Stubble retention in cropping in South-East Australia: benefits and challenges

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Keywords: burning, conservation tillage, farming systems, stubble retention, yield impact

Introduction
Late stubble burning just prior to sowing is commonly practiced in the south-eastern cropping areas of Australia. With large stubble loads before sowing, late stubble burning in March/April minimises the duration the soil surface is exposed before the establishment of soil surface protection, usually by early winter (June/July). However better alternatives are needed because burning may become prohibited due to the perceived public health hazard from smoke. Consequently, we reviewed information from southern Australia, particularly from southern and central NSW, relative to other areas, to identify the basis for non adoption of stubble retention (Figure 1). We sought to highlight gaps in knowledge of stubble retention practice, and reasons why perceived benefits from adoption may not accrue, as these may contribute to non adoption.

Soil Water, Nitrogen, Carbon and Acidification
The presence of stubble can increase water infiltration and slow evaporative moisture loss, thus increasing soil moisture storage at sowing (Figure 2). These effects are likely to be of most value in Queensland and northern NSW, where production of winter cereal crops is highly reliant on stored soil moisture, but likely to be of less importance in the southern cropping areas where winter crop growth is more dependent on incident rainfall. In central and southern NSW, there is a component of summer rainfall which could be stored in the soil, and be of benefit to a subsequent crop, particularly in lower rainfall years or environments. It is unclear what the effect of late stubble burning has on stored soil moisture.
Figure 2. Soil moisture storage at Wagga Wagga NSW in May 1985 under a range of stubble loads following 140 mm of rain, and 35 mm of additional irrigation (Reproduced from Cornish 1987).

Nutrient impacts were comprehensively reviewed by Scott et al (2010). In dryland crops, burning of stubble causes losses of approximately 4 kg N/t of wheat stubble burnt; with average losses of 26 kg/ha of N in high yielding areas. These losses are less than suggested elsewhere. Furthermore, in stubble-retained systems, N may be immobilised. While immobilisation rates of 5-13 kg N/ha from the decomposition of 1 t/ha of wheat stubble are reported from European research, the optimal rate of N fertiliser was only increased slightly by stubble incorporation in WA. Soil organic carbon (OC, t/ha) was less in stubble-burnt or removed systems than in stubble-retained systems. However, there was no evidence of sequestering of C in stubble-retained systems; rather the amount of OC in the soil declined at a slower rate with stubble retention than stubble burning in cropping systems. Organic carbon was greater in the shallow surface soil (0-5 cm) with stubble retention, than when stubble was burnt. This may contribute to greater structural stability and water infiltration in the soil surface and greater earthworm populations.

Acidification of the surface soil (0-10cm) was greater under stubble retention than stubble burning, in both southern NSW and South Australia. The effect was confined to the shallow surface soil (0-5cm). Some nutrients (P, Zn, Cu) accumulate in the soil surface under conservation tillage. Stubble retention may contribute to this stratification, and increased fertiliser input or occasional cultivation are suggested amendments. Similarly, stratification of soil pH can be amended by the addition of lime and its incorporation through cultivation.
Figure 3. Relationship between rainfall parameters (GS, growing season, May-October; spring; winter) and the mean difference in yield between stubble-retained and stubble-burnt/removed wheat crops in two long-term experiments (Billa Billa and Wagga Wagga; from Kirkegaard 1995). A fitted line (grey, broken) to the Wagga Wagga (GS) is also shown – Reproduced from Figure 27 of Scott et al 2010.

Pests, Diseases, Weeds and Mechanisation

Blockages of sowing implements by stubble are the primary reason for non adoption of stubble retention by farmers in southern and central NSW, where stubble load is high. Existing sowing machinery is limited to sowing through 2-3 t/ha of cereal stubble; modification of machinery combined with pre-treatment of stubble (slashing, harrowing) can enable sowing into 4 - 5 t/ha of stubble. Scott et al (2010) have estimated from field reports that 20-49% of the stubble biomass at harvest is decomposed and lost by sowing in southern Australia compared with 57-84% in Queensland, where greater rainfall in summer would hasten decomposition.

Burning stubble rather than its retention reduced the disease and pest carry over to follow-on sensitive crops. The temperatures achieved in a stubble fire influenced the effectiveness of the fire in controlling some plant disease on the stubble and we have recorded Australian field examples of the effectiveness of stubble burning in the control of crown rot, common root rot, eyespot, and yellow spot. Similarly, stubble retention increased the populations of some grasses in subsequent crops.

Conservation farming systems with stubble retention rely on herbicide use for weed control, and this may lead to a problem with herbicide resistant weeds, particularly annual ryegrass, wild oats, and wild radish. The integrated management recommended for control of resistant weeds includes, as one component, a reversion to stubble burning.

Conclusions

Stubble retention is often claimed to increase cereal yield. The evidence, however, is that there is often no effect on yield, or more frequently, that yield is lower with stubble retention compared to stubble burning or stubble removal. In most experiments, the small yield loss is not related to seasonal rainfall, but in a few experiments, the adverse effect of stubble retention
on yield is greater in wetter seasons (Figure 3). Interaction with growing season rainfall needs to be better understood, as yield reductions with stubble retention may be high (up to about 1 t/ha of grain) in seasons with high yield potential (EH Graham Centre 2010). Further research is needed to explain these interactions.

We suggest that research is also needed into systems maintained in long-term conservation farming in which the system is “disturbed” by infrequent cultivation and/or stubble burning. These practices appear necessary to control weeds, mix the surface soil to de-stratify nutrients and incorporate lime in acidifying soils. If the benefits of conservation tillage accumulate in the longer term, however, such disturbances may negate the benefits.

References


