

Impacts of Direct Seeding on Soil Biology

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Introduction

Soil organisms are very important in agriculture because they mediate many beneficial processes that include:

- (a) Recycling of plant nutrients: Nutrients like N, P and S in organic materials (manures, crop residues, etc) occur mostly as organic compounds that are not available to plants. During decomposition, soil microorganisms break these compounds and convert the nutrients into inorganic forms that plants can utilize. Meeting some nutrients requirements through recycling reduces fertilizer requirements.
- (b) Nitrogen fixation: Plants also cannot utilize the nitrogen in the air that we breathe. In nodules of leguminous plants, soil microorganisms from the genus *Rhizobium* convert (fix) the gaseous nitrogen to a form that plants can utilize. Because legumes meet their N requirements from nitrogen fixation, most do not need fertilizer N.
- (c) Maintenance of soil structure (tilth): Good soil tilth results from aggregation of soil particles, held together by fungal hyphae and microbial excretions that act like gum. Soils with good tilth are less susceptible to erosion, have better water infiltration and aeration, and offer less resistance to plant germination and root penetration, than soils with poor structure.
- (d) Degradation of agrochemicals and pollutants: Almost all the herbicides, fungicides, insecticides, etc, that are applied to soil would have serious residual effects if they were not degraded by soil microorganisms. Some soil pollutants are converted into less toxic chemicals during microbial breakdown. Un-degraded agrochemicals would also contaminate water supplies.
- (e) Control of plant and animal pests: Soils with active microbial communities have few pest problems because of biological control through predation, antibiotic production and competition for resources. Encouraging biological pest control reduces use of pesticides.

Therefore, soil management systems that foster the development of healthy, diverse microbial communities are more likely to be sustainable than those that do not.

Tillage effects on soil microbial biomass, diversity and activity

Direct seeding (reduced or no tillage) is one soil management practice that usually increases soil microbial biomass (Fig. 1) and diversity (Fig. 2). At the same time, direct seeding reduces soil microbial activity (Fig. 3). Reduced microbial activity is also an advantage because it means reduced greenhouse gas emissions. In these results, only the top 3 inches of soil was sampled. When soil is sampled at different depths, stratification of microbial biomass is evident, i.e., direct seeding increases microbial biomass only in the top 2 inches of soil (Fig. 4).

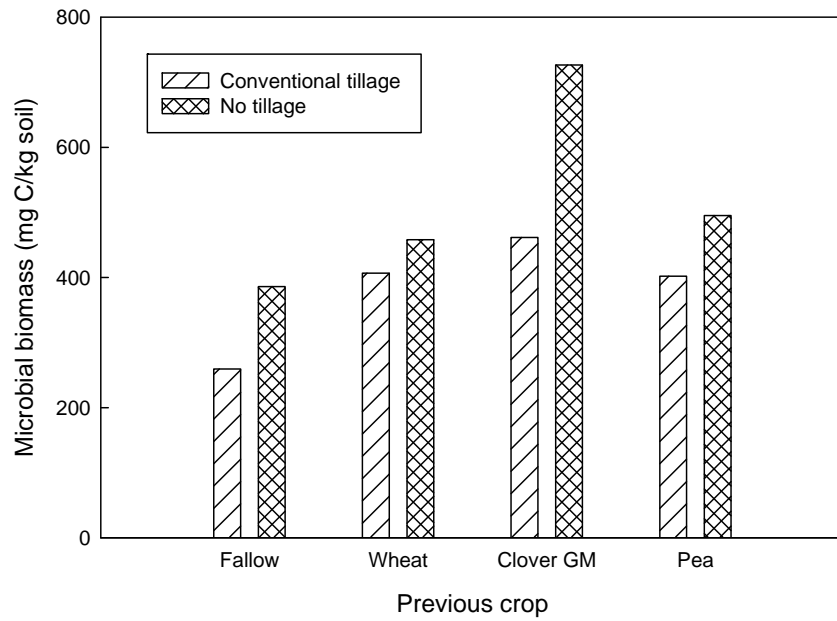


Figure 1. Tillage effects on soil microbial biomass in various rotations at Fort Vermilion, Alberta.

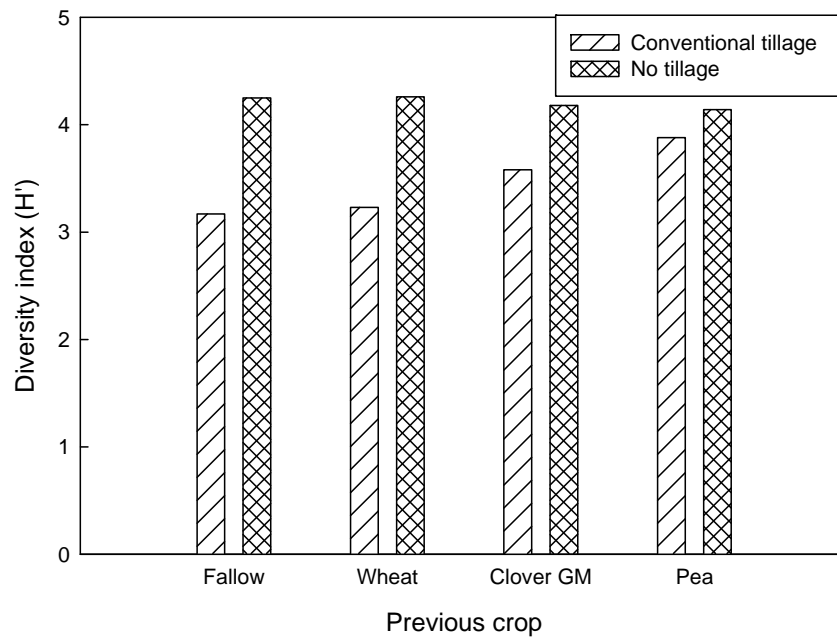


Figure 2. Tillage effects on the diversity of soil bacteria in various rotations at Fort Vermilion, Alberta.

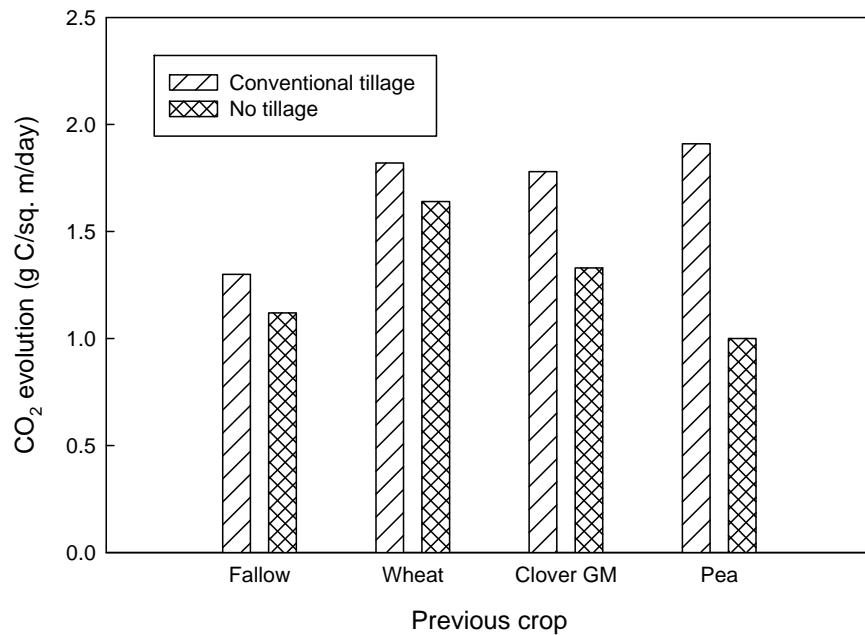


Figure 3. Tillage effects on soil microbial activity (CO₂ evolution) in various rotations at Fort Vermilion, Alberta.

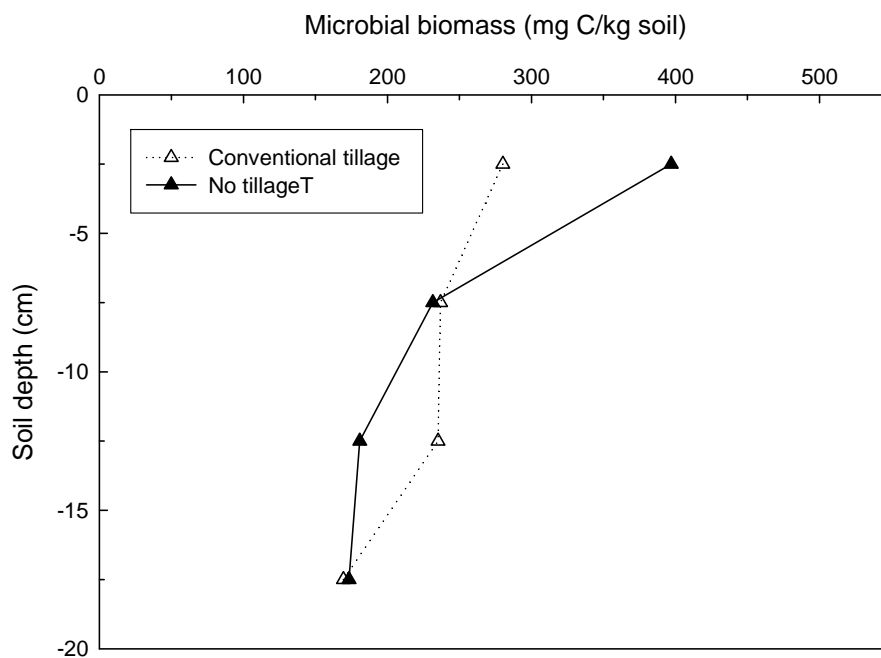


Figure 4. Tillage effects on soil microbial biomass at various depths at Fort Vermilion, Alberta.

Understanding tillage effects on soil microbial dynamics

Most soil microorganisms depend soil organic C for energy and cell synthesis. Therefore, soil management systems that increase or reduce soil organic C usually also increase or reduce soil microbial biomass and diversity. The amount of soil organic C is a balance between the amount added as organic materials and the amount lost, mainly through decomposition by soil microorganisms:

Soil organic C = organic C added – organic C lost.

Direct seeding increases storage (sequestration) of soil C because less C is lost, and often results in increased soil microbial biomass and diversity (Table 1).

Table 1. Effect of tillage on soil organic C and soil organisms, assuming that similar amounts of organic residues are added to soil in each system.

Conventional tillage	Direct seeding
Tillage breaks soil aggregates, exposing organic C to microbial attack, and soil stirring (mixing) increases contact between organic material and microorganisms, thereby increasing decomposition (more C loss).	Soil aggregates protect organic C from microbial attack (less C loss).
Tillage improves short-term soil aeration, which increases C decomposition (more C loss).	No gush of oxygen into soil (less C loss).
Bare soil increases soil temperature, which increases C decomposition (more C loss).	Organic material at or near surface: <ul style="list-style-type: none"> - Microbes mostly near surface. - Reduces soil temperature (less C loss). - Increases soil moisture (less C loss in cold spring, more C loss in warm summer).
Increases C loss through erosion of surface soil (more C loss).	Less soil erosion (less C loss).
Tillage breaks fungal hyphae. Soil dominated by bacteria.	Relatively undisturbed fungal hyphae. Soil dominated by fungi.
Result: increased microbial activity (greenhouse gas emissions), but depletion of organic C eventually reduces microbial activity, biomass, and diversity: poor biological soil health.	Result: reduced microbial activity (greenhouse gas emissions), and accumulation of organic C increases microbial biomass and diversity: good biological soil health.

Soil disturbance by tillage is a major factor in tillage effects in soil biology. These disturbances may result in reductions in the population and diversity of soil organisms due to desiccation, mechanical destruction, soil compaction, reduced pore volume and disruption of access to food

resources. Tillage also accelerates C mineralization by increasing soil aeration and the contact between soil and residues.

Apart from reducing the physical disturbance of the soil, direct seeding leaves residues from previous years' crops on the soil surface. In crop rotations under direct seeding, the residues from several different crops in preceding years result in a greater variety of food resources than in tilled soils where litter does not accumulate. In addition, the soil-mixing action of tillage disperses patches of crop residues into a relatively uniform mixture. Therefore, the diversity of food resources under direct seeding results in a more diverse microbial community than that under conventional tillage.

Summary

Direct seeding usually increases soil microbial biomass and diversity, but reduces soil microbial activity. Microbial biomass and diversity increase because direct seeding increases storage of soil organic C, and microbial activity decreases because the organic C is protected by soil aggregates. The decrease in microbial activity under direct seeding means reduced emission of greenhouse gases. Therefore, direct seeding improves the biological health of the soil, and crops grown under direct seeding benefit from the various biological processes that occur in healthy soils.