Carbon Sequestration Through Conservation Tillage

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Carbon is one of the several constituents of soil organic matter. The sequestration of carbon in soils involves the availability of the other building blocks. Carbon sequestration refers to the provision of long-term storage of carbon in the terrestrial biosphere, underground, or the oceans so that the build-up of carbon dioxide (the principal greenhouse gas) concentration in the atmosphere will reduce or slow. Transfer of atmospheric CO_2 into other long-lived pools so that it is not re-emitted into the atmosphere is called carbon sequestration. Carbon sequestration by agriculture may be one of the most effective ways to slow down the processes of global warming.

Over 60 per cent of the World's carbon is held in both soils (more than 41 per cent) and the atmosphere (20 per cent) (as carbon dioxide). However, soil disturbance is redistributing the carbon, augmenting the atmospheric carbon pool. Thus, a part of carbon dioxide increase in the atmosphere is thought to have come from agriculture, affecting not just climate change but also productivity and sustainability of agriculture and natural resources.

Agriculture must undergo a significant transformation in order to meet the challenges of food security and climate change. Changes in climate can be expected to have significant impacts on crop yields through changes in temperature and water availability.

The purpose of mitigation and adaptation measures is therefore to attempt a gradual reversal of the effects caused by climate change and sustain development. There are several mitigation and adaptation practices that can be effectively put to use to overcome the effects of climate change with desirable results. These methods fall into the broad categories of under crop/cropping system-based technologies, resource conservation-based technologies and socio-economic and policy interventions. The mitigation and adaptation practices includes i) carbon sequestration in soils and on-farm emissions reductions, ii) resource conservation-based technologies are in situ moisture conservation, rainwater harvesting and recycling, conservation agriculture covering no-till agriculture, or conservation tillage, etc,. contingency crop planning to minimize loss of production during drought/flood years.

In modern highly mechanized intensive cropping systems, CO_2 is also emitted from a number of fuel-consuming operations. In contrast, soil organic carbon sequestration in agricultural lands has recently drawn growing attention for its promise in mitigating rises in atmospheric CO_2 concentrations. In principle, agricultural soils can provide a large carbon sink and their SOC can be increased through the implementation of efficient agronomic practices.

Depending on the land use and management options, agriculture can be a source or sink for atmospheric CO_2. Agricultural practices with impact on atmospheric chemistry include production and management of crop residue, tillage systems, soil fertility and pest management, and supplemental irrigation. With the impending threat of climate change, there is a strong need for a critical appraisal of land use and soil management practices, including crop residue production and management in conjunction with the appropriate tillage methods, nutrient and pest management, water conservation and supplemental irrigation.

Conservation Agriculture (CA) is defined as a concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment. It is premised on three key principles, namely, minimum mechanical soil disturbance, permanent soil cover and diverse crop rotations. Conservation tillage practices include, amongst others, strip tillage, cover cropping, contour farming, zero or chemical tillage, mulch tillage, and reduced tillage, with the ultimate being low disturbance no-till or direct seeding.

Tillage

Sequestered carbon is stored in soils, resulting in increases in soil organic carbon (SOC). Estimates indicate that tillage reductions on global cropland could provide a full "wedge" of emissions reductions upto 25 Giga tonnes over the next 50 years.

Conventional tillage practices decrease soil organic carbon concentration while conservation tillage improves SOC concentrations and water storage reduces soil erosion. Deep tillage increases CO_2 release from the soil, the implementation of conservation tillage (no till or reduced tillage) appears to be a practice that can enhance soil C sequestration.

The principal mechanism of C sequestration with conservation tillage is the increase in micro-aggregation and deep placement of SOC in sub-soil horizons Continuous C input to the soil through crop residue return and manure application is a crucial practice for enhancing crop yields and soil C sequestration. Soil disturbance through tillage is a major cause of reduction in the number and stability of soil aggregates and subsequently organic matter depletion. The differences among tillage practices, we use the following terms:

- *Conventional tillage* leaves less than 15 percent residue cover after planting through intensive tillage.
- *Conservation tillage (con-till)* covers 30 percent or more of the soil surface with crop residue after planting.
- *Reduced-till* leaves 15 to 30 percent residue cover after planting.
- *No-till* leaves the soil undisturbed from harvesting to planting except for nutrient injection.
- Planting and fertilization are done with row cleaners and slits in the soil for placing seed and
- nutrients. Weeds are controlled with herbicides except when doing emergency weed control.
- *Ridge-till (stale seed bed)* leaves the soil undisturbed from harvesting to planting except
- for nutrient injection, but rows are rebuilt during cultivations for next year's crop. Permanent
- rows and traffic patterns are important to the success of this system.
- *Mulch-till* disturbs the soil before planting with chisels, field cultivators, disks or sweeps. Weeds are controlled by cultivation/and or herbicides.
- *Strip-till and zone-till* are not separate systems, but are variations of systems. A fertilizer

knife or mole knife is typically run in the row in the fall, early winter or late spring to loosen the soil and inject fertilizer. The soil usually is tilled with sweeps or disks over the row only, leaving the soil in between the rows untilled. The width of the tilled area can vary, and a bed may or may not be formed. Performing strip-till or zone-till occasionally is the best compromise between conventional tillage and no-till. Yield with these systems is comparable to that of conventional tillage — without the cost.

Crop residue

Crop residue is defined as the non-edible plant parts that are left in the field after harvest. Some researchers also include remains that are generated from crop-packing plants or that are discarded during crop processing into the generic category of crop residue. Principal benefits of retaining crop residue include soil erosion control, maintenance of soil structure, moderation of soil moisture and temperature regimes, energy source for soil biota and maintenance of soil organic matter (SOM) content. Crop residue and tillage cultivation on agricultural land are regarded as techniques for carbon sequestration through their ability to increase SOC. Increasing the total C input from plant residue biomass is crucial to soil C sequestration. Global annual production of crop residues is about 3.4 Pg/yr.

Soils are a major reservoir of carbon (C) and an important sink. The soils of the world contain more C than total amounts occurring in vegetation and the atmosphere combined. Farming activities in many parts of the world have resulted in large declines in soil organic matter (SOM) and concomitant degradation of soil fertility, resulting in reduced crop yields and lower quality.

Addition of crop residues on conventionally tilled soils did not increase soil organic matter content, while minimum tillage coupled with crop residue addition increased the soil organic matter content of the surface soil horizon. Removal of crop residue from the fields is known to hasten SOC decline especially when coupled with conventional tillage. Minimum tillage systems, which maintain high surface soil coverage, have resulted in significant changes of soil physical properties, especially in the upper few centimetres. Crop residue strongly impacts both C and N cycles, and there is a great potential to enhance the sequestration of C and N in soils with the implementation of appropriate tillage methods and crop residue management.

Crop residues are an important resource, with numerous competing uses. However, the most appropriate use of crop residue is to enhance, maintain and sustain soil quality by increasing the soil organic carbon pool, enhancing activity and species diversity of soil fauna, minimizing soil erosion and non-point source pollution, mitigating climate change by sequestering C in the pedosphere and advancing global food security through enhancement of soil quality. There exists a direct relation between the amount of residue retained and soil organic matter content on the one hand, and between soil organic matter content and crop yields on the other.

Conclusion

Reduction in soil disturbance combined with residue retention increased the C retained in the small and large macro-aggregates of the top soil due to greater aggregate stability and reduced the emissions of CO2 compared with conventional tillage without residues retention. The retention of residues increased the C in aggregates of the top-soil and the reduction in soil disturbance resulted in a decrease in emissions of CO2.

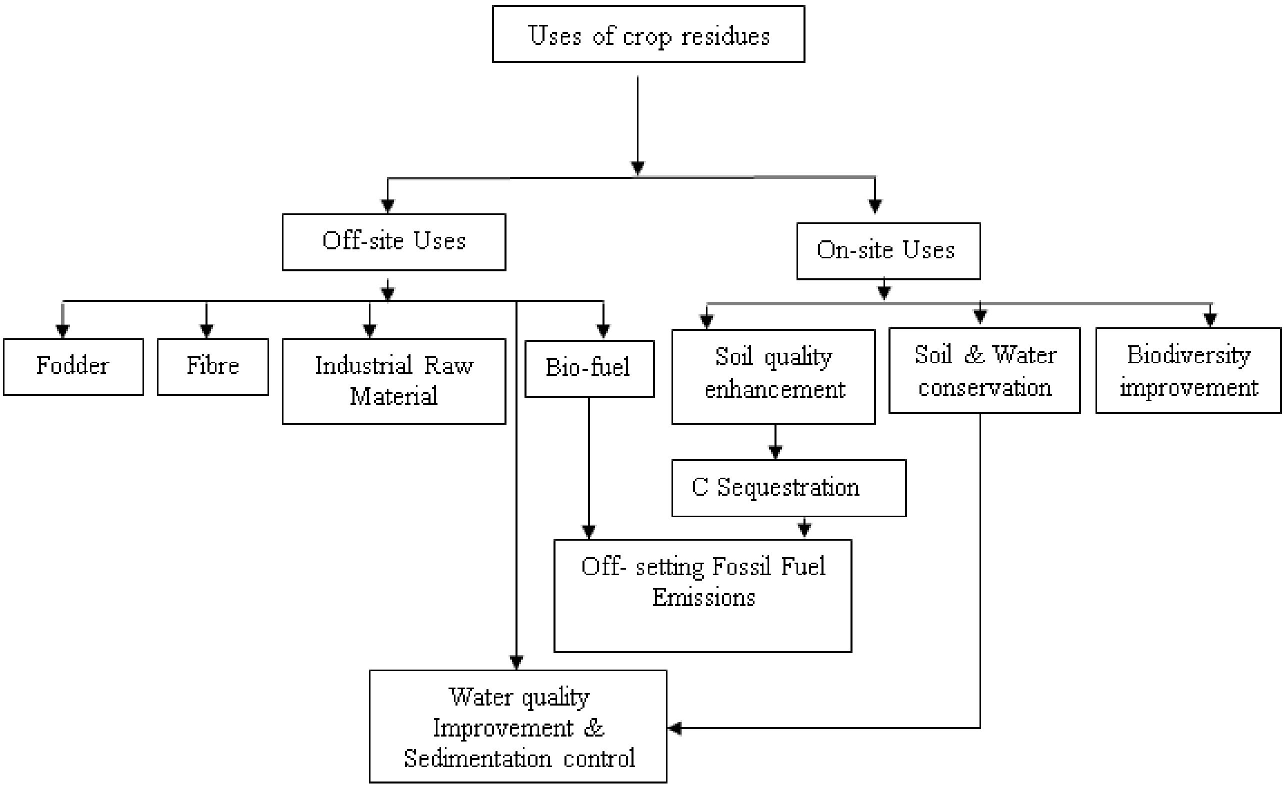

Fig 1. Alternative and competing uses of crop residues.

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