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Fertiliser N requirements for spring barley in Ireland

Key external stakeholders:

Cereal and crop growers; Crop production industry; Malting companies; Other research teams.

Practical implications for stakeholders:

The demand for spring malting barley, with specific grain protein concentration requirements, is increasing but there was relatively little recent information regarding the effect of rate or timing of fertiliser N application to spring barley on grain yield and grain protein concentration under Irish conditions. This project aimed to test the robustness of current fertiliser N recommendations for spring barley by examining the effects of fertiliser N, both in terms of timing and amount, on grain yield and grain protein concentration.

- Fertiliser nitrogen rate has a bigger impact on both grain yield and protein concentration than fertiliser N timing.
- There was little consistent difference, in terms of grain yield or grain protein concentration between applying the first N at sowing compared to where the initial N application was made at crop emergence.
- Altering the proportion of N applied in each application of a two-split programme, irrespective of whether the first application was at sowing or at crop emergence, had little effect on either yield or grain protein concentration.
- Both the level of yield attained for a site and the supply of nitrogen from the soil affect the economic optimum N rate for spring barley but relationships were variable
- There is little evidence to support altering fertiliser N levels based on cultivar grown

Main results:

Fertiliser N rate has a much larger influence on both grain yield and grain protein concentration than fertiliser N timing

Provided the majority of N is applied before stem extension, there is relatively little effect of altering the timing of fertiliser N applications.

There is little consistent difference between modern spring barley cultivars in terms of their grain yield or grain protein concentration response to fertiliser N level.

In season crop measurements were only moderately predictive of grain protein concentrations, particularly when those measurements were made early in the season.

Opportunity / Benefit:

The datasets generated during this project provide a sound basis for current fertiliser N recommendations for spring barley, particularly barley destined for malting.

Collaborating Institutions:

SRUC, Scotland; University of Edinburgh, Scotland.

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1. Project background:

Spring barley is the largest arable crop in Ireland and the majority of the grain produced is used for animal feed. A proportion is used for malting which is a premium market with specific grain quality requirements. N applications to spring barley, as with other crops, are subject to maximum allowed amounts that are set out in legislation. There was concern amongst growers that the permitted N application rates for spring barley were not sufficient to produce high yields. There was particular concern that restrictions on N fertiliser use were compromising grower's ability to produce malting barley with acceptable protein levels, with protein levels achieved in the years prior to the initiation of the project being below the acceptable range. This project aimed to test the robustness of current fertiliser N recommendations, both in terms of timing and amount, for spring barley by examining the effects of fertiliser N on grain yield and grain protein concentration. It also aimed to identify factors affecting grain protein concentrations in spring barley under Irish conditions.

2. Questions addressed by the project:

Should fertilizer N applications to spring barley be adjusted based on yield?
Should fertilizer N applications to spring barley be adjusted based on soil N supply?
Does the number of splits and the timing of those splits have an effect on the response to fertilizer N?
Can protein concentration of spring barley be predicted from measurements made during the growing season?
Are there varietal differences in the response of spring barley to fertilizer N?

3. The experimental studies:

A series of 20 field experiments were set up in some of the main spring barley growing areas of the country over four growing seasons (2011-2014). These experiments examined the effect of fertiliser N rate and fertiliser N timing on both grain yield and grain protein concentration. Fertiliser N rates from 0 kg N/ha to 240 kg N/ha were included. Timing treatments included comparisons of application of the first fertiliser N at sowing versus at emergence, comparisons of altering the proportion of the total N application applied at each timing in a two split program and an assessment of the use of a third split after the beginning of stem extension. A comparison of the N response of a number of modern cultivars (Snakebite, Frontier, Sebastian, Taberna, Propino was also carried out to determine if N requirements varied between cultivars. The potential of in season crop measurements, such as the quantity of biomass present and the N concentration of that biomass at anthesis as well as proximally sensed reflectance data, as a means of predicting protein concentration at harvest were also assessed.

4. Main results:

As expected there was large variation between sites and seasons in the economic optimum rate of fertiliser N for yield. Both soil N supply, as indicated by crop N uptake at harvest where no fertiliser N was applied, and yield level were related to economic optimum rate of fertiliser N. The economic optimum N rate increased by 20-24 kg/ha per tonne of extra yield per hectare. The economic N rate decreased with increasing soil N supply.

A key finding of the study was that rate of fertiliser N was far more important than timing of fertiliser N in terms of both yield and protein concentration. As long as the majority of fertiliser N had been applied before stem extension, the number or timing of applications or their relative size had little impact on either yield or protein concentration.

Protein concentration of grain was positively affected by increasing fertiliser N rate. Protein concentration of grain increased by, on average, 0.2% for each 10 kg N/ha increase in fertiliser N rate. However there was considerable variation between sites and seasons with in some cases an increase of over 0.35% for each 10 kg N/ha of additional N being observed and at other sites little or no increase in protein levels until high levels of fertiliser N (>150 kg N/ha) were applied. It was also clearly evident that a given level of fertiliser N input could lead to a wide range of protein concentrations, depending on site and season. As an example, application of 150 kg N/ha gave rise to protein concentration of 7.7% at one site and 13.7% at another site,

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which clearly indicates that protein concentration is influenced to a considerable extent by factors other than nitrogen fertiliser inputs.
A comparison of treatments where the first fertiliser N was applied at sowing with treatments where the first fertiliser N was applied at crop emergence indicated that there was no consistent effect of delaying the first fertiliser N until crop emergence on either grain yield or grain protein concentration, even in crops which were not sown until early April.

Differences between cultivars in terms of economic optimum N rate were generally small and inconsistent between sites and seasons and there was no evidence to suggest that fertiliser N inputs should be altered based on the cultivar grown. Similarly the response in protein concentration between cultivars to fertiliser N was similar indicating that there was little evidence to support altering fertiliser N inputs based on cultivar in order to achieve a particular protein concentration.

Attempts to predict protein concentration of spring barley using data from crop samples taken during the season proved only moderately successful. Protein concentration was related to both grain N content and grain yield at harvest; these in turn were strongly associated with crop N content and biomass, respectively, at ear emergence. Statistical models using measurements of crop N content and biomass at ear emergence accounted for up to 80% of the variation observed in protein concentration at harvest suggesting that the models could be useful practical tools for predicting protein concentration. The accuracy of predictions was tested using a separate set of data collected in 2015 from experimental plots and commercial spring barley crops representing several varieties grown over a range of sites. The accuracy was assessed by comparing values of protein concentration predicted from crop measurements made at ear emergence with actual values measured at harvest. The best model gave accurate predictions when weather conditions were comparable to the long term average for the region. However there were clear indications that when weather conditions deviated from the long term average, particularly between the time when crop samples were taken and harvest, the accuracy of predictions declined.

The potential to use a reflectance sensor instead of taking crop samples, which can be time consuming and laborious, was also investigated. Measurements made with a reflectance sensor at ear emergence, at the same time as crop samples were taken, gave reasonable estimates of grain protein concentration at harvest but the predictions were never as accurate as those achieved via destructive sampling of the crop.

Crop measurements made before ear emergence, when modifications to fertiliser N inputs could be still made, were usually less predictive than crop measurements made at ear emergence or later in the season suggesting that measurements of the crop alone may not be sufficient as a means of guiding fertiliser N inputs in order to achieve required protein specifications. However the inclusion of soil measurements, particularly those that could indicate soil N supply, may allow better prediction of fertiliser N requirement earlier in the season.

5. Opportunity/Benefit:

Relevant output from this project has been communicated to malting barley growers and Irish malting companies through various conferences/meetings as well as through the tillage advisory service to allow the required specifications for malting barley to be achieved more frequently.

6. Dissemination:

Information from the project has been disseminated to growers and advisers at a range of open days, conferences and inservice training events. Information from the project was also used to support changes in the National Action Plan governing the use of fertiliser N in crops as well as being used to update the ‘Green Book’.

Main publications:

Hackett, R. Effect of nitrogen fertiliser application timing on grain yield and grain protein concentration of spring barley. Irish Journal of Agricultural and Food Research (accepted manuscript)

Nolan, E. (2016). Understanding and Predicting Grain Nitrogen Concentration in Malting Barley. PhD thesis, University of Edinburgh.

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Popular publications:

Hackett, R. (2018). N management for malting barley, Focus on distilling. Teagasc, Malting barley seminar, Enniscorthy, February 2017

Hackett, R. (2017). Meeting the protein specification for malting barley. Teagasc, Malting barley seminar, Corrin Centre Fermoy February 2017.

Hackett, R. (2017). Producing low protein malting barley. Teagasc, Malting barley seminar, Millrace Hotel, Bunclody, February 2017.

Hackett, R. (2014) Spring barley N response. In: Proceedings National Tillage Conference, Kilkenny, January 2014.

Hackett, R. (2013). Nitrogen for malting barley, an update on Teagasc Oak Park trials. Irish Farmers Journal March 2013

Hackett, R. (2013). Fertiliser N requirements of spring barley in Ireland. Fertiliser Association of Ireland Summer Field Event Wexford May 2013.

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