Shaping Wheat for the Future: Leveraging the Wheat genome in Crop Efficiency Research and Breeding

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Bayer CropScience

Agenda

Why is Bayer investing in Wheat
Pillars of Bayer’s Wheat strategy
Examples from R&D
Bayer and the IWGSC
New era for the wheat genome

Wheat Yield Frontiers

Potential of Wheat Seed/Trait market

Why is Bayer investing in the Wheat Seeds & Traits market?

Bayer CropScience investing EUR 1.5 billion in new solutions in cereals from 2010 to 2020
Bayer’s Seeds and Traits strategy

- **Traits and technology**
  - Build competitive GM and non-GM trait platform via:
    - In-house expertise
    - Strategic partnerships

- **Germlasm and breeding**
  - Access global germplasm for synthesis into a regional breeding efforts
  - Working to bring enhanced yield and yield stability through hybrids

- **Enabling Technologies**
  - Build competitive enabling technologies to rapidly process candidate traits through pipeline

- **Unique technology offerings within Bayer CropScience**

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The hybrid wheat challenge...

- **Today’s “fine” varieties**
  - Self-pollinating
  - 100% seed recovery from area

- **Today’s hybrid system**
  - Strip planting:
    - Harvest tolerance: 60%–70% seed recovery
    - Chemical gametocide timing critical

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Crop Efficiency Research

- **Exploiting today’s potential**
  - Expanding the yield frontier
  - Exploiting today’s potential

- **Native**
- **GM**
- **Non-GM**

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Crop Efficiency Research Strategy:

- **Product concept**
- **Phenotypic trait**
- **Biological process**
- **Crop & Breeding Expertise**
- **Consistent**
- **Focused**
- **Stringent**

- **Tools to enable idea**
- **Idea to improve crop**

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So where does the wheat genome fit in???

Everywhere!!!
From map-based cloning to QTL Causal Gene mining

Original QTL region, few and highly fragmented sequence anchor points

Long and tedious process of map-based cloning for each locus of interest to arrive at small set of likely candidates

Computational overlay with other omics data allows extraction of candidate gene list for evaluation and for experimental validation

Map-based cloning process becomes cheaper and faster

Requires complete and well-annotated (reference) genome

Translational biology

- Translational biology
  - Is that gene available in my crop?
  - Does it have the same expression pattern?
  - Which is the functional/structural ortholog?
  - Has it been selected for in domestication or breeding?

- Annotation
  - What is the function of my “new” wheat gene?
  - Sequence assembly
    - How should I assemble these contigs? Are they part of the same gene or paralogous?

Orthology inference

- BlastPrcip, BLAST/OrthoMCL perform poorly when high redundancy
- Orthologous Matrix is a better alternative
- Collaboration to develop OMA for Bayer crops
  - Christophe Desimiz project lead
  - Henning Redestig Bayer lead
  - Natasha Glover Post-doc
  - Ivana Pilizota, Alex Warwick-Vesztroky PhD

Orthology inference

Requires complete and well-annotated (reference) genome

Translational genetics: circadian clock and wheat yield

Hypothesis: The circadian clock co-determines yield and yield associated traits in wheat

- PhD Student: Lukas Wittern
- Supervisors: Alex Webb (Cambridge), Andy Greenland (NIAB) & Matthew Hannah (Bayer)

Positioning clock gene orthologs on the draft wheat genome

- 2015: Arabidopsis gene -> wheat ortholog -> CSS contig -> SNP -> genetic map
- 2016: Arabidopsis gene -> wheat ortholog -> Draft genome assembly

Requires complete and well-annotated (reference) genome

Linking clock gene orthologs to phenotypic traits...

Multiple Quantitative Trait Analysis Using Bayesian Networks

An Eight-Parent Multiparent Advanced Generation Inter-Cross Population for Winter-Sown Wheat: Creation, Properties, and Validation

Page 16: Bayer @ PAG 2016

Page 17: Bayer @ PAG 2016
Bayer and IWGSC

November 2011
• Bayer joined IWGSC

December 2013
• Bayer-sponsored project (€ 1 mio)
  "Whole Genome Profiling BAC libraries and physical map construction 8 chromosome arms"

November 2015
• Bayer-sponsored project (€ 420K)
  "Whole Genome Profiling of BAC minimal tiling paths for 14 chromosomes"

Jointly with: CNRGV, INRA, KeyGene and Abraham Korel

A new era for the wheat genome!

• Whole wheat genomes can be delivered in large scaffolds within a few months at a fraction of the cost
• One reference genome is not enough to capture all larger-scale variation (SV, introgressions, ...)
• There will be multiple wheat genomes before the end of this year!
• Consistency and high-quality must be assured

Proposed future role of IWGSC in partnering with Industry & Academia

IWGSC can continue to serve the wheat community
• Provide core set high resolution, high-quality reference genomes
• Coordinate annotation and additional data layers on core reference genomes
• Nurture community, ensure quality and standards

Wheat community and Industry can leverage the information of public reference genomes in “private” and collaborative wheat genome projects

Wouldn’t it be great if the largest crop genome had the best platform?!

Bayer’s focus on Integrated Solutions

1. Weed Management Systems for grass & broad-leaved weeds
2. Disease management strategies to minimize loss, improve crop health and reduce disease control & post-harvest issues
3. Drought Tolerant genetics
Wheat Seed Investments since 2010

- 2010 Strategic decision to build global wheat seeds business
- 2015 Launch of first Bayer wheat varieties
- >2020 Hybrid seed varieties, locally adapted with higher yield potential