



SUMMARY OF THE ANSWERS TO THE CONSULTATION ON THE WHEAT INITIATIVE DRAFT STRATEGIC RESEARCH AGENDA (SRA)

- July 2015 -

The questionnaire targeted organisational stakeholders interested in the development of wheat research, such as public and private research organisations, funding bodies, extension services, farmers' organisations and industry.

AIM OF THE CONSULTATION

The Consultation aimed to evaluate the Wheat Initiative's analysis of the key issues to be addressed and identify potential gaps in the draft Strategic Research Agenda. It provided wheat stakeholders the opportunity to contribute to the definition of the research priorities that would be best tackled through international coordination and collaboration, including public and private partnership.

PERIOD OF CONSULTATION

The survey was open from January 20 until April 30, 2015.

THE SURVEY

Only contributions from organisations were taken into account.

Only one contribution per organisation was considered – it was assumed that internal consultations took place before finalising the answer to the survey.

The consultation was organised in 16 different sections:

- Sections 1 to 5 corresponded to general questions about the SRA,
- Sections 6 to 16 of the questionnaire corresponded to the different themes and subtopics of the SRA.

Only section 1 of the questionnaire (contact details) was mandatory.

The survey contained yes-no-other box-ticking questions, with the possibility to add comments. Respondents were welcome to answer one or more of the questionnaire's sections.

Overall, the response to the survey was very supportive. However, suggestions for improvement or requests for clarification were made by some respondents. When originating from several respondents or considered particularly relevant, they were incorporated into the final version of the SRA by a task-force comprising representatives from the Scientific Board, the Research Committee and the Institutions' Coordination Committee of the Wheat Initiative.

This document provides a summary of all answers and comments received.

GENERAL INFORMATION ABOUT THE RESPONDENTS AND GLOBAL APPRECIATION OF THE SRA

1. Information about the respondents

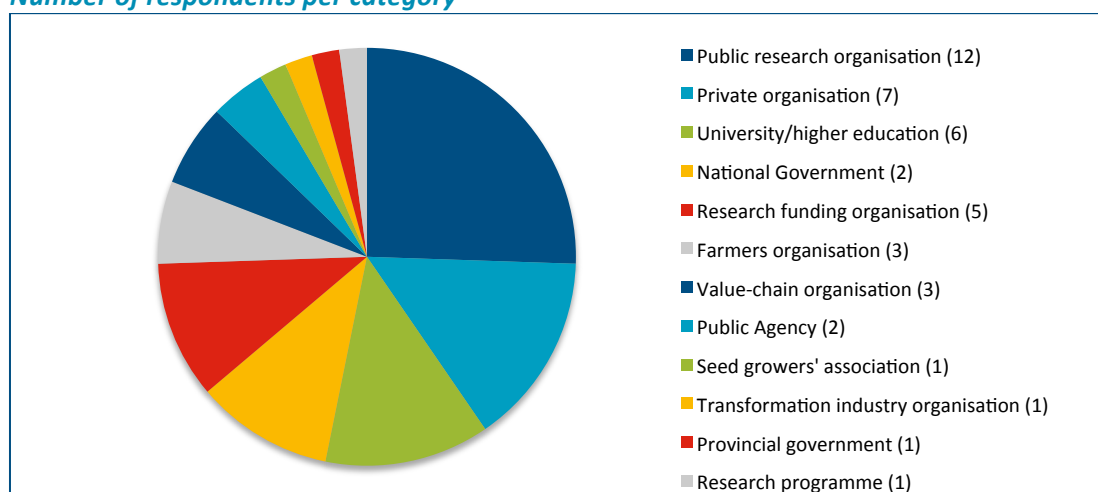
A total number of **47 organisations from 13 countries answered the web-survey** about the Wheat Initiative SRA, among which 28 could be considered as public (research or funding organisations, universities, governments, public agencies) and 14 as private (private breeding companies, organisations of farmers, value-chain, seed growers, transformation industry).

Number of answers per country and by category

Country/category	#	Organisations
Argentina	2	
Public research organisation	2	INTA, CONICET
Bangladesh	1	
University/higher education	1	Bangladesh Agricultural University
Canada	13	
Farmers organisation	3	Grain Farmers of Ontario, Manitoba Wheat and Barley Growers Association, Saskatchewan Wheat Development Commission, Atlantic Grains Council
Public research organisation	1	National Research Council Canada, Canadian Grain Commission, Agriculture & Agri-Food Canada, Manitoba Agriculture, Food and Rural Development
Research funding organisation	2	Alberta Crop Industry Development Fund Ltd (ACIDF), Saskatchewan Ministry of Agriculture-Agriculture Development Fund
Seed growers' association	1	Canadian Seed Growers' Association
University/higher education	1	University of Saskatchewan
Value-chain organisation	1	Cereals Canada
France	8	
Private organisation (<250 employees)	2	Florimond Desprez Veuve et Fils, Saaten Union Recherche SAS
Private organisation (> 250 employees)	2	RAGT, Limagrain
Public Agency	1	FranceAgriMer
Public research organisation	1	INRA
Transformation industry organisation	1	Association nationale de la meunerie française
Value-chain organisation	1	Intercéréales
Germany	1	
Private organisation (<250 employees)	1	proWeizen
Hungary	1	
Public research organisation	1	Cereal Research Non-profit Ltd.
India	5	
Public research organisation	3	ICAR, Indian Agricultural Research Institute - Regional Station, ICAR-Vivekananda Institute for Hill Agriculture
University/higher education	2	University of Agricultural Sciences, Dharwad, C.S.Azad Univ. of Agric. & Tech., Kanpur
Italy	2	
National Government	1	Mipaaf
Public research organisation	1	Consiglio per la Ricerca in Agricoltura e l'analisi dell'economia agraria (CRA)
Switzerland	1	
Private organisation (> 250 employees)	1	Syngenta

Turkey	1	
National government	1	Field Crops Central. Res. Ins
UK	10	
National Government	2	DEFRA, Scottish Government
Private organisation (> 250 employees)	1	KWS
Public research organisation	1	Rothamsted Research
Research funding organisation	3	AHDB, BBSRC
Research programme	1	John Innes Centre
University/higher education	2	University of Nottingham, University of Bristol
Uruguay	1	
Public research organisation	1	INIA- National Agricultural Research Institute
USA	1	
National Government	1	USDA-ARS
Total	47	

Number of respondents per category



2. Endorsement and implementation of the Wheat Initiative SRA

The Wheat Initiative SRA received global broad endorsement from the stakeholders answering the survey. Among the 47 respondents, 38 endorsed it, 7 wished the SRA would be modified according to the suggestions they provided in answer to the survey, and 1 did not wish to endorse it before meeting and discussing with the Wheat Initiative.

Respondents to the survey envisaged to support the implementation of the SRA by:

- Aligning their strategic plans and research priorities on the SRA
- Supporting/contributing to research projects and programmes aligned with the priorities of the SRA
- Encouraging /engaging active research collaborations
- Encouraging /participating in knowledge and resources exchange
- Participating in the Wheat Initiative Committees and contributing expertise to the Expert Working Groups
- Communicating to farmers.

It was suggested, however, that restricting the priorities to 3-4 major ones of global importance may help make better use of available resources.

3. Game-changers identified in the SRA

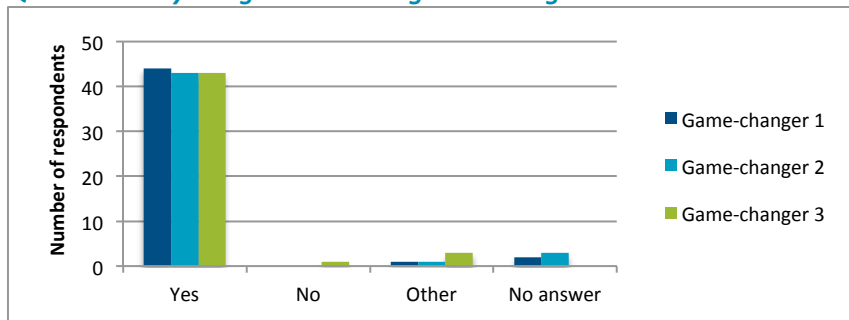
The game changers identified in the SRA are:

1. A fully assembled and aligned wheat genome sequence,
2. The availability of all wheat scientific data via a global information system dedicated to wheat,
3. The ability to build new combinations of alleles by increased deployment of natural and engineered genetic variability.

For each identified game-changer, the survey invited to indicate agreement, disagreement, and/or to provide comments.

The respondents to the survey broadly supported the game-changers identified in the SRA, with a vast majority of respondents agreeing with them.

Question: Do you agree with the game-changers?



Summary of comments

Some respondents commented that game-changer 1 (a reference wheat genome sequence) could be broadened to cover aspects related to post-genomics, including diversity, population genetics, regulation and epigenetics.

Sharing data and information freely was considered of utmost importance and several respondents noted that intellectual property (IP) should not be a hindrance to the flow of information between all parties.

Some respondents recognised that societal acceptance of engineered variability was a hurdle and it was noted that exploiting untapped natural variation in cereals should be the primary goal for breeders.

Additional game-changers

Additional game-changers were suggested by 13/47 respondents, including: enhancing the photosynthetic efficiency in wheat, engineering wheat to fix Nitrogen, standard phenotyping terminology and technologies, hybrid wheat, integrated phenotyping and genotyping databases, accurate measurement of yield and other traits in field plots, developing and using new techniques to evaluate field scale performance, development of TILLING populations for wheat, additional tolerance to abiotic and biotic stress, knowledge about wheat health benefits, de novo sequencing of wheat lines, improved agronomic practises, selecting of a wheat/soil microbiome combinations to support healthy soil and sustainable production, free exchange of germplasm, introduction of genes from wild relatives in adapted background, development of an international communication strategy to promote and educate on engineering genetic variability.

Some of these suggestions were already covered as research objectives in specific sections of the SRA or added to them rather than to the outstanding game-changers, since they were not supported by the majority of respondents.

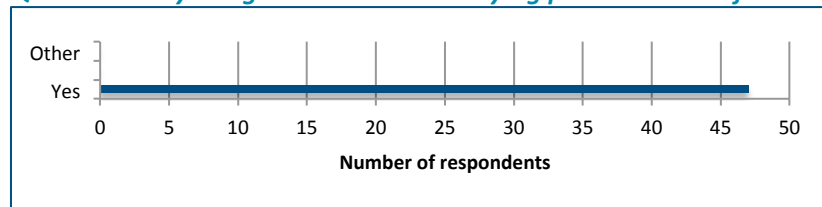
4. Underlying key priorities

Underlying key priorities identified in the SRA are:

- Maintain a continued support for existing activities aimed at yield improvement through conventional breeding methods;
- Understanding the genetic, molecular and physiological basis as well as the identification of the gene networks involved in the expression of traits of agronomic and nutritional importance;
- Integration of genetics and agronomy to develop sustainable growing systems;
- Partnerships between private and public organisations with broad sharing of knowledge and germplasm;
- Deployment of new breeding technologies and improved crop management to increase wheat yield potential and close the on-farm yield gap in different wheat growing areas, while minimising the impact of agriculture on the environment and addressing global change challenges.

All respondents agreed with the underlying priorities.

Question: Do you agree with the underlying priorities identified in the SRA?



Summary of comments

Several respondents commented that agronomic, technological and nutritional quality traits should be targeted. It was suggested that priority should be given to the simultaneous increase of yield and nutritional quality.

It was also noted that understanding the interactions between the genetic networks and the environment was important to predict phenotypes.

Additional underlying key priorities

Only 10 of the respondents suggested additional underlying priorities, including: technology opportunities afforded by precision agriculture, integration of technological quality and nutritional/food quality traits to develop a sustainable food chain from the field to the consumer, interaction between genotype and environment, environmental sustainability factors, a global economic analysis of wheat markets and the factors that influence them, training of new breeders with agronomic experience, a background in molecular genetics and a desire to work in the field.

The importance of farmers and consumers for adoption of innovations was emphasized, as well as that of capacity building in agricultural research.

5. General comments on the draft Wheat Initiative Strategic Research Agenda

Several respondents considered the draft SRA well written and covering all scientific aspects ahead of wheat research and breeding in the near future and that the challenge will be to engage and coordinate the wheat community as a whole to implement it.

It was noted that integration of scientific groups with different expertise and from various organisations would be key to the success of its implementation. The role of Experts Working Groups

in providing ways to achieve the objectives was mentioned, provided they are truly representatives of the research community.

It was suggested that the Wheat Initiative should create a framework for establishing public–private collaborations, with clear and overarching regulations regarding technology transfer and intellectual property, to enhance knowledge transfer from the public to the private sector and enable innovations.

It was noted that regulatory issues were missing from the draft SRA and that it would be necessary to avoid unnecessary regulations for the latest plant breeding methods as they will severely hamper the utilisation of these innovations by plant breeders.

A few respondents were concerned about how the Wheat Initiative SRA will be used globally by funders, considering that too many priorities were identified. *A new section was added to the SRA to describe the mechanisms that the Wheat Initiative will be using in the future to implement the SRA.*

In addition to these general comments, a few respondents stressed out the importance of specific topics, and in particular: Genotype*Environment*Management interactions, systems approaches and interrelations of wheat with companion plants, weeds, insects, pathogens, microbiota and other biotic and abiotic components of agro-ecosystems, precision agriculture, and access to plant genetic resources.

CORE THEMES AND CROSS-CUTTING THEMES

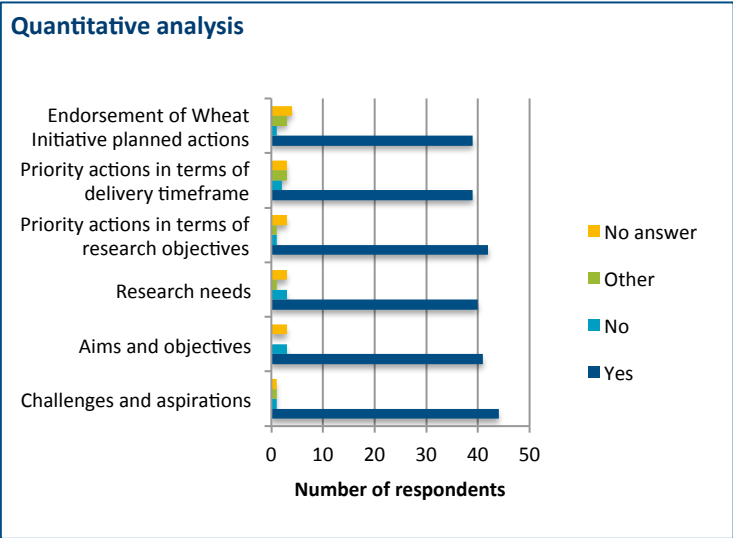
For each theme, respondents were invited to indicate whether they agreed with the challenges and aspirations, aims and objectives, research needs and priority actions, as well as whether they endorsed the Wheat Initiative planned actions. They were also given the opportunity to comment all sections.

Questions asked for each theme:

- *Are the challenges and aspirations addressed adequately?*
- *Are the aims and objectives well defined?*
- *Are the research needs appropriately covered?*
- *Do you agree with the priority actions in terms of research objectives?*
- *Do you agree with the priority actions in terms of delivery timeframe?*
- *Do you endorse the Wheat Initiative planned actions?*

A quantitative analysis to these answers as well a summary of the respondents’ comments is provided for each theme.

6. Core theme 1: Increase wheat yield potential



Overall, the respondents supported this core theme, although there were some comments about the target and timeframe, some respondents considering them insufficient in terms of ambition, whereas others considered them to be overly ambitious.

It was suggested to clarify that the need for an increase of the yield potential varies according to the production areas, current yield, type of wheat, etc., and that the strategic objectives should be developed according to the diversity of

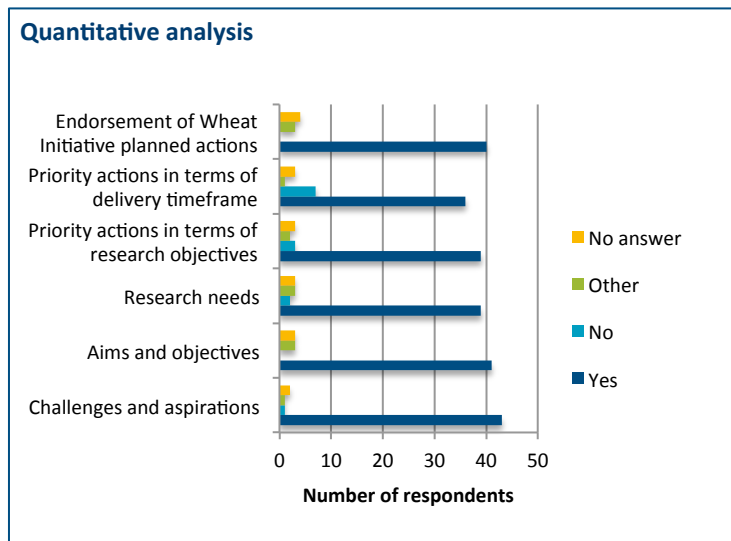
agriculture practices and climate. In particular, it was mentioned that hybrid wheat would only be a game-changer in high yielding environments.

Several respondents mentioned that other traits should be improved together with wheat yield potential. A specific concern was expressed about the risk of diluting grain quality if yield potential increase was treated independently.

Several comments emphasised the importance of agronomy and environmental conditions for yield and closing the yield gap. *Whereas agronomy is of primary importance for sustainable yield improvement, this section is dedicated to yield potential: in order to prevent any misunderstanding, a definition of yield potential was added to the introduction.*

7. Core Theme 2: Protect yield potential

Subtopic 2.1 - Controlling wheat diseases and pests



The respondents were broadly supportive of this subtopic of the draft SRA.

Special emphasis was given to the importance of stewardship and management of resistance genes at different geographical scales, together with a multiple strategy approach involving cropping systems and chemicals.

It was suggested to mention in the SRA the role of the wheat microbiome in the transfer of and resistance to microbial pathogens and viruses.

It was also suggested that the organisation of a database including information about the standard resistant/susceptible varieties and differential hosts would help to identify novel resistance sources.

The analysis of pathogens virulence was identified as an important research aim.

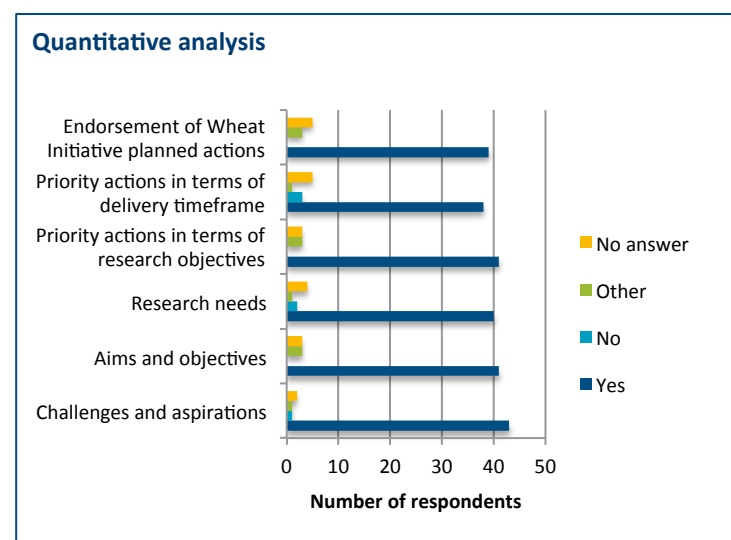
The importance of regional approaches was emphasised to answer specific diseases.

The importance of pre-breeding and breeding schemes to rapidly deliver wheat resistant varieties with increased yield potential was also mentioned.

Finally, some respondents suggested that weed control should be included in this core theme subtopic. *However, it was considered that weed control would better fit in the 'Agronomy and crop management section'.*

8. Core Theme 2: Protect yield potential

Subtopic 2.2 - Improving tolerance of wheat to abiotic stress



Overall, the respondents supported this subtopic of the draft SRA.

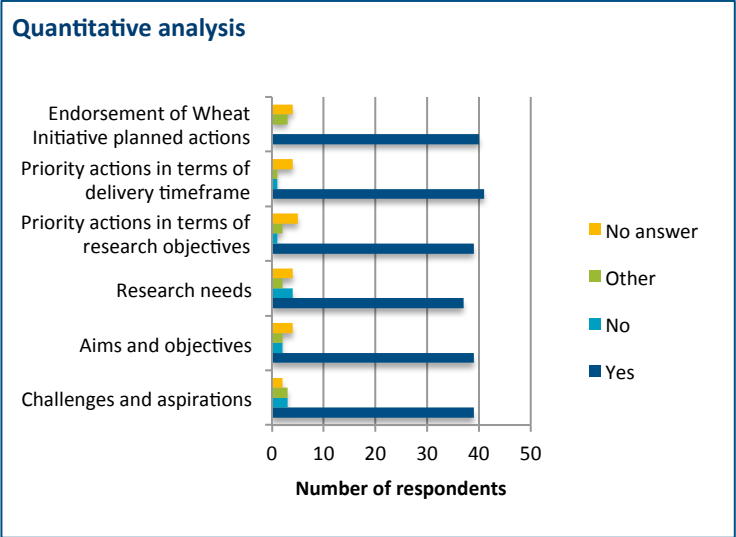
It was suggested to work on wheat resilience to increase its tolerance to various stresses during the growing season. The importance of field phenotyping in various conditions and environments was emphasized to cover G*E interactions, as well as the use of modelling. The development of a network of well-characterised sites for germplasm evaluation was suggested as an action for the Wheat Initiative to coordinate.

In addition, it was mentioned that farm management practises and agronomy could mitigate some impacts of abiotic stresses.

It was also recommended to include in this section the impact of abiotic stress on grain quality, considering that the stability of the chemical content of the grain under stresses is also an important goal for breeders.

9. Core theme 3: Protect the environment and increase the sustainability of wheat production systems

Subtopic 3.1 - Nutrient use efficiency (NUE)



While the respondents were broadly supportive of this sub-topic, a number of comments / recommendations were made.

The broad aspiration of increasing the use by the crop to 60% of applied fertilisers was questioned by some respondents. The need to address the nutrient delivery issue was also mentioned.

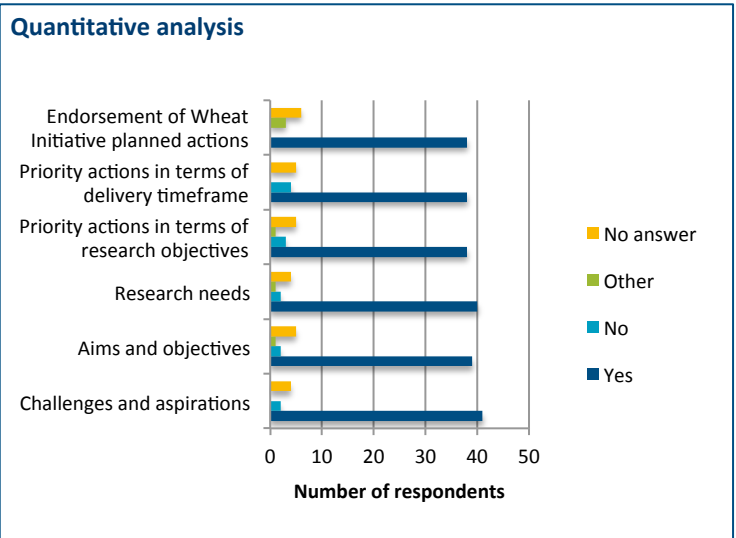
The soil microbiome for advancement in NUE was considered critical. Some respondents suggested the ability of wheat to fix its own nitrogen as a game-changer.

Several respondents commented on the need for a holistic approach, including the environment and agricultural systems, to achieving NUE.

It was recommended to give a higher priority to improving the nutrient efficiency of micronutrients and developing quality wheat coupled with grain yield under changing climatic conditions.

10. Core theme 3: Protect the environment and increase the sustainability of wheat production systems

Subtopic 3.2 - Agronomy and crop management



Overall, agronomy was considered to be crucial to close the yield gap and to the sustainability of wheat production systems.

One respondent commented that some agronomic fundamentals were missing such as nutrient placement and foliar feeding models which are not yet predictable. It was also recommended to give more emphasis to integrated nutrient management.

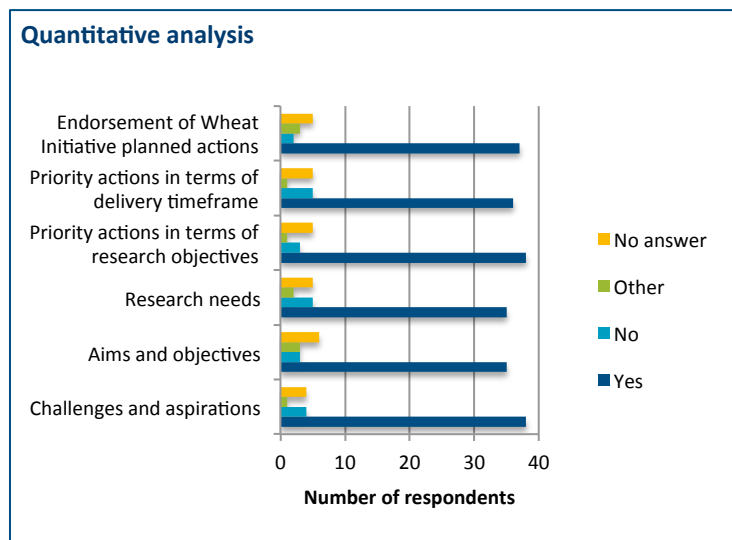
It was suggested that precision farming and remote sensing should be considered as priority actions requiring development of

applications as the industry develops the tools.

One respondent suggested that integrated crop management around chemistry and genetics would deliver tangible outcomes in the short term.

A number of comments were received relating to issues such as skills, innovation and knowledge transfer. The need to develop a new generation and continuous pipelines of agronomy experts was expressed. It was also mentioned that supporting robust and independent testing of novel genetics, chemistry, equipment and machinery would decrease the risk of farmer decision-making and increase nutrient uptake.

11. Core theme 4: Ensuring the supply of high quality, safe wheat



Several respondents thought that too much emphasis was given to allergens compared with nutritional quality and health benefits. It was noted that less than 0.5% of the population was allergic to wheat. On the other hand, some respondents suggested that more emphasis should be given to reducing mycotoxins.

It was also mentioned that it would be important to understand the impact of wheat 1st and 2nd transformation on its health potential and develop less drastic processing methods, considering that nutrient

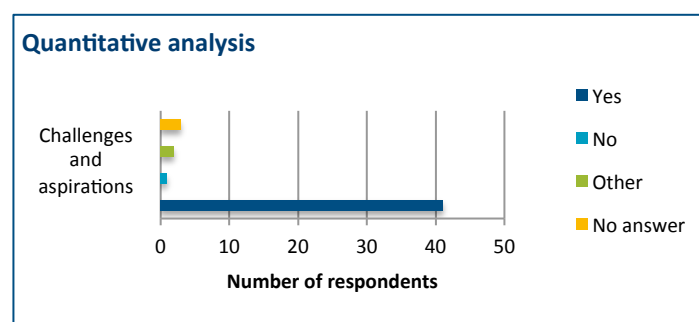
densities could be levelled by processing and refinery.

It was suggested to mention the dilution of protein content arising from yield enhancement. A better understanding of the functionalities of all proteins would allow the enrichment of the grain in important protein components and the reduction of disposable components while maintaining the end-use properties and allowing improvement of nitrogen use efficiency.

It was also noted that of Genotype x Environment x Management interactions should be taken into account.

The importance of regulations on the commercialisation of varieties with improved quality but maybe lower yield was emphasised.

12. Cross-cutting theme 5: Enabling technologies and shared resources

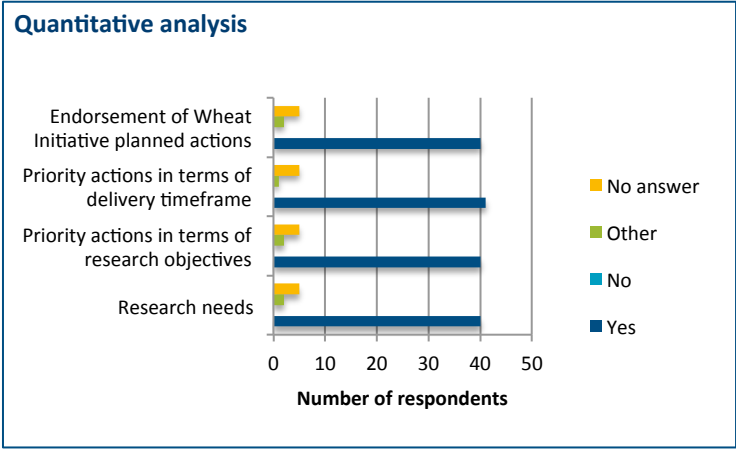


The respondents broadly endorsed the challenges and aspirations of this cross-cutting theme and only very few comments were made, mostly regarding its subtopics. It was highlighted that this section was essential to enable other themes to be delivered.

Some responses suggested however that too much emphasis had been placed on the completed genome sequence and informatics in this section, and that it should be more forward-thinking.

Only one respondent did not agree with the aspirations as stated, considering that the aspiration should be to have all resources and capabilities available to all, including public sector researchers, large companies and small companies to facilitate co-operation and increase progress.

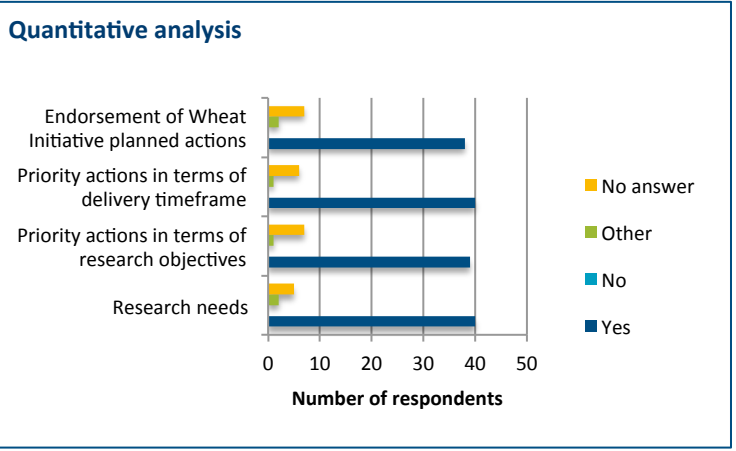
13. Cross-cutting theme 5: Enabling technologies and shared resources
Subtopic 5.1 - Enabling technologies and methods



Only a few comments were made by the respondents, in particular to emphasize the importance of accelerating the development of new breeding tools, such as genetic editing, genetic suppressors, modulation of genetic recombination, and enzyme modifications.

The need to identify post-genomics challenges was raised by one respondent, including: diversity, population genetics, regulation and epigenetics.

14. Cross-cutting theme 5: Enabling technologies and shared resources
Subtopic 5.2 - Shared platforms and technologies



The issue of how the Wheat Initiative will support access to genomic tools throughout the community according to their needs was raised. It was suggested that the Wheat Initiative could coordinate a shared sequencing and bioinformatics effort in Genotyping by Sequencing for wheat, accessible to both public and private sectors, or organise shared purchasing arrangements to reduce the cost of genotyping arrays.

In addition to the resources and tools mentioned in this section, it was also suggested to share information on agronomic methods and technologies.

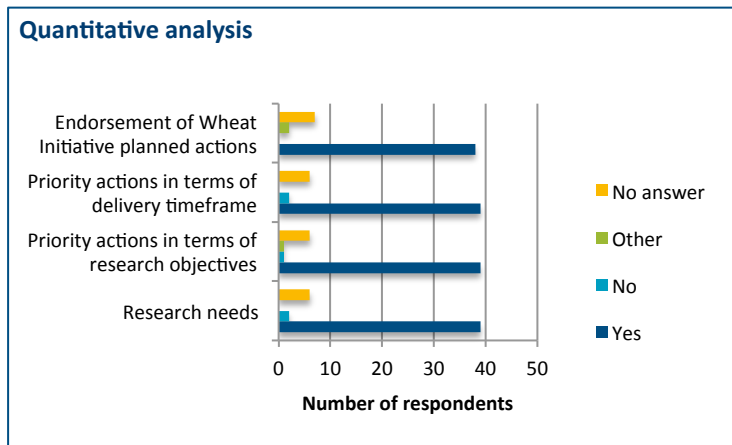
A specific concern was raised relating to the implication of generating centralised facilities as opposed to coordination of a number of complementary ones.

Standardisation of phenotyping and genotyping methods within a 1-5 years timeframe was considered unrealistic by one respondent.

It was also noted that this section failed to address Intellectual Property issues.

15. Cross-cutting theme 5: Enabling technologies and shared resources

Subtopic 5.3 - Genetic Resources



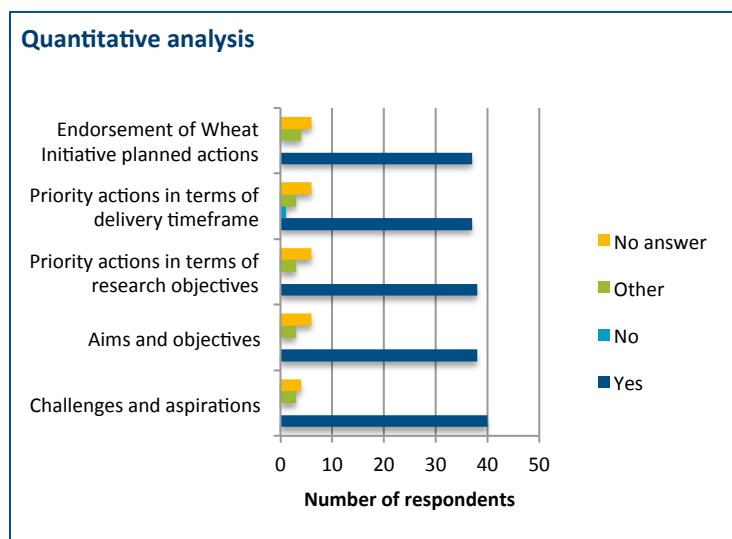
Respondents were broadly supportive of this subtopic, essential for wheat breeding.

It was noted that in-situ conservation in the centres of origin of wheat was important to maintain diversity and provide access to new combinations of genes and alleles.

Prediction of the usefulness of genetic resources for hybrid approaches was considered a research need.

It was also suggested to do more research on novel methods to identify beneficial traits in diverse germplasm and to introduce them into elite material while avoiding linkage drag of deleterious traits.

16. Cross-cutting theme 6: Knowledge exchange and education



Overall, the respondents were supportive of this section and reinforced the need for attracting biology undergraduates to wheat research, continued training of the scientific community, as well as for exchanges. In particular, it was suggested that opportunities should be developed for public sector staff to spend time in private companies.

Education of farmers, end-users and policy-makers was also mentioned as being an important target.

It was suggested that the Wheat Initiative coordinate funds to develop

a Human Resources Exchange Program that could include advanced training of wheat researchers from developing nations in global centres of excellence.