**Biological and nutritional value of stubble retention**

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**Biological and nutritional value of stubble retention**

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Crop residues are one of the major sources of carbon for soil biota in low fertility agricultural soils of Southern Australia and stubble retention can provide benefits through changes in soil physical, chemical and biological properties. It is generally believed that stubble retention could provide benefits from improvements to different biological properties. Soil biota play a key role in a number of essential biological functions, carbon inputs from plant roots and crop residues form the essential supply of C (energy source) and nutrients for biological activities. Therefore in most Australian agricultural soils carbon inputs through above (stubble) and below ground (roots) plant residues have a major influence on populations of biota and their activities.

**Nutrients in crop stubble**

Crop residues (stubble) are one the major sources of available carbon for soil biota, in particular in the lower organic matter Australian soils. Crop stubble generally contains ~40% of carbon (dry weight basis) and a large portion of it is biologically available (labile) in the short-term (<3 years). Retention of stubble after harvest would also contribute to the conservation of nutrients taken up by the plant within the cropping system. The amount of nutrients in stubble at harvest depends upon crop type, soil fertility, nutrition received through fertilizers and nutrients removed in the grain. Average concentrations of nutrients in the stubble from some grain and pasture plants are given in Table 1. The rate and timing of availability of nutrients from stubble to the following crops is determined by the rate of decomposition and immobilization (tie-up) by soil micro-organisms. For example, release of nutrients from legume residues with narrower C/N ratios is quicker compared to that from cereal crop stubble. In the southern Australian cropping regions, the effect of absolute loss of nutrients from stubble burning may be greater than the temporary tie-up of nutrients during the decomposition; however the significance of these effects vary depending upon stubble load, time and type of burning and other agronomic factors.

*Table 1. Typical amounts nutrients and nutrient rations in the stubble from some common crops*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Stubble****type** | **Carbon** | **N** | **P** | **S** | **K** | **C/N ratio** | **N/P ratio** | **N/S ratio** |
|   | (kg / one tonne stubble) |   |   |   |
| Wheat | 400 | 5 | 0.4 | 1.0 | 13 | 87 | 12 | 4 |
| Medic | 400 | 26 | 1.7 | 1.8 | 14 | 15 | 16 | 15 |
| Canola | 400 | 6 | 3.0 | 3.2 | 30 | 91 | 3 | 2 |
| Lucerne | 400 | 26 | 2.1 | 2.2 | 28 | 15 | 13 | 12 |
| Soybean | 400 | 26 | 1.1 | 1.1 | 16 | 15 | 24 | 23 |

Various stubble management strategies can influence the rate of stubble decomposition and the proportion of C that remains in the resistant pool and soil organic matter. Soil organisms respire 60-90% of added C and only 10-30% will remain in soil 3 years after its addition. Decomposition of crop residues and formation and mineralization of soil organic matter (SOM) are influenced by soil and climatic conditions, activities of microorganisms and soil fauna (biological processes) and quantity and quality of crop residues (resource quality). In addition, the change in the timing of N release (slower and sustained release through the season) due to stubble retention and direct drilling provides an opportunity to better synchronize N release to plant demand. For example, results from field studies in SA indicated that the distribution of available N down the profile at sowing was influenced by the type of stubble treatment and this varied with soil type. Accelerated crop residue decomposition following cultivation indicates that reduced tillage is critical to arresting C loss and increasing the build-up of soil C in annual cropping systems.

**Biological effects from stubble retention**

It is generally believed that stubble retention can provide benefits from improvements to different biological properties (Table 2). Results over 20 years of research in Australia have clearly shown that practicing conservation farming would lead to a better overall soil biological health as seen by increased microbial biomass, populations and activities of key groups of microorganisms and soil fauna. However, in different cropping regions of Australia, the nature and extent of these benefits and changes on microbial diversity are not well understood. For example, in some cases, the presence of other biological constraints such as deleterious rhizosphere bacteria or build up of soil-borne plant pathogens can restrict the translation of above benefits into increased grain yield.

Soil type, residue quality and environment can significantly impact microbial populations and their metabolic activities, potentially influencing the timing and extent of the biological benefits derived from stubble retention. Both tillage and stubble management can impact on the diversity and activity of soil biota and influence crop production. The magnitude of responses of microbial communities to no-till practices can differ according to soil type, environmental conditions, duration of changed management and other farming practices. For example, results from no-till plus stubble retention experiments in eastern, southern and western Australian environments indicated significant increase in populations and diversity of microflora, especially those involved in decomposition. Direct drilling generally promoted fungal based microbial communities and assated soil fauna through decreased disturbance, improved C availability, soil structure and soil moisture. Biota changes due to long-term adoption of conservation cropping practices generally enhanced the cycling and availability of nutrients (N and P) and increased the opportunity to better synchronize N release with plant demand. Although changes in populations of soil microorganisms and some biological processes may be seen within 1-2 years after the adoption of stubble retention and no-till practices, significant changes in the diversity of biota and stability in the improvements in biological functions can take longer than 5 years. For example, research in South Australia indicated that it may take more than 5 years of continuous adoption of conservation tillage to cause sufficient changes in soil microbial communities to give high levels of biological disease suppression against important soilborne diseases.

Some of the decomposition products of stubble decomposition, especially anaerobic degradation products, can be toxic to germinating seedlings; however such effects are only seen in the presence of wet and cool soil conditions and large amounts of undecomposed stubble at seeding.

*Table 2. Stubble retention and no-tillage effects on soil biota*

|  |  |
| --- | --- |
| **Biota benefits** | **Biota negatives** |
| ·      Higher populations and activities of soil biota, esp. Cellulolytic (C decomposing) bacteria and fungi·      Increased amounts of C and nutrients in the microbial biomass, the engine for all biological activities·      Improved nutrient mineralization and nutrient supply potential·      Improved soil enzyme activities related to N, P and S mineralization.·      Reduced opportunities for leaching loss of N·      Increased N2 fixation from non-symbiotic nitrogen fixing bacteriaLong-term:·         Improved disease suppression·         Improved soil aggregation and structure = reduced soil erosion | ·      Increased incidence of soilborne plant diseases (short-term only)·      Short-term tie up of plant available nutrients; reduction in the availability of N early in the season·      Reduced early seedling growth·      Increased foliar diseases (crop variety dependant) |

Conservation farming practices offer potential to increase the supply of nitrogen to crops by modifying the composition of different soil pools of C and N and the nature of microbial activities that mediate the N cycling processes. Results from 8 years of field trials on light textured Mallee soils in SA, Vic and NSW indicated that C inputs from <3t dry matter/ha may not be adequate to meet the C needs of soil biota and maintain soil organic C levels. In higher rainfall regions and heavier soils greater amounts of C inputs are required to meet biota needs. It was found that high microbially available C inputs were the driver for improved biological functions. Reducing C inputs through stubble burning, removing stubble by over grazing and export of residue would impact on the level of biological activities related to nutrient cycling (mineralization, timing nutrient release and free-living N fixation), disease suppression and contribute to losses in soil organic matter.

Three years of field studies conducted at two trial sites in South Australia with contrasting soil types and rainfall showed that while stubble retention caused significant changes in the catabolic diversity of microbial communities in both soil types, changes in the genetic diversity of bacteria were primarily seen in the sandy Waikerie soil. Effects of stubble retention on the diversity and population of fungi (both beneficial and plant pathogenic) were seen in the first 3 years of stubble retention. Results from other research in Australia demonstrated increases in populations and changes to diversity of various groups of soil fauna due to stubble retention.

Since stubble retention effects are soil type and environment based it is recommended that field based experiments are used to determine stubble effects on soil biological function and to identify linkages with crop yield.

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Figure 1. Photos of crop residues taken using Scanning Electron Microscope showing the various types of microorganisms colonizing different crop residues. Extensive colonisation of nitrogen rich vetch residues by bacteria and fungi. Fungi were the dominant microflora colonizing wheat residues where as fungal growth on canola residues was less and limited to specific fungi such as Pythium species.*