Ecological Farming (ECO Farming): Improving agricultural efficiency

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What is Ecological or ECO Farming?

Ecological of ECO Farming works with Mother Nature to improve soil productivity and nutrient efficiency while protecting the environment. ECO Farming allows Mother Nature to recycle soil nutrients for plant production and only uses other agricultural inputs (fertilizer, pesticides, fuel, equipment, labor) as needed to maximize crop production. ECO Farming is based on three major assumptions.

First, soil is considered a living breathing organism that needs to be fed and nurtured. Soil is meant to be protected and conserved, not destroyed with tillage. Soil on the planet Earth is like a protective layer of skin around your body. No one would voluntarily cut their skin from their body. Tillage is like peeling the skin away from your body, resulting in excessive bleeding and moisture lost (nutrient and water runoff, hard compacted soils (scabs), and soil erosion).

Second, soil is meant to be covered with live plants, nurtured by soil microbes, year round. Live plants and microbes evolved together 400 million years ago and they are both mutually dependent on each other for survival. Live plants and roots promote healthy microbial populations which efficiently recycle soil nutrients. The soil microbes process over 90% of the soil nutrients and they get their energy directly from live plant roots. This process is so important to the plants that they exude as much as 25% of their total root carbohydrate reserves just to feed the soil microbes (Kuzyakov, 2002). There are 1,000-2,000 times more microbes associated with live plant roots than what there are in the bulk soil without live roots (Foster, 1988). Without live plants and live roots, microbial populations decline and nutrient efficiency also declines. Soil microbes are like "soluble bags of fertilizer", promoting plant growth and production. A healthy soil efficiently utilizes and conserves soil nutrients and promotes healthy plant growth without excessively utilizing supplement agricultural inputs like fertilizer.

Third, ECO Farming uses our full knowledge of modern best management practices to enhance crop production. Practices like controlled drainage, controlled traffic, Integrated Pest Management (IPM), and multi-species crop diversity can enhance soil functions along with the ECO Farming system. The goal of ecological farming is to produce profitable high yielding crops that utilize crop inputs efficiently while protecting the environment (Hoorman, 2012).

ECO Farming Defined (Taken from ECO Farming in the 21st Century, SAG-12-12 Factsheet by Hoorman et al 2012)

ECO Farming is a new systems approach utilizing current best conservation management practices to improve carbon sequestration, improve biodiversity, and improve the environment.

ECO Farming is an acronym that stands for the following:

E = *Ecological farming* is an economically profitable farming method that collaborates ecologically and environmentally with the natural ecosystem to be sustainable. ECO Farming starts with zero-tillage which reduces physical disturbance to the soil ecosystem. Continuous long-term no-till protects the soil habitat, increases carbon sequestration, and allows the soil ecology and soil diversity to recover to improve sustained crop production. This promotes an ecological viable practice that is economically and environmentally sound while being sustainable because it mimics natural processes.

C = *Continuous Living Cover* means keeping a living and growing crop on the soil during the entire year to protect and feed the soil ecosystem. A continuous living cover will increase the quantity, the quality, and the timing of organic residues in the soil. A continuous living cover impacts the soil ecology, nutrient cycling, bulk density and soil compaction, runoff, flooding and even climate.

O = *Operational technologies* used on the farm that protect and improve the soil ecosystem through human manipulation. Operational technologies may include controlled traffic, water table drainage management (where applicable), integrated pest management (IPM), precision farming, genetic manipulation (GMO), diverse crop rotations, multi-species cover crops, livestock and crop integration, biological controls, and/or other best management practices.

How Tillage Destroys our Soil

Tillage dramatically changes soil ecology according to Don Reicosky, USDA-ARS who says that "soil disturbance to the soil microbes is like the worst hurricane, earthquake, forest fire, and tornado (HEFT) all occurring at the same time" (Reicoski, 2006). Only the smallest soil microbes (viruses, bacteria, protozoa) can survive disturbed soil conditions related to tillage but other soil microbes populations (fungus, nematodes) tend to decline with tillage. This upsets the natural ecosystem balance and results in poor nutrient efficiency and poor nutrient recycling in the soil.

Tillage results in excess oxygen in the soil and this oxidation is like burning wood in a fireplace, once the soil carbon is lost to the atmosphere (>60% lost, Lal, 2004), fewer soil nutrients (water, N, P) can be stored in the soil (Islam, 2008). Our current nutrient efficiency for nitrogen is 30 to 50% and for phosphorus it is 25 to 50% (Sims et al 1995, Powers, 1978). Most of the NO3-N leaching occurs during the fall and early spring months when the soil is fallow in the typical corn-soybean rotation of the U.S. Midwest (Owens et al, 1995). Carbon is the key factor in controlling and storing most soil nutrients needed for crop production (Reicoski, 2006).

Crop residues and living plants protect soil from adverse weather conditions. Soil stays cool in the summer due to a mulching effect of decomposing crop residues which improves water infiltration and water storage like a sponge. Soil is insulated by crop residues in the winter and

live plant roots allow soil to "honeycomb" and not freeze solid, allowing air and water to infiltrate the soil, even in the winter.

Tillage breaks open the soil releasing soluble nutrients. The bacteria microbial population thrives for a short period of time, consuming the released soluble nutrients and active carbon (sugars and easily digested nutrients) released from the roots. As the active carbon is consumed, the microbial population starts to decline and nutrients fail to be recycled due to a lack of carbon. Adequate active carbon from plant roots is needed to tie up soluble soil nutrients.

Tillage generally occurs in late fall and winter, so melting snow in late winter and spring rains wash many soluble nutrients to surface water (Hoorman, 2012). Most carbon in the soil (65-70%) comes from the roots (Aziz PhD thesis, 2011). Carbon is needed to tie up soluble nutrients and recycle the nutrients back to the plants. Also, live plants and live roots absorb soluble nutrients which can be lost in runoff to surface water. Without live plants and live roots, the natural ecological cycles are broken and our soil nutrient efficiency decreases.

Ecological Solutions to Agricultural Environmental Issues

Hoorman says "In natural systems, live plants cover the soil nearly continuously. A conventional corn-soybean crop rotation generally only has live plants and roots four months of the year, so this system has less total energy (1/3) to feed the soil organism. A cover crop with live roots increases the soil energy needed to keep the soil ecosystem active and healthy.

Carbon controls most soil nutrients and is responsible for most chemical, physical, and biological processes. Carbon ties up and stores major nutrients (water, N, P, S) and micronutrients (zinc, boron). By adding a cover crop to a grain crop rotation, farmers increase the total soil carbon because there are two sets of living roots adding carbon and energy to the soil continuously. Keeping the soil undisturbed and covered with live plants greatly increases the soil carbon content.

Nutrient efficiency improves when plants exist on the soil year round because the soil is protected by crop residues 1) reducing soil erosion and sedimentation, 2) increasing water infiltration, 3) increasing the soil water holding capacity and water storages, 4) reducing water and nutrient runoff and flooding, and 5) creating a healthy soil system that recycles and stores soluble soil nutrients." (Hoorman, 2012).

Almost 90% of the available N (Espinoza, et al) and 50 to 80% of the P in the soil is tied up in an organic form (Dahl, 1977) and without carbon; these nutrients may be lost from the soil profile. Tillman found that crops acquire 40-80% of their N from organic soil reserves and an average of 50% of the N applied as fertilizer is lost from agricultural landscapes (Tilman 1999).

Cover crop planted in late summer or fall feed the soil microbes active organic matter and the soil microbes may recycle soluble nutrients and/or the nutrients may be taken up by the cover crops. Nutrient efficiency improves because the soluble nutrients are not as easily lost to surface runoff. Active carbon has two major functions: 1) food and energy to sustain the soil microbes, and 2) active carbon is like glue that improves soil structure. (See Hoorman article on Soil Compaction). Active carbon has to be continually produced because it only lasts five to seven days, some as long as three months in the soil.

Farmers may have to change their crop management to see long term higher economic yields from ECO Farming. Cover crops need at least 60 to 90 days of growth before winter occurs (Midwest Cover Crops Council, 2014). To accomplish this, shorter maturity corn or soybean variety may need to be planted so that cover crops can be established before cold weather sets in for the winter. Cover crops are often inter-seeded into maturing crops, however; moisture and soil seed cover may be an issue in dry years. The improved environmental benefits of cover crops and the improved soil structure and addition of soil carbon protect the soil and can outweigh short-term negative effects that may occur during the transition period to a biologically stable system.

Farmers often report that the transition period may last 5-7 years with no-till, but with the addition of cover crops, the transition period may be reduced to 3-5 years or even 1-3 years if the soil has been in long-term no-till. Hoorman says "Higher yields and increased profitability may not occur until most of the initial soil problems (soil compaction, poor soil structure, lack of biodiversity) are resolved. As the ecological system recovers in the long-term, less farm inputs may be needed to produce sustainable and profitable crop yields" (Hoorman, 2012).

The most pronounced effects from ECO Farming occur under "stressful" conditions because ECO Farming increases a soil resiliency to change. In a dry year, the increased water infiltration and water storage along with increased nutrient availability associated with the active organic matter, allows the plants access to more available nutrients and water, increasing crop yields.

Summary

ECO farming is a sustainable and economical way to improve the environment by using continuous no-till or zero-till with continuously living crops on the soil year round. Operational technologies like controlled traffic, water table management, integrated pest management, genetic manipulation and other technologies may be utilized to improve soil health, soil structure, nutrient recycling, and soil productivity which ultimately leads to higher and sustainable crop yields that are more profitable to produce.

References

Aziz, I. (2010) PhD dissertation: Tillage and Crop Rotations Impact on Soil Carbon Sequestration, Ohio State University, Columbus, Ohio and Department of Agronomy Faculty of Crop and Food Sciences, Arid Agriculture University, Rawalpindi, Pakistan.

Dahl, R.C. (1977) Soil Organic Phosphorus, Advances in Agronomy 28:83-117.

Espinoza, L, Norman, R, Slaton, N, and Daniels, M. The Nitrogen and Phosphorus Cycle in Soils, Arkansas University Cooperative Extension Printing Service.

Foster, R.C. (1988) Microenvironments of soil microorganisms. Biol. Fertility Soils 6:189-203.

Hoorman, J.J. (2012) ECO Farming in the 21st Century: Improving Agricultural Efficiency and Crop Production, In: Manitoba- North Dakota Zero Tillage Farmers Association, 35th Annual Zero Till Workshop. (2013): pg. 22-26.

Hoorman, J.J., Sundermeier, A.P., Archuleta, R., Brandt, D., and Scarpitti, M. (2012 Draft), ECO Farming in the 21st Century, Ohio State University Extension, SAG-12-12.

Islam, K. R. (2008) Power point presentation: Cover Crops, No-till, and Water Quality, Ohio State University Extension

Lal, R. (2004) Soil Carbon Sequestration impacts on global climate change and food security. SCi. 304:1623-1627.

Kuzyakov, Y. (2002) Review: factors affecting rhizosphere priming effects, J. of Plant Nutr. Soil Sci. 165:382-396.

Midwest Cover Crops Council (2014) Midwest Cover Crops Field Guide, 2nd ed., ID-433, www.mccc.edu.

Owens, L.B., Edwards, W.M, and Shipatalo, M.J. (1995) Nitrate leaching through lysimeters in a corn-soybean rotation, Soil Sci. Am. J. 59(3): 902-907.

Reicoski, D. (2006) Tillage "Myth" versus Carbon "Reality" power point presentation, USDA-ARS Soil Scientist, Waseca, Minnesota.

Power, J.F. (1978) Residual Effect of N Fertilization on dryland spring wheat in Northern Plains.2. Fate of Fertilizer N, Agronomy Journal 70 (2): 282-286.

Sims, J. T., B. L. Vasilas, B.L., Gartley, K.L., Milliken, B. and Green, V. (1995) Evaluation of soil and plant nitrogen tests for maize on manured soils of the Atlantic Coastal Plain. Agron. J. 87:213-222**.**

Tilman, D (1999) Global environmental impacts of agricultural expansion: The need for sustainable and efficient practices. Proceedings of the National Academy of Sciences of the United States of America 96:5995-6000.