# Investigating the potential for allelic variation of key inflorescence development genes to increase yield potential in wheat

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**Objective**: The objective of this IWYP aligned project is to investigate the potential to use diverse alleles of inflorescence architecture genes to improve yield potential in wheat. This research will follow on from our recent discoveries of genetic loci and genes that regulate spikelet architecture in wheat, which has included identification of variant alleles for these genes that are present within modern breeding programs. As part of this aligned project, we will develop near isogenic lines for these alleles within elite germplasm, in combination with diverse alleles for the major flowering time genes of Ppd-1, Vrn-1 and FT1, which will be used in yield trials and to investigate the potential to use these alleles to optimize plant architecture traits.

Specifically, the genes/loci that we have identified include:

- TEOSINTE BRANCHED1 (TB-1), which is a TCP transcription factor that interacts at the protein level with the major flowering gene (FLOWERING LOCUS T) and regulates inflorescence architecture in a dosage dependent manner [Dixon et al. Plant Cell, 2018].
- A locus on chromosome 2DS that we predict regulates inflorescence architecture in a semi-dominant manner that is dependent on Ppd-1. We hypothesize that this locus modifies inflorescence architecture by altering meristem size, and that the effect of this locus on yield potential can be optimized using floral promoting alleles of Ppd-1 and FT1 (Dixon et al. unpublished data).

**Materials and methods**

**Plant material**

Analysis of the TB-1 alleles will include variant alleles of TB-1 on the B and D genomes, which have been termed TB-B1b and TB-D1b, with the reference WT alleles being termed TB-B1a and TB-D1a. Initial crosses are currently being performed between i) Baxter, which is an Australian cultivar that contains the TB-D1b allele, and elite CIMMYT germplasm including Reedling, Weebil, a WYCT line and Baj to introgress the variant allele into these backgrounds, and ii) Claire and Brompton, which are UK winter wheat lines that contain the TB-B1b allele and the same CIMMYT germplasm. These lines will be used to develop spring wheat NILs in each of the above-mentioned backgrounds that contain either the WT or variant alleles of TB-B1 and/or TB-D1. We are also performing crosses to develop similar material in winter wheat germplasm using KWS Santiago and KWS Zyatt, which are elite UK winter wheat cultivars. We aim to continue development of these NILs until BC3F3 or BC4F3 generations to be bulked in the field before analysis of BC3F4 and or BC4F4 generations. This is an objective that could be assisted by partnerships within this IWYP aligned project.

At the same time, germplasm is also being developed for the locus on chromosome 2D that promotes paired spikelet development. We are developing NILs that contain either the paired spikelet allele or the WT allele, in the background of Paragon NILs that contain different Ppd-1 alleles. These NILs either contain the WT Ppd-1 sensitive allele or the insensitive Ppd-D1a allele. We will continue to use marker assisted selection to develop BC3F3 and BC4F3 generation NILs, which will then be bulked up in the field to be used in this IWYP aligned project. For each of the loci, backcrossing will be performed using speed breeding conditions.

**Yield trial analysis**

Following development of the NILs, yield trials will be conducted that will include detailed phenological analysis of inflorescence development and investigation of key yield related traits, such as spikelet number, floret fertility,

duration of inflorescence development, tiller number, height and flowering time. These yield trials will be performed in the UK; however, a significant advantage of this IWYP aligned project would be to perform these yield trials at CIMMYT sites including Toluca and Obregon, and to interact with commercial partners to perform yield trials in northern Europe.

**Project plan**

**Development of NILs**

Development of the 2DS locus NILs will occur under speed breeding conditions. It is anticipated that the BC3F3 and BC4F3 lines could be generated within a year under these conditions, which will then be bulked up under either speed breeding or glasshouse conditions. For the TB-D1 NILs, we also anticipate that the BC3F3 and BC4F3 lines will be developed within a year. However, development of the TB-B1 NILs will require one or two rounds of vernalization that will include 8 weeks of cold treatment, and we therefore anticipate that the development of the TB-B1 NILs will be completed in approximately 16 months. Seed will then be bulked up under speed breeding or glasshouse conditions.

**Outcome**: Development of TB-B1 and TB-D1 NILs, and development of NILs for the 2D locus, in elite spring and winter wheat backgrounds. This objective will be completed by September/October 2019.

**Yield trials**

The yield trials will initially be performed at the Church Farm site of John Innes Centre, Norwich. Following production of sufficient seed, similar yield trials will be performed at the CIMMYT sites of Toluca and Obregon for the spring wheat germplasm. As part of this project, there will also be some coordination with an industry partner (e.g. KWS or Limagrain) to perform similar yield trials using both the spring and winter wheat germplasm.

As part of the yield trials at Church Farm, several key yield related traits that are influenced by TB-1 and the locus on Chromosome 2DS will be analyzed, including spikelet number, floret fertility, tiller number, duration of inflorescence development and height. Similar traits could be analyzed by CIMMYT staff as part of the CIMMYT-based field trials.

**Outcomes**:

1. Yield trial data demonstrating the effect of the TB-B1 and TB-D1 alleles on key yield related traits.
2. Yield trial data showing the effect of the 2DS locus on key related traits, which will include data about its genetic interaction with the key flowering time gene, Ppd-1. The aim is to complete this objective by December 2020.

**Deliverables**

- New germplasm to be used within breeding programs, which will be near to elite germplasm to facilitate rapid deployment into CIMMYT and commercial material.
- Publications and grant applications.
- Training of students.