Project number: 5179
Funding source: Teagasc
Date: May 2015
Project dates: Jan 2003 - Dec 2009

Investigations into the use of winter cover crops in spring barley production

Key external stakeholders:
Tillage farmers, advisers and agronomists, policy makers, seed merchants

Practical implications for stakeholders:

- This work provides growers, advisers and policy makers with information regarding the use of cover corps in Irish arable agriculture. It provides an independent assessment of the potential of different cover crops to absorb nitrogen over the autumn period, and the effect that these cover crops will have on succeeding crops following incorporation.

Main results:

- Cover or catch crops can absorb significant amounts of nitrogen over the autumn period and thereby reduce the risk of nitrate leaching, where the risk of leaching is high.
- Any species or mix of species that will grow over the autumn period, including natural regeneration can have these effects.
- Benefits to succeeding crops, in terms of yield or response to fertiliser N, after incorporation of cover crops are variable and often small. However, leguminous cover crops can make a significant contribution to the nitrogen nutrition of the succeeding crop.
- Variable and often small benefits to succeeding crops coupled with the costs associated with establishment and destruction of the cover crops make the use of cover crops economically unattractive in the absence of financial incentives.

Opportunity / Benefit:

The results provide guidance to growers, advisers and policy makers when making decisions regarding the use of covers crops in Irish arable agriculture.

Collaborating Institutions:

UCD, TCD

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1. Project background:

Spring barley is the most significant cereal grown in Ireland, generally occupying over 50% of the tillage area. Land used for spring barley is typically left fallow between harvest and ploughing for the subsequent spring barley crop during late winter/early spring. In the absence of a crop nitrate present in the soil during the fallow period is susceptible to environmental loss. Loss of nitrate from soils to water is environmentally unacceptable and represents an economic loss to the grower. Preventing nitrate loss during the fallow period could result in both environmental and economic benefits. Establishing a vegetative cover, either by natural regeneration or a sown cover or catch crop, is one method by which over-winter nitrate leaching can be reduced. A winter cover crop is a plant species sown in the autumn that uses residual nitrate in the soil thereby reducing its loss. Depending on the species, winter cover crops can supply nitrogen to the following crop and enhance carbon concentrations in the soil. Little experimental data exists regarding the use of winter cover crops under Irish conditions. There is a need therefore to investigate the use of cover crops in Ireland and in particular to determine the most suitable cover crop in terms of N scavenging ability and effects on succeeding crop. In addition to examining the use of cover crops where conventional plough-based seedbed preparation methods are used, their use in reduced cultivation systems of seedbed preparation, which are gaining in popularity, also requires investigation.

2. Questions addressed by the project:

The principal questions that the work set out to answer were:

- What effect do winter cover crops have on nitrate loss from spring barley production systems under Irish conditions?
- How do different cover crop species compare under Irish conditions in terms of overwinter growth, N scavenging ability and subsequent spring barley crop growth, N uptake and fertiliser N requirement?
- What is the economic impact of winter cover crops on margins from spring barley production?

3. The experimental studies:

One experiment compared a range of overwinter covers in terms of N accumulation and effects on yield and N response of a subsequent spring barley crop on a light textured soil and medium textured soil at Oak Park in Carlow. On the light soil overwinter covers included bare stubble, natural regeneration, mustard, rye, Westerwolds ryegrass, phacelia, forage rape, peas, oats and a cereal/pea mixture. On the medium soil covers included bare stubble, mustard, oats, peas, and fodder radish. Cover crops were sown in late August/early September and incorporated by ploughing in February or March, prior to planting spring barley. Biomass and N accumulation of the covers were determined. A range of fertilizer N rates were applied to the barley to determine the effect of different covers on the grain yield response to fertilizer N.

A second experiment compared the effect of three overwinter covers (no vegetative cover, natural regeneration and a sown mustard cover crop) on nitrate leaching and spring barley productivity in two cultivation systems (plough based and non-inversion tillage based). Nitrate leaching was assessed using porous ceramic cups installed at 90cm depth which were monitored over the

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autumn winter period (Premrov et al. 2014). The spring barley crop received a standard fertilizer N rate but areas within each plot were maintained free of fertilizer N to determine the effect of the different covers on the supply of nitrogen to the crop in the absence of fertilizer N. Grain yield was determined at crop maturity. A field scale experiment was also conducted looking at groundwater quality response to no cover, mustard and natural regeneration (Premrov et al. 2012).

4. Main results:

The study showed that, compared to no vegetative cover, overwinter vegetative cover could significantly reduce the amount of nitrate leaching on a leaching prone site irrespective of whether the method of primary soil cultivation was plough or non-inversion tillage based. A sown cover of white mustard gave the more consistent effects in this regard but natural regeneration, particularly when stimulated by autumn cultivation, could give similar effects. In terms of effects on nitrate leaching a mustard cover crop gave a significant reduction of 74-86% under reduced tillage and conventional ploughing compared to bare soil. Natural regeneration, where autumn cultivation was practiced, reduced nitrate leaching by 42% compared to bare soil (Premrov et al. 2014). Groundwater quality was also observed to respond rapidly to over winter cover where nitrates were reduced by 25% and DOC significantly increased in winter (Premrov et al. 2012). The increased loss of DOC to groundwater was observed to increase groundwater nitrate reduction through denitrification (Jahangir et al. 2014).

Effects of vegetative cover on grain yield and grain quality in this experiment were generally small and not statistically significant compared to the no vegetative cover treatment. Effects of the different covers on soil nitrogen supply to the succeeding crop were inconsistent and relatively small. This makes reductions in fertiliser inputs as a result of cover crop use difficult to justify.

A comparison of the N accumulation of different overwinter covers indicated that, provided growth was not restricted either by pest or diseases or environmental constraints, all covers investigated could accumulate significant amounts of N, with up to 80 kg N/ha being accumulated in some cases. However observations indicated that the N accumulation by any overwinter cover was strongly influenced by the amount of mineral N in the soil and by the time of establishment of the cover, with establishment as soon as possible after harvest of the previous crop giving the highest accumulation. Fast growing species, particularly species of brassica such as white mustard and forage rape, tended to give the highest N accumulation values. Graminaceous species such as oats and ryegrass tended to give lower amounts of N accumulation than the brassica species. Due to lower amounts of biomass, which appeared related to lower plant density, natural regeneration tended to give lower N accumulation than sown species.

Cover crops can have other positive environmental effects such as increasing soil organic matter and increased biodiversity. However, particularly in the case of soil organic matter, effects of cover crops on overall levels are generally small but significant effects on the composition of the organic matter can occur which can positively impact subsequent crop production.

Effects of overwinter cover on grain yield were variable, both between sites and between seasons. On the medium soil there was no effect of the sown cover crops on grain yield compared to bare stubble. On the light soil site mustard, phacelia, forage rape and peas gave an increase in yield compared to bare stubble but the effect varied considerably between seasons. Incorporation of rye had a visible negative effect on spring barley growth in one season and is not recommended for use as a cover crop. Effects of covers on the response to fertiliser N were inconsistent and it would be difficult to recommend reductions in fertiliser N inputs to spring barley where non-leguminous cover crops are used. An exploratory trial investigating the effect of a range of leguminous cover crops indicated that they have the potential to both accumulate significant quantities of N and make a significant contribution to the nitrogen nutrition of subsequent crops (Hackett, 2015).

Given the inconsistent and generally small beneficial effects of sown cover crops on grain yield and that sown cover crops incur seed costs, establishment costs and destruction costs the use of sown species of cover crops is often not economically justified (in the absence of financial incentives to do so). However management factors such as correct choice of species or species mixture, and good management in terms of sowing date and destruction date can improve the chances of

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achieving economically beneficial results.

5. Opportunity/Benefit:

The results provide guidance to growers, advisers and policy makers when making decisions regarding the use of covers crops in Irish arable agriculture.

6. Dissemination:

Hackett, R. (2012). Effects of overwinter vegetation cover on soil nitrogen supply to spring barley in Ireland. In: Richards, K.G., Fenton, O., Watson, C. J. (Eds). Proceedings of the 17th Nitrogen Workshop –Innovations for sustainable use of nitrogen resources. 26th – 29th June 2012, Wexford, Ireland, pp. 88-89.

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Hackett, R (2015). The role of cover crops in cereal production in Ireland. Teagasc National Tillage Crops conference 2015. Lyrath Estate, Kilkenny.

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Jahangir M.M.R., Minet E.P., Johnston P., Premrov A., Coxon C.E., Hackett R., Richards K.G. (2014) Mustard catch crop enhances denitrification in shallow groundwater beneath a spring barley field Chemosphere 103, 234–239.

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