Stubble Management and Cotton Nutrition

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A three-year study completed in 1994 indicated that burning cotton stubble reduces cotton yields and profitability. Although the study was conducted at only one site, it provides an insight into the sustainability of our cotton growing systems.

In recent years, pulling, raking and burning stubble has become more widespread. This practice removes stubble which may have hindered cultivation operations, impeded irrigation water recirculation equipment or promoted seedling diseases which survive on stubble between crops. However, the removal of stubble under this system of management can adversely affect productivity. Before burning was common, cotton stubble was slashed near ground level and the trash incorporated into the surface soil to hasten its decomposition, using a disc or chisel plough.

An experiment at ACRI over three consecutive cotton seasons (1991/2 to 1993/4) investigated the two stubble management systems on cotton growth, lint yield and recovery of fertiliser N.

The field had grown cotton since the 1960s, and continuously since 1984 using minimum tillage on 1 m permanent rows. Within two months of picking in each year, cotton stubble was either:

1: retained by slashing at ground level and incorporated with go-devils
2: removed by stalk-pulling and raking from the plots

On average, the 3.4 tonnes of stubble/ha removed each year contained 1.5 t carbon (C)/ha and 20 kg N/ha. Each September, urea was applied at 0, 50, 100, 150 and 200 kg N/ha to each of four replicates of the two stubble management systems to determine the optimum input of N for each system. Each year the same stubble and N treatments were maintained in every plot and Siokra 1-4 was sown in mid-October.

Stubble management effects on the soil

At the start of the experiment, the soil organic C content was slightly higher with stubble retention (1.07 compared with 1.01% C); this difference can be explained by the carbon removed in the stubble, which accounted for about 5% of the organic C in the soil plough layer (30 cm). At the end of the study, soil organic C averaged 1.03% C in both systems. Further analyses of these soil samples by Conteh and Blair found a substantial increase of Labile C over the period of the experiment where stubble was retained.

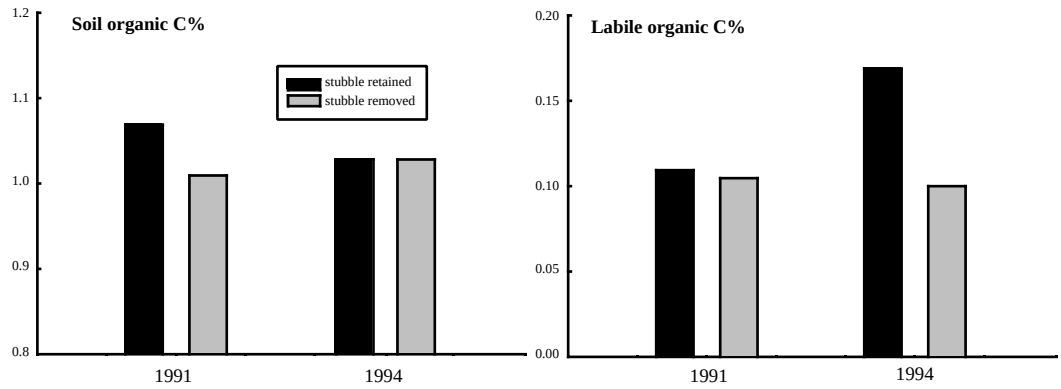

Figure 1. Labile C (%) increased where cotton stubble was retained, although organic C% did not change substantially.

Where stubble was removed, biological activity in the soil was found to be 7% lower than where stubble was retained – even 6 months after stubble incorporation. The carbon in the stubble may either be immediately returned to the atmosphere with burning, or pass slowly through the food chain in the soil, providing the energy essential to maintaining active populations of soil organisms. Similar amounts of stubble-C were respired by these microbial populations each year as were physically removed in the raking/burning operation.

With stubble removal, soil nitrate concentrations were slightly higher in the first two years, indicating that slightly more N was available at squaring. During stubble decomposition, plant-available N will be taken up by the soil microorganisms, a consequence of the high energy and low N content of cotton stubble.

The size and diversity of the soil microbes may decline in systems where stubble is removed, as the source of energy which sustains them is not maintained. In turn, this disturbs the recycling of N and other nutrients.

A system which retains stubble will support a much more active soil biomass and hence, generally healthier soil. Other researchers have shown greater biological activity and nutrient cycling in stubble-retained systems, compared with those where stubble is burned.

Stubble management effects on cotton growth and yield

The yield reduction with stubble removal became more apparent with time - a one year study would have lead to a different conclusion about stubble management. Removal of stubble reduced lint yield in the second and third years by 3 and 9% respectively (Figure 2). An economic analysis of the yield and N fertilizer response data indicate that stubble removal decreased profits substantially each year (Figure 3).

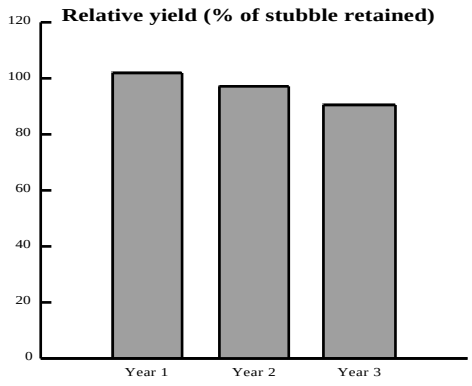

Figure 2.: Lint yield where stubble was removed, relative to stubble retention.

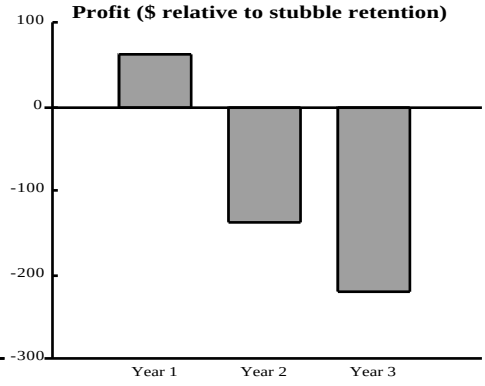

Figure 3: Profitability where stubble was removed, relative to stubble retention

N fertiliser recovery

The crops required 140 kg N/ha to maximise profitability and 175 kg N/ha to maximise yield, averaged over seasons and stubble treatments. Where stubble was retained, much more fertiliser N was recovered early in the growing season, where stubble was removed N fertiliser recovery was consistently lower. Our data indicate that more N fertiliser was lost from the stubble-removed system.

Initially, we thought the removal of stubble would limit denitrification and improve N fertiliser recovery as organic matter provides the energy for the denitrification process. However, that assumption was wrong. In fact, stubble retention provided a soil environment more conducive to biological activity and nutrient cycling. The 60 kg N/ha removed in the stubble burning management system during the 3-year study was a significant export of N from the system.

Other cropping systems

Yield increases are commonly reported where stubble is retained in rain-grown sorghum and wheat cropping systems, although stubble management may have little effect on disease incidence or weed infestation. Research conducted in the MIA has shown that retaining and incorporating rice stubble, compared with burning, improved crop N fertiliser recovery and reduced N loss by 23%.

Related issues

The increasing trend towards retaining stubble in Australian agriculture provides a means by which soil organic matter can be maintained or increased and soil bulk density decreased, thus encouraging more active populations of microorganisms. Soils which maintain an active microbial biomass will degrade agricultural chemicals more quickly, whereas microbial populations (particularly mycorrhizal fungi) decline with stubble removal. As our cotton growing soils already have a low organic matter content, it is important we aim to at least maintain these levels.

Growers should be realistic when deciding which stubble management system best suits their particular situation. There is the additional time consumed in the stalk-pulling, raking and burning operations, compared with a single pass of a mulching slasher. Where timeliness is important, as in a continuous cotton system, stubble retention should be the preferred management option in combination with pupae destruction. The retention of stubble may reduce soil loss, particularly from steeper slopes, and improve rainfall infiltration: both of which are particularly important for dryland growers.

Nutrient loss and transport associated with Raking and Burning

Because of the intense heat generated in stubble fires all the C, N and S in the stubble is volatilized into the atmosphere. The heat from the fire will also destroy soil OM immediately below the fire.

The transport of other plant nutrients contained in the stubble into windrows where they are concentrated in the ash is another important factor: P, K, Zn, Ca etc become more concentrated in the soil below windrows at the expense of the surrounding soil and create in-field fertility patterns and gradients which would be difficult to remedy. In some valleys, bands of darker green cotton corresponding to stubble windrows can be seen from the air.

Environmental problems associated with burning stubble may well lead to the cessation of this practice. The N contained in the stubble is completely lost to the atmosphere when burned, and further losses of soil N occur as soil organic matter is destroyed beneath these fires. The appreciable quantities of other plant nutrients found in the stubble which are transported to and concentrated at the fire sites, also contribute to an uneven distribution of plant nutrients and irregular crop growth.

Soil OM and nutrient cycling

Stubble returned to the soil supplies energy to soil microbes which perform various functions including the decomposition of stubble and maintaining the supply of nutrients to crops. Removal of stubble from the system starves the soil organisms of their energy source, limiting their capacity for performing these ecological processes and the size of the soil biomass is accordingly diminished.

`Cropping systems involving legume green manures

In 1997, legume green-manuring between back-to-back cotton crops was tried. This aimed to provide the following cotton crops with fixed legume-N, with the possibly that the OM input to the soil would provide an additional benefit to cotton production.

In April 1997, following cotton picking, the stubble was slashed and the hills cultivated to destroy pupae. Vetch, clover, medic or field peas were sown in single rows on each hill and

in mid September all crops were slashed after DM samples had been taken. this provided an estimated 4 t DM / ha. The slashed material dried quickly and was incorporated with 2 passes of go-devils within two weeks. These crops were estimated to have fixed up to 200 kg N / ha, and an additional 100 kg N / ha was applied as anhydrous ammonia. The site was pre-irrigated and sown on October 13.

This system offers several advantages:
· legume N replaces some fertiliser N
· OM is added to the soil
· the soil is not left fallow
· soil biomass and biological processes are enhanced by incorporating legume stubble

Conclusions

The removal of cotton stubble from cotton fields:
· reduces N fertiliser recovery
· reduces lint yield
· reduces biological activity and nutrient cycling
· reduces the activity of the soil microbial biomass

On the other hand, the traditional method of cotton stubble management, which uses slashing and shallow incorporation, promotes a more ecologically and economically sound system. It also enables better use of fertiliser N and maintainshigher cotton lint yields.

Acknowledgments

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Further reading

Rochester IJ, Constable GA and Saffigna PG. (1997) Retention of cotton stubble enhances N fertilizer recovery and lint yield of irrigated cotton. *Soil and Tillage Research* **41**, 75-86.

Rochester IJ and Constable GA. 'Retain your cotton stubble - burning can reduce yields' *Australian Cottongrower* (Jan-Feb, 1996) pp 62-64.