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Designing future wheat

NIAB is a partner in the new BBSRC-funded five-year Designing Future Wheat (DFW) Cross-Institute Strategic Programme, spanning eight UK research institutes and universities. It is a fully integrated and cohesive national research programme that places UK wheat research at the forefront of global efforts to boost yields. DFW will exploit novel wheat lines to discover and characterise genetic variation underpinning key traits.

Wheat is one of the most important cereal crops worldwide, being grown on more land than any other commercial crop, and accounting for more than 20% of human calorie consumption. Over the next 50 years, predicted population expansion and rapid urbanisation in many developing countries will increase demand for total wheat production to the equivalent of that previously produced over the last 10,000 years. Recognising that it currently takes 15 to 20 years for research findings to reach farmers in the form of improved varieties, BBSRC have made a substantial commitment to future-proofing UK wheat production through DFW.

Within DFW NIAB will continue to exploit unexplored diversity from ancestral wheat species that has been re-captured through inter-crossing and re-synthesis (the creation of synthetic wheat). Large, diverse populations have been generated capturing this diversity and within DFW systematic and targeted assessments aims to isolate favourable genetic regions conferring agronomic advantage. Within the BBSRC Wheat Improvement Strategic Programme (WISP; which ran from 2012 to 2017), NIAB produced around 200 novel wheat populations, capturing 50 new re-synthesised wheat and 50 tetraploid wheat accessions in crosses with elite wheat varieties. This material is now being further exploited in DFW.

DFW addresses four major research themes, of which NIAB is contributing to three. In the novel germplasm development theme, Richard Horsnell and Fiona Leigh will continue the generation and exploitation of diverse wheat germplasm for wheat improvement. Within the increased efficiency and sustainability theme Robert Jackson will contribute to the identification and optimisation of wheat ideotypes for current and future conditions and in the development of material with advanced resource use efficiency. NIAB is also involved in the added value and resilience theme and within this Kay Trafford and her team will work on grain traits with a particular emphasis on wheat starch biosynthesis.

In 2018 the NIAB team will be displaying DFW material at Cereals and showing progress from across the programme at the NIAB Cambridge Open Day – please come along and hear about the latest developments in UK wheat research. For regular updates on the progress of DFW visit the project website: https://www.jic.ac.uk/research/designing-future-wheat/

Stéphanie Swarbreck, University of Cambridge

Dr Roger Sylvester-Bradley, ADAS

Shifting our thinking from high nitrogen use efficiency to low nitrogen optimum

Soil application of nitrogen (N) fertiliser has remained necessary to reach the yield potential of the current recommended cereal varieties. This practice is costly to both farmers and the environment, with the risk of N leakage and eutrophication. Although projects aiming to develop cereals with the capacity to establish symbiotic relationships with N-fixing bacteria and use nitrogen from the air are underway, they remain in their infancy. Thus, shorter term solutions are necessary to reduce the N requirements of crops; these range from better prediction of crop requirements (e.g. Nutrient Management Guide published by AHDB) and more efficient fertiliser application to the development of new varieties.

Progress in improving N use efficiency (NUE, defined in agronomic terms as the ratio of grain produced to N supplied to the plant) has been slow partly because it is a complex trait, unlike disease resistance where the modification of a single gene can

confer resistance to a specific pathogen, which is likely to be maintained whether plants are grown under controlled conditions or in the field. High NUE rely on many processes that are also dependent on environmental conditions. These include an efficient N uptake, a high photosynthetic activity for high primary productivity and high N remobilisation from the flag to the grain.

These processes involve many biochemical pathways, which have been well characterised over the years. We know which enzyme is important for reducing nitrate in nitrite, then ammonia for further assimilation in amino acids, for example. And with the advance of genomic technology, we also know the genes underlying these biochemical and physiological components. However, it is still a long way between modifying a single gene and developing a variety that will sustainably show a higher NUE. Also, what is less well understood is how these genes and pathways are regulated, what makes a process more or less efficient given a set of environmental conditions for example. Interestingly, plants grown under low N conditions tend to have higher NUE compared to plants grown under high N conditions. Thus, understanding how the biochemical and physiological processes are regulated under low versus high N conditions may give us clues as to how we can improve N use in cereals.

The N response curve for yield is well-known (Figure 1). N addition increases the yield up to a level where further addition of N fertiliser results in no further yield gain. This has helped define the N optimum. The concept of economic N optimum (Figure 1), defined as the level of N necessary to produce grain while producing a profitable margin, was introduced also to capture the idea that solely improving NUE in crop varieties is not sufficient and that high yield must also be achieved. Nitrogen optima vary amongst varieties and sites. In practical terms, it is difficult to assess as yield must be measured under many levels of N. To tackle this issue, ADAS has now developed a protocol for opti-plots trials that enable the testing of many varieties under six N levels across a single plot within a single field (Figure 2). The reduced scale of these experiments enables commercial varieties as well as pre-breeding material, for which seeds are still scarce, to be tested.

Figure 1. Yield increase in response to increased N availability in varieties showing putative differential sensitivity to N availability. The N economic optimum is defined as the level of N necessary to produce grain and a profitable margin (i.e. N:grain price ratio of 5:1)

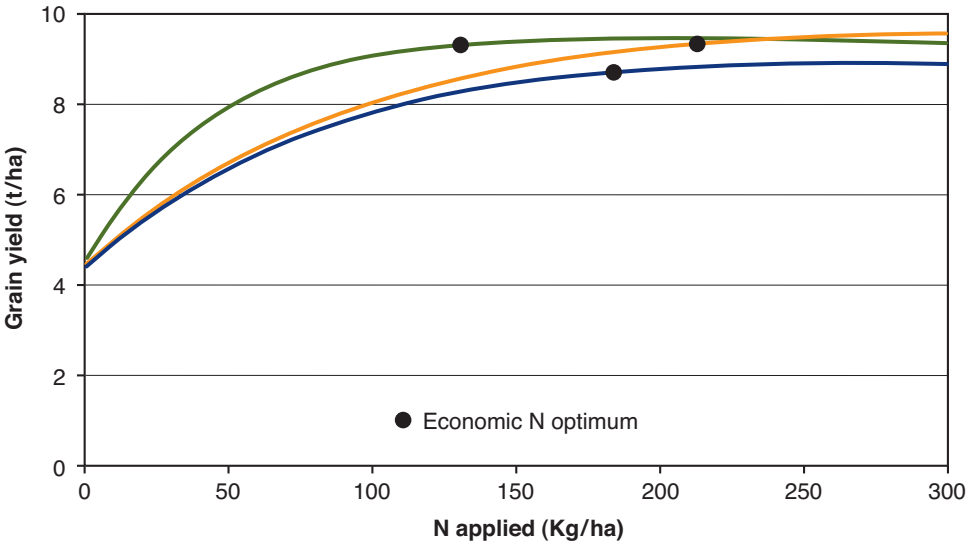

Figure 2. Aerial view of ADAS opti-plots

NIAB is involved in research projects aiming to reduce N demands of cereal varieties, for example CINTRIN (Cambridge-India Network for Translation research in Nitrogen). As part of the CINTRIN project in the UK, we are now developing experimental protocols to assess the N response of different wheat varieties, at even smaller scale since plants are pot-grown. The N response from many different varieties will be measured under controlled conditions, with the same varieties also grown in opti-plot field trials. Comparing the response between controlled conditions and field is an important step and a strength of our translational collaborative CINTRIN project. The aim is ultimately to have a reliable experimental system to study N response and identify varieties that are highly responsive to N or show high NUE, which may perform well in the field.

We are also characterising the physiology of wheat varieties grown under different N levels. Focusing on the post-anthesis period, we are measuring N remobilisation efficiency in the flag leaf during grain filling as well as measuring post-anthesis N uptake. High post-anthesis N uptake is thought to lead to higher GPC. Studying the response to increased N availability in different genetic backgrounds should also help us to understand the regulation of these processes and give further clues as to how these can be modified.

Thus, shifting our thinking from improving NUE to lowering N optimum while maintaining the yield is a useful approach in developing varieties with lower N requirement because the goal becomes better defined. To achieve a low N optimum, physiological and biochemical processes need to be efficient in plants grown under high as well as under low N conditions and using our experimental system we aim to find conditions that would allow us to identify interesting new varieties with lower N requirement. And as part of the CINTRIN project we collaborate closely with researchers in India, sharing our approach and findings, to achieve low N requirement for wheat varieties grown in India and additional crop such as sorghum and millet.

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Cabbage stem flea beetle survey – 2017

At the end of September NIAB TAG is re-issuing its crowd sourcing survey of damage by cabbage stem flea beetles (CSFB) to oilseed rape crops. By this time we hope that their impact on this year's plantings will be fully evident. The survey is proving a very useful resource and indicates the pest problem has been spreading, mainly to the north and west, since the original neonicotinoid seed treatment ban was introduced in autumn 2014.

The first survey, in autumn 2015 was quite clear in its findings that early sowings were advantageous in minimising the damage. More tenuous were the indications that well-worked seedbeds were useful in promoting good establishment and getting the crop away from beetle grazing. We observed greater crop losses with hybrids, probably due to the straightforward relationship with the typical lower seed rates of hybrids versus conventional varieties. In that season the Government allowed derogation for the limited use of neonicotinoid seed dressings in the worst affected counties but the survey suggested that this was largely ineffective because of the intensity of the flea beetle damage in those areas.

The very dry conditions in the south-east in autumn 2016 impacted severely crop establishment and the survey gave a more confused set of findings. It was clear that some growers, in a swathe of the country from Suffolk through into Hertfordshire, had made the decision to come out of oilseed rape cultivation for the time being. From reports from NIAB TAG's own trial locations at Croft, in north Yorkshire, and Callow, in Herefordshire, we have seen the potential for the CSFB problem to spread. The only positive to come out of the 2016/17 season was the early onset of cold weather which may have reduced the beetle population moving into the new sowings.

So, once again, we are asking you to participate in our survey, in the NIAB TAG Membership area of the niabnetwork.com website (under *Crowdsource* on the left-hand menu) or on the NIAB Network app on your smartphone.

I have simplified the questionnaire this year to make it quicker and easier for you to complete. Ideally we would like you to submit separate entries for individual fields, rather than whole farms. The exception is where you have gone out of rape growing; drop a pin into your farm location with an estimated number of hectares that you would normally have grown.

For those of you still growing oilseed rape, for each field we would like information on the area, sowing date, cultivation technique and whether the variety is hybrid or conventional. Then assess the level of CSFB damage on a 1-5 scale, where 1 = no damage and 5 = complete crop loss.

I would like to re-emphasise that we are just as interested in receiving returns from growers have gone out of the crop, or are having no problem with CSFB, as we are with those that are struggling to achieve establishment.

I hope that you will find participation interesting and informative. I personally find it really exciting to get to work and log onto the survey site, once it is up and running, to see how the new season's picture is evolving! Do join me!#.

Caption?