natural, symbiotic system that leads to healthy soils and more sustainable and profitable agriculture.

Tillage is the main cause of soil disturbance. In the minds of many, a freshly tilled field means it's ready for the next planting. But soil scientists can prove that tillage generally isn't good. When soil is tilled, the top 20 centimeters of the soil is often disturbed and even inverted. The plowing and discing implements often make a compaction zone in the soil at the lower dept of the implement, which limites root growth and water infiltration. CA-based crop management technology recommends, when practical, leaving the previous year's crop residues on the soil surface as well as growing a cover crop between cash crops to provide more surface and subsurface biomass to improve soil health. Tillage destroys the soil's pore space which is a critical part of how water gets into the soil (infiltration). When we till the soil, we destroy the soil aggregates creating a tighter soil where water infiltration and soil water storage for the plants are severely reduced. Instead of water going deep into the soil for the plant to use, the water runs off the soil surface taking valuable topsoil with it.

Promoting CA-farming practices that involve minimal soil disturbance, permanent soil cover and the use of crop rotation to simultaneously maintain and boost yields, increase profits and protect the environment – is a keystone of Iran's Ministry of Agriculture's current strategy to conserve water and make farming more sustainable. These practices reduce costs for farmers – especially by saving fuel for the soil tillage – increase soil quality, reduce soil erosion and improve biological activity, all while increasing agricultural productivity, especially by increasing resilience to drought. Unplowed fields that retain crop residues are better at capturing and holding moisture, often raising yields with less water. Building knowledge of CA practices at a local level is critical to change agriculture in Iran. Investing in farmer learning process for adoption of CA will be requird as well. CA requires good timing of operations and excellent adjustments of the planters to match the soil conditions. Sucessful CA is knowledge intensive.

CA is a conservation practice that can save on irrigation, labor and fuel costs. Studies show a producer can save at least 30% of water consumption per hectare by changing from conventional tillage to CA. It's a sound investment for the environment and the farmer. Since tillage began, crop producers have been aware of important soil properties affecting plant growth and yield. The term tilth evolved from an old English term meaning tillage and included many of these properties in one term. A soil was often referred to as having 'good tilth' if it had stable aggregates, high organic matter content, was easy to till, did not readily crust, made a good seedbed, took in water rapidly, and had low bulk density. Soils with poor tilth crusted easily, were hard, resistant to tilling, had low organic matter, and were difficult to prepare for planting. Thus, tilth refers to "the physical condition of the soil in relation to plant growth". In the last few years, the term 'soil health' has replaced 'tilth.' Soil health includes the properties mentioned above, but also includes soil temperature, water content, soil faunal populations, pH, fertility, and nutrient cycling. USDA's Natural Resources Conservation Service defines soil health as 'the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation.

There are four key soil health concepts to remember when trying to develop a healthy soil. They are: 1- Disturb the soil as little as possible; 2- Increase diversity by using crop rotation;

3- Keep living roots in the soil as many days as possible throughout the year; and 4- Keep the soil covered as much as possible.

Disturbances such as tillage introduce an abundance of oxygen to the soil that accelerates the action of bacteria that process organic matter. This leads to rapid oxidation of organic matter (OM) and an overall loss of OM in the soil as it is decayed and released into the atmosphere as carbon dioxide (CO_2). Conventional tillage systems that disturb the soil multiple times a year cause the soil biological system to be dominated by a bacterial community. Removing tillage and minimizing disturbance allows the fungal, micro-arthropod, protozoa, nematode and earthworm populations to come into balance with their environment and produce a more diverse biological community. Processing of OM becomes more consistent throughout the year with CA practices and OM levels will actually begin to increase.

"Healthy soils with conservation agriculture systems" is written to encourage farmers to obtain the benefits of reduced time spent tilling, increased moisture content in the soil, and healthy soil for growing crops from the micro- and macro-invertebrates that live within. Many thanks to those farmers who have put these practices to work on their land and shared their successes. They are truly stewards of the land. Also many thanks to Mr. Seyyed Aref Siadat general director of Boukan Kaveh Sazeh-Kesht agricultural implement manufacturing company. This publication was produced with funding, and production assistance from Bukan Kaveh Sazeh-Kesht Company a CA machinery manufacturer based in West Azerbaijan Province, Iran. I also thank Dr. Eric Kueneman**,** retired FAO deputy director of the crop production and protection division, and independent global consultant/advisor, for his encouragement and valuable comments.

Since 2008 Iran's Ministry of Agriculture has been importing direct seeding planter– tools which help farmers improve soil and soil moisture conservation. Recently, seeders and other CA equipment are being produced by private manufacturers within the country. Boukan Kaveh Sazeh-Kesht Company is one of the agricultural machinery factories in Iran that has successfully developed and manufactured CA machines.

CA-based crop management technologies and practices can ensure a food secure Iran. We live in an arid and semi-arid belt of the world with limited access to water resources. In addition to our declining groundwater reservoirs we receive just one third of the average global rainfall. Using our groundwater efficiently is essential to reduce aquifer depletion and rates of salianation of our soils from resulting from water application in conditions of very high evaporation. Sustainable agriculture is the strategy to follow if we are to increase production while maintaining our natural resources base. To make this vision a reality, continued investment in CA cropping systems and other sustainable strategies will be necessary to mitigate Iran's water crisis, adapt to new climates and be resilient against other political and environmental shocks.

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