NATIONAL AGRICULTURAL CONFERENCE

BURNING BAN — THE FINAL STRAW ?

WEDNESDAY 28th NOVEMBER 1990

Jointly organised by:
Royal Agricultural Society of England
Agricultural Development and Advisory Service

at the National Agricultural Centre

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BURNING BAN – THE FINAL STRAW
CONFERENCE WEDNESDAY 28 NOVEMBER 1990

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STRAW INCORPORATION - NITRATE IMPLICATIONS

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Mineralization and immobilization of nitrogen in soil

The microorganisms in soil, collectively known as the soil microbial biomass, obtain energy by decomposing organic matter such as plant and animal residues and soil humus. This leads to the production of carbon dioxide and, at the same time, new humus is formed. Some of the nitrogen contained in the incoming material will be retained in the cells of microorganisms and some will become part of the soil humus. If the material is rich in nitrogen (e.g. containing more than about 1.4% N corresponding to a carbon-to-nitrogen ratio of about 30:1) there will be an excess of N which will appear as inorganic N in the soil. Ammonium is formed first but, at least in agricultural soils, this is rapidly converted to nitrate. If the material is poor in N (having a lower percent N and wider C:N ratio) there will be no excess of N from the decomposition process and, indeed, the organisms will absorb inorganic N from the surrounding soil to allow decomposition to proceed. The conversion of organic N to inorganic forms is called *mineralization* and the tie-up of inorganic N when N-poor material decomposes is called *immobilization*. Both processes can, and usually do, occur concurrently in soil but at any given time one will predominate.

Straw incorporation and nitrate leaching

Cereal straw commonly contains between 0.4 and 0.8% N so would be expected to cause some immobilization. This can be demonstrated in laboratory experiments and results from field experiments conducted during the 1950s and 1960s were also consistent with immobilization. Decreases in crop yield were sometimes observed where straw was incorporated and this could be overcome by applying extra nitrogen fertilizer. At this time the apparent tie-up of nitrogen was perceived as a problem. More recently attention has been focused on the leaching of nitrate from arable soils during winter. At the time when leaching begins, most arable soils contain a substantial amount of nitrate derived from the mineralization of soil humus. Any tie-up of inorganic N in autumn should decrease the amount that is exposed to leaching. Some calculations suggest that 5-10 kg/N ha should be immobilized per tonne of incorporated straw, so decreases in leaching of about 25-50 kg/N ha might be expected for typical cereal crops (Jenkinson, 1985; Powlson *et al*, 1985). Does this actually happen? Currently available data is somewhat contradictory but it appears that the beneficial effect on nitrate leaching is more modest than these calculations suggest.

Amounts of nitrate entering the drainage system of a Denchworth series clay soil are currently measured at the Brimstone Experiment in Oxfordshire. In the of winter 1988-89 about 10 kg/ha *less* nitrate-N leached if straw was incorporated

prior to drilling a winter cereal than if it were burnt (Christian *et al.*, 1990). Changing from conventional cultivation, involving ploughing, to shallow tine cultivation caused a similar decrease. For comparison, the presence of a growing crop, as opposed to bare soil during winter, had a much greater effect - decreasing leaching by 30 kg/N ha.

In a lysimeter experiment in Sweden, incorporating straw decreased leaching during winter by 5 and 11 kg/N ha respectively for a loam and clay soil averaged over five years (Bertilsson, 1988). In field experiments in Denmark (Kjellerup, 1986; Schønning, 1986) decreases in leaching of between 3 and 25 kg N/ha (averaging about 10 kg N/ha) resulted from the incorporation of 4-5 t/ha of cereal straw.

Why are the decreases in leaching less than expected?

Microbiological studies (Harper & Bowen, 1988) have shown that some of the most decomposable materials in straw (cellulose and hemicellulose) that would be expected to cause considerable immobilization, are protected from decomposition by their physical association with lignin. Lignin can only be decomposed by certain slow growing fungi, so the time at which some of the immobilization occurs may be delayed or perhaps spread through the year. Another factor may be that straw grown under current conditions of high fertilizer nitrogen usage has a slightly greater percent N than that grown, say, 30 years ago and so will have a smaller tendency to cause immobilization.

Some recent work at Rothamsted (Ocio *et al.*, 1990) has raised further intriguing questions that are still being studied. In field and laboratory experiments either straw or inorganic N added to soil was labelled with ^{15}N, the heavy isotope of nitrogen. It was found that a large part of the nitrogen entering the soil microbial biomass was derived from that originally present in the straw rather than from inorganic N. Again this suggests that the immobilizing effect of straw may be less than originally thought. However, this work did show that the processes occurred rapidly; the amount of N in the microbial biomass doubled within a week of straw incorporation.

Long-term effects

Any N that is immobilized as a result of straw incorporation adds to the reserves of organic N in soil, and, eventually, some of the additional N will be remineralized. Indeed, newly immobilized N is more readily mineralized than the older N already present in humus. Thus it might be expected that a long-term consequence of straw incorporation would be to *increase* the amount of nitrate produced in soil as a result of mineralization. Is there evidence of this occurring? The answer appears to be yes.

One example is from an experiment at Woburn (Cottenham series soil) in which nitrate was measured in the soil profile (0-90 cm) in October 1986 (Hewitt, personal communication). A soil with a history of 12 years straw incorporation contained 25 kg/ha *more* nitrate N than one from which straw had been removed. In two other experiments (Powlson *et al.*, 1987) the effects of 18 years of burning

or incorporating straw on various soil properties were assessed. Although the increases in *total* soil carbon or nitrogen were too small to measure accurately, the soil microbial biomass had increased by 37-50%. In a short-term laboratory incubation N mineralization was the same whether straw had been incorporated or burnt. If, however, the incubation was continued for longer 40-50% *more* N was mineralized in the straw incorporation treatment.

Conclusions

Incorporation of cereal straw causes some immobilization of N but the resulting decreases in nitrate leaching appear to be less than was previously expected - perhaps around 10 kg N/ha per year for an application of around 5 t/ha of straw. Although small, such decreases could make a significant contribution to the overall amount of nitrate leaching to aquifers in the low rainfall areas of eastern England. In the longer term the continued incorporation of cereal straw increases the stock of potentially mineralizable N in soil. This could have both beneficial and detrimental consequences. Extra mineralization in spring should allow nitrogen fertilizer applications to be decreased somewhat. However, extra N mineralizing during other parts of the year will lead to additional nitrate being exposed to leaching. It is not yet clear whether or not this will outweigh the small beneficial effect on nitrate leaching.

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