Cover Crops on Irish Tillage Farms

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Summary

- Cover crops reduce nitrate leaching
- Covers crops can contribute towards soil carbon sequestration
- Impacts of cover crops on direct GHG emissions is variable
- Reductions in fertiliser N in succeeding crop are difficult to predict
- Benefits of cover crops linked to the amount of biomass produced
- Cover crops can positively impact environmental sustainability on tillage farms but there can be a net economic cost

Introduction

Cover crops are species or mixtures of species grown over the autumn-winter period between two cash crops mainly for the purpose of generating some benefits for the cropping system rather that as cash crops themselves. Generally, they are not harvested, but in some instances may be grazed. Benefits of cover crops can include reduced nutrient loss, improvement of soil organic matter or carbon levels, reduced soil erosion, improved soil structural characteristics, improved biodiversity, reductions in pests and diseases of the following crops, increased nutrient supply to the following crop and yield benefits in the following cash crop. Cover crops also have some potential disadvantages including negative yield effects on the following crops. In addition they introduce additional costs both in terms of their establishment and destruction and careful consideration is required before adopting cover crops to ensure that they do not have a negative effect on profitability.

Currently there is considerable interest in cover crops as a measure to reduce nitrate loss to water and also a means of further improving the greenhouse gas balance of Irish cropping systems. Cover crops are being implemented on the majority of the Teagasc Signpost farms to improve the sustainability of the production systems on those farms. This paper aims to summarise research on cover crops as it relates to improving sustainability in an Irish context.

Cover Crops and N Loss to Water

In terms of nitrate leaching cover crops have been shown to substantially reduce leaching of nitrate in comparison to soil with no vegetative cover. Work at Oak Park found consistent reductions in the concentration of nitrate in the soil solution at 90 cm depth where a cover crop was established in mid to late August in a continuous spring barley rotation, in comparison to where there was no vegetative cover (Premrov et al. 2014). The work also indicated that natural regeneration, largely consisting of volunteer cereal plants where the soil was cultivated after harvest, could also reduce soil solution nitrate concentrations at depth (Figure 1). When the amount of N leached was calculated it was found that, compared to bare soil, a cover crop could reduce N lost by up to 52 kg N/ha and natural regeneration could reduce N lost by up to 21 kg N/ha (Premrov et al, 2014).All this work was carried out on a very leaching prone site (sandy soil overlaying gravel) and the benefits of overwinter vegetation on medium or heavy textured soils, in terms of nitrate leaching, may be more modest. The effects of a cover crop or natural regeneration on leaching, will be dependent on the amount of N accumulated by the cover crop before drainage occurs, which in turn will be linked to the growth or biomass production of the cover crop; the greater the biomass accumulation the greater the N uptake the greater the reduction in N leached.

However, the work clearly demonstrated the positive benefit both a sown cover crop and natural regeneration can have on reducing nitrate loss from Irish cropping systems when established in a timely manner.

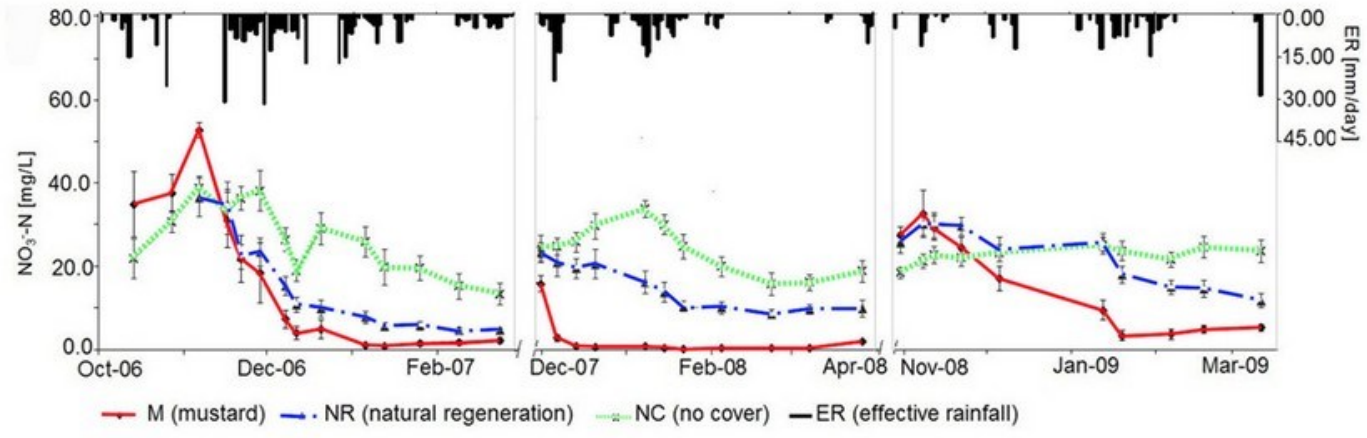

Figure 1. Effect of a cover crop (mustard), in comparison to natural regeneration and bare soil, on soil solution nitrate concentrations over the autumn winter period at 90cm depth (Premrov et al., 2014).

Cover Crops and Greenhouse Gas Emissions/Carbon Footprint

From a greenhouse gas/carbon footprint perspective cover crops, in comparison to soil without overwinter vegetation, can have effects, both positive and negative, through a number of routes, including increased carbon sequestration, reductions in fertiliser N requirements and changes in nitrous oxide emissions. The net effect of cover crops will be dependent on the magnitude of these individual processes.

Carbon Sequestration

The amount of carbon sequestered will be influenced by the amount of biomass accumulated by the cover crop and the degree to which the carbon in this biomass is retained in the soil when it is incorporated. Work at Oak Park has indicated that biomass production of cover crops is typically between 1 and 3 t/ha above ground dry matter, depending on factors such as species and sowing date.

Taking the 3 t DM/ha, assuming that there would be a further 30% present in root biomass and assuming a carbon content in the biomass of 43% would suggest a total carbon input to the soil via plant biomass of 1.68 t C per hectare. If it is then assumed that there is 20% efficiency of retention of that carbon as soil organic carbon (SOC), this would lead to an increase in SOC of 335 kg C per hectare. The actual efficiency of retention will be affected by a range of factors including the type of biomass incorporated (roots tend to show higher retention than aerial part, its C:N ratio and the soil type (clay soils are likely to retain a greater proportion than sandy soils). Assuming a depth of 20 cm and a bulk density of 1.3 g/cm3 this would lead to an increase of ~0.01 percentage points in SOC content per year. Thus, the effects of cover crops on SOC are likely to be relatively small and slow and will require repeated growing of cover crops over time to have a significant effect. This does not mean that agronomic benefits of cover crops require long periods to become evident. While total SOC may be slow to change there will be more rapid changes within different fractions of SOC, particularly in the more labile pools, which can often be more beneficial in agronomic terms than changes total SOC.

Fertiliser N Effects

Fertiliser N can account for over 70% of the carbon footprint of cereal crops in Ireland. Practices which reduce the fertiliser N requirement of cereal crops without leading to substantial increases in direct emissions or without having significant negative effects on grain yield have the potential to reduce the carbon footprint of cereal crops. Cover crops can accumulate substantial amounts of N during the autumn winter period, with amounts of over 100 kg N/ha being recorded in some situations, although amounts of 50-70 kg N/ha for cover crops sown in mid to late August might be more typical. However, when the cover crops are incorporated into the soil (or left on the soil surface after destruction) generally only a small and variable proportion of this N will become

available to the succeeding crop such that it can be difficult to give precise recommendations as to the amount that fertiliser N inputs should be reduced by in any given situation. Factors influencing this variability include the quality of the material being incorporated, particularly in terms of its C:N ratio with material with a low C:N ratio (typically greener leafier material) more likely to release a greater proportion of its nitrogen to the subsequent crop. Soil conditions such as soil moisture status and soil temperature will also have a role to play. Research at Oak Park has indicated that the nitrogen benefit of non-leguminous cover crops is often negligible although work with cover crops with a substantial proportion of legumes has indicated that in this situation significant reductions in fertiliser N inputs could be made without compromising yield. Such cover crops have potential therefore to reduce the carbon footprint of the following cereal crop, but only if they do not cause a significant increase in emission of nitrous oxide and if the reduction in fertiliser N inputs can be predicted in advance of fertiliser N application.

Direct Nitrous Oxide (N_2O) Emissions

Nitrous oxide emissions as a result of residue decomposition contribute to the carbon footprint of arable crops. As cover crop biomass is returned to the soil, either by incorporation or left on the surface to decay, there is potential to increase nitrous oxide emissions.There is currently little Irish research on changes in nitrous oxide emission as a result of the introduction of cover crops to arable systems. A summary of a large number of studies from abroad indicated that cover crops didn't significantly change direct nitrous oxide emissions (Abdalla et al., 2019). However individual studies have found increases in N2O emissions as a result of cover crops particularly where a significant proportion of legumes were included in the cover crop mix (e.g. Kandel et al 2018, Olofsson and Ernfors, 2022).

Maximising the Benefits of Cover Crops

The magnitude of many of the benefits of cover crops is dependent on the total amount of biomass produced. In an Irish context the principal factor affecting the amount of biomass produced by a cover crop is its sowing date. Research has shown a significant reduction in biomass production by cover crops as sowing date is delayed from late July until early September (Figure 2). Biomass production and N uptake of crops sown after mid-September is likely to be limited in most years, particularly where drainage begins in early to mid-October, thereby reducing the amount of N available to the cover crop before it has been able to accumulate that N.

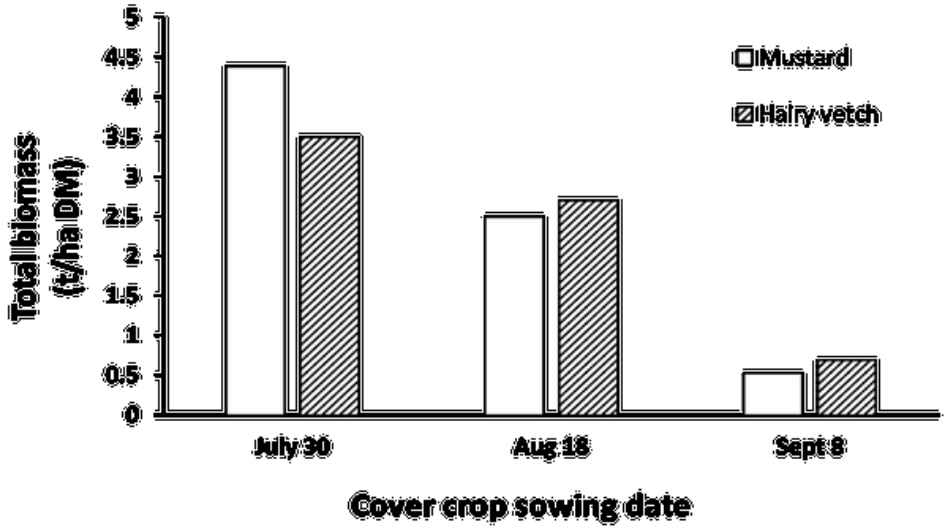

Figure 2. Effect of sowing date on aboveground biomass production by two cover crops at Oak Park, Carlow.

Conclusion

Cover crops can contribute positively to a range of environmental indicators for arable cropping in Ireland. There can also be positive agronomic benefits, although these benefits are not always consistent. For both environmental and agronomic benefits achieving good biomass production by careful species choice and sowing early is desirable. If any additional cost of establishing and destructing cover crops is not matched by increased returns from the cash crop cover crops may not be economically sustainable in the absence of external financial support.

References

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