NUE EWG

7th October 2020

Virtual meetings

Agenda (request to record)

1. Welcome and round-table introductions
2. Reason for this meeting
3. Summary of key topic points
4. Inputs from participants – more welcome
5. Status of annual face-to-face meetings
6. Increasing membership of NUE EWG
7. Chairs of the NUE EWG – need for change!
8. **Scientific strategy - need to update?? Research topics and activities!**
9. Other activities
    1. Papers
    2. Current projects – a new survey?
    3. Collaborative projects
10. AOB

Topics for discussion within agenda

- Should we continue the EWG?
- Should we plan for a face to face meeting next year? If so place, time, topic? Would a virtual meeting be viable alternative?
- Should we link up with another EWG for a joint meeting, and address a specific theme e.g. with the Agronomy Group on low input systems?
- How should we attract new groups (especially increasing representation from Asia, Africa and the Americas)?
- What key (new?) scientific questions should we have for going forward?
- Are there any new developments or opportunities we should be aware of?
- Is it time to conduct a new survey of existing projects running within the EWG?

Other topics/points from participants

- Can we align a future meeting with Grains Research and Development Corporation (**GRDC), Australia**? Munir Zia
- Mexico could be given a 2nd chance after July, 2021. Munir Zia
- Suggested science areas: (1) Wheat **root systems traits and NUE** and (2) carbon and N relationships and interactions. Jairo Palta
- **Action Research for NUE**, https://www.yen.adas.co.uk/projects/yen-nutrition Roger Sylvester-Bradley
- Development of wheat varieties (and identification of cost-effective polymers) that could help farmers grow wheat under **deficit irrigation**. Munir Zia

Should we plan for a face to face meeting next year? If so place, time, topic? Would a virtual meeting be viable alternative? 2020 meeting planned for Mexico was cancelled.

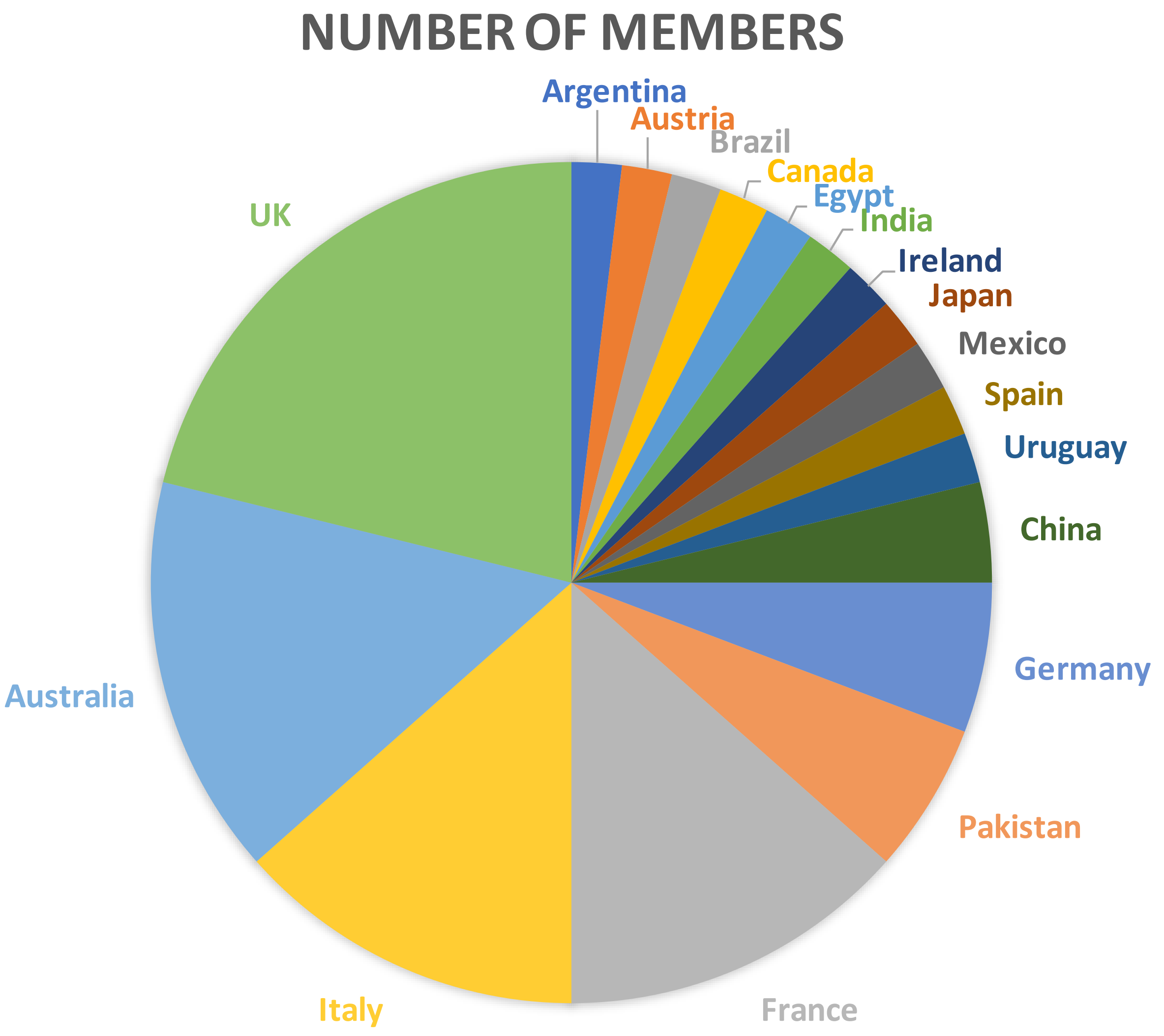
Topic	Meeting date	Location	# attendees
Definitions and measuring	18-19 June 2015	Rothamsted, Harpenden, UK	16
Strategic needs and priorities	9-11 Mar 2016	CIMMYT, Cuidad Obregon, Mexico	14
Priorities	16-19th May 2017	Rothamsted, Harpenden, UK	39
Modelling and phenotyping	26-27 Nov 2018	INRA, Clermont Ferrand, France	20
Other nutrients	17-19 Sept 2019	Uni. Bari, Bari, Italy	16
P proposal	4-5 Nov 2019	Arvalis, Beauce La Romaine, France	14

← Presentations online

How should we attract new groups (especially increasing representation from Asia, Africa and the Americas)?

Country	Number of members
Argentina	1
Austria	1
Brazil	1
Canada	1
Egypt	1
India	1
Ireland	1
Japan	1
Mexico	1
Spain	1
Uruguay	1
China	2
Germany	3
Pakistan	3
France	7
Italy	7
Australia	8
UK	11

52 members from 18 countries



Chairs

- Malcolm Hawkesford
- Jacques Le Gouis
- Ivan Ortiz-Monasterio

Strategy - activities

- Meetings: face to face and virtual (short and targeted)
- Joint projects
- Training workshops/masterclasses – virtual
- Membership drive – please all help
- New Chairs, vice chairs, election
- Work with WI to develop a research programme

Strategy - science opportunities

- 2015 SRA and 2017 Executive summary report
- Link to agronomy
- Low input systems
- Roots
- Genomics
- Life cycle
- **More suggestions please**

Short-term (1-5 years)	• Standardise definitions and phenotyping • Identify key traits and ideotypes
Medium-term (5-10 years)	• Identify natural variation for relevant traits • Quantify potential impacts in different environments and cropping systems • Identify favourable alleles for target genes • Develop molecular tools to breed cultivars which interact favourably with beneficial soil micro-organisms
Long-term (>10 years)	• Deploy germplasm with enhanced nutrient use efficiency • Develop wheats with high nutrient density in grain • Introduce the capacity to biologically fix atmospheric nitrogen

SRA (WI Strategic Research Agenda): NUE aims and objectives (from 2015)

- **Enhancing use efficiency for all the macro- and micro-nutrients that are important for optimal crop production**. Special focus should be given to nutrients that are either costly to produce and supplied in excess of plant requirements in some agro-ecosystems (e.g. N), derived from finite rock mineral resources (e.g. P), have negative environmental impacts if inappropriately used (e.g. N), and/or are essential elements of human and animal diets (e.g. Zn and Fe);
- **Combining cultivars adapted to optimal agricultural practices** (Subtopic 3.2) and optimising nutrient uptake by the roots, nutrient utilisation to produce biomass, and nutrient translocation to the grain to ensure quality;
- **Integration** of genetics, ecophysiology, rhizosphere microbiology, and symbiotic interactions to identify traits and chromosomal regions relevant for nutrient use efficiency improvement;
- Take into account **global change impacts** on nutrient use for production and quality.

SRA NUE research needs (from 2015)

- Improving the capacity to **phenotype** nutrient use efficiency in a **standardised** way in terms of definitions and practical aspects, such as controlling the environment to create defined nutrient availability and measurement technologies to evaluate the responses of the plant/crop at different physiological levels;
- Develop **pre-breeding programmes** to facilitate the use of genetic resources (e.g. landraces, synthetics, and wild relatives) for traits that will enhance nutrient use efficiency. This may include further research regarding increasing leaf/canopy photosynthesis per unit of N using the existing genetic variability;
- Favour beneficial **interactions with soil microorganisms** and enhance the capability to capture N and other nutrients (e.g. root architecture, mycorrhizal/diazotroph associations, chemical and biological nitrification inhibitors, and root exudation of organic acids);
- **Identify loci and alleles involved in enhanced nutrient use efficiency**. This approach may be combined with the development of crop simulation **modelling** and sensitivity analysis for nutrient use efficiency traits, as well as the identification of chromosomal regions associated with model parameters.

As of 2015

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September 2017

Executive summary report of the Wheat Initiative Nutrient Use Efficiency (NUE) Expert Working Group on the case for coordinating research on genetic improvement of nutrient use efficiency in wheat

(available on request or on website)

1. Nutrient, especially N uptake

- Capture of applied N fertilizer and efficient extraction of soil N underpins NUE, has considerable economic value and will minimize N-pollution issues (improving on the 30% capture calculated by Raun and Johnson, 1999). Key areas revolve around root characteristics.
- Innovative phenotyping platforms
- Root system architecture (root angles, root depth)
- Root microbe interactions (Plant Growth Promoting Rhizobacteria)
- Root exudates (Biological Nitrification Inhibitors)
- Transporter genes
- N storage capacity (stem, leaves)
- Post-flowering N absorption
- Use of genetics (diversity, meta-QTL) / physiology / modeling

2. Nutrient utilization, partitioning and remobilization

- Nitrogen taken up is used for canopy production and hence photosynthesis, the main driver of yield. Efficiency drivers in this area involve canopy architecture, N-partition, senescence and remobilization.
- G x E x M interactions
- Developmental and phenological impacts on NUE
- Carbon x nitrogen interactions - Grain Protein Deviation
- N remobilization
- C-N vertical distribution
- Senescence (early senescence / stay green)
- N losses (roots, leaves)
- Use of genetics (meta-QTL) / physiology (C x N metabolism interactions) / modeling

3. Nutrient interactions

- Efficiency of any nutrient uptake and utilization depends upon adequate availability and balance of other nutrients. An integrated approach is required rather than the usually focus on single nutrients. This would require appropriate coordination of teams with contrasting expertise and pooling of resources. Examples are:
- Importance of K for nitrogen NUE
- importance of Mg for nitrogen NUE
- Micronutrient interactions with macronutrient availability
  - Impacts on Zn and Fe accumulation
  - Sulphur and Se interactions

4. Phosphorus uptake

- Rock phosphate reserves are a finite recourse and efficient use of current resources alongside recycling schemes is essential. P is easily immobilized in the soil and plant non-available. Mechanisms to improve PUE will include root structural features and plant mechanisms to enhance P-availability.
- P precipitation in high pH soils (xx% of wheat cultivation area)
- P fixation in low pH soils
- Target 1 high total P but low available P (India, Pakistan, North-Africa)
- Target 2 high available P (Europe / China)
- Identify genotypes that can access this P
  - Root system architecture (RLD)
  - Root microbe interactions (Pseudomonas, Bacillus,): P solubilizing microbes
  - Root exudates (change the pH, phosphatase)
  - Transporter genes
- Use of genetics / physiology / modeling / high throughput phenotyping

NUE priorities and gaps

Environment and Agronomy

- 01. Focus on low input systems, comparisons with high input
- 03. Defining different geographic areas, farming scenarios
- 10. Unravelling G x E x M
- 11. Alternative fertilizers (agronomy?)
- 16. Climate change and nutrition
- 17. Environmental impacts
- 19. Ideotypes for different environments
- 21. Recycling in cropping systems
- 34. Timing, rate, placement and source (x G)

- **Abiotic interactions**
- 07. N, P, K, S and micronutrients (Mg, Zn and Fe) interactions/ cross talk
- 24. Interaction with other abiotic stresses, particularly drought
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- **Biotic interactions**
- 06. Biological Nitrification Inhibition (BNI)
- 14. Microbe interactions – wheat mycorrhiza
- 23. Pathogen interactions
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- **Phenotyping**
- 05. Common protocols/ontologies/NUE definitions
- 12. High throughput systems for advanced analysis (metabolite, transcriptome, phenotyping etc) physic-chemical and traits
- 25. Low cost approaches for phenotyping
- 26. High throughput screens, smart screens, lab to field translatable

- **Approaches**
- 04. Meta-analyses of genetic studies
- 13. Network analysis for wheat and nutrient responses for gene discovery
- 15. Modelling
- 27. GM approaches, novel gene manipulation
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- **Diversity**
- 02. Screening of landraces and wild relatives
- 20.Feed v bread wheats v durum wheats
- 36. Other NUE cereals e.g. rye and Zn and triticale
- 37. Synthetics hexaploid wheat
- 38. Hybrids and NUE, different phenology, take up more N?
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- **Relation to quality**
- 08. Yield protein negative correlation – coordinated effort
- 22. Is protein quality impacted by nutrition (all nutrients)

- **Traits of interest**
- 09. Biomass, HI and nutrient (micronutrient) accumulation and partitioning
- 18. ROOTS – phenotyping, internal structure, architecture, wide diversity, modelling,
- 28. Partitioning, remobilization,
- 29. Reserve N, use during senescence
- 30. Stem architecture – stem reserves
- 31. Canopy structure, N-stores
- 32. Stay green and N accumulation in grain
- 33. Phenology, N supply and efficiency
- 35. Root responsiveness to N and other nutrients
- 39. Post flowering mineral nutrient uptake
- 40. Plant N-losses late in cycle
- 41. Sink or source
- 42. Why non-linear responses? Photosynthesis

EWG action plan guidelines

Include actions and tasks leading to the delivery of an Implementation Plan for the SRA core-theme(s)/ topics covered by the EWG, such as:

- *A map of current research programmes at national and international level in the EWG research area*
- *A gap analysis identifying additional activities that should be carried out (if any)*
- *Top research priorities in the EWG area*
- *Priority actions to implement the SRA*
- *Collaborative mechanisms and processes to engage with national and international programmes and include new activities as they arise*
- *Research areas that would benefit from the set up of international research programmes*
- *Research areas where setting up large international research programmes would have an added value to complement the coordination and alignment of national programmes*
- *Suggested mechanisms for funding international programmes*
- *Education and training objectives and the means to address them*
- *The identification of research topics or areas missing from the SRA to update the SRA on a regular basis.*

Action plan guidelines 2

In addition, EWGs are expected to deliver in a defined and timely manner outputs contributing to the implementation of the SRA such as:

- *Shared standards for data and methods*
- *Position/scientific papers*
- *Creation of researchers' networks on dedicated topics*
- *Establishment of links with other EWGs or networks*
- *Organisation of scientific and training workshops*
- *Collaborative projects and their outcomes*
- *Funding elicited at national or international level independently from the Wheat Initiative*
- *Outreach and dissemination*
- *Etc.*