2014 Large-Scale Applied Research Project Competition: Feeding the Future

Created: 05/06/2015
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Full Application Reviewer Form

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GENERAL INSTRUCTIONS

Please refer to the *Request for Applications: 2014 Large-Scale Applied Research Project Competition* and the *Guidelines for Funding Research Projects*. In addition, please consult the *Instructions for the Full Application Review Committee* (details of the evaluation criteria are provided in Appendix A of this latter document).

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* ELEMENTS WHICH YOU ARE UNABLE TO REVIEW *

Please review all sections of the Full Application (Scientific, Social and/or Economic Benefits, Management and Financial) to the best of your ability. If you have specialized expertise and are not comfortable commenting on a particular area (e.g., social and/or economic benefits reviewers may not be comfortable commenting on the research proposal) please enter N/A (not applicable) in the text box for the criteria that you are not reviewing.

ELIGIBILITY

Provide your assessment of the eligibility of the proposal. Does/Is the proposal:

- respond to the objectives of the Genome Canada competition;
- include genomic approaches as essential components in terms of importance to the overall outcomes of the project; *
- address challenges and opportunities related to global food safety, security and sustainable production;
- of a scale and scope such that it is able to address challenges requiring a genomics approach; and
- internationally competitive and has potential to have a major impact

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This project addresses sunflower breeding with respect to abiotic stresses and utilizes genomics approaches to identify loci and genes of interest. It will generate germplasm, an integrated phenotype and genomic data resource and crop yield models. I would say it leans more towards a basic science project than most in this competition as, while there is a clear path to future application, realization is not the main focus for the project duration.

A. RESEARCH PROPOSAL, INCLUDING RESEARCH ON THE ETHICAL, ENVIRONMENTAL, ECONOMIC, LEGAL AND SOCIAL ASPECTS OF GENOMICS (GE3LS)

Provide your assessment of the strengths and w eaknesses of the research proposal, including research on the ethical, environmental, economic, legal and social aspects of genomics (GE3LS), taking into consideration the review criteria w hich has been summarized as follow s:

- Research context and originality
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- Research support - access to facilities, equipment and services
- GE3LS research - alignment, integration, potential for know ledge advancement

This project has assembled an excellent team and outstanding facilities for field studies in sunflower with respect to several abiotic stresses. The phenotyping includes high throughput technologies. Population development is an important component. While applying state of the art genomics tools, I do not find their integration in the project to be highly original. However, the association mapping and GxE interaction modelling appear to be cutting edge, as far as I can say with my limited expertise.
With respect to the workplan of activity 1.5, I think the plans for RNAseq could be updated: 100 bp paired end reads would be state of the art. I am also not convinced that sequencing three biological replicates is most efficient. Especially if, as stated, gene regulatory networks are to be derived, sampling more time points will have more effect than controlling biological variation.
I am concerned about the “central data mining and analysis resource” as there is not much information about this and SAP has only committed an in-kind contribution for use of a cloud instance. While use of the SAP HANA infrastructure has potential for developing novel bioinformatics analyses with higher throughput, the project partners have access to adequate computational resources also without it.
Activity 5, crop yield modeling, is an excellent addition to the proposal and has impact on realization of benefits from this project as well as wider benefits.

B. SOCIAL AND/OR ECONOMIC BENEFITS

Please provide your assessment of the strengths and weaknesses of the social and/or economic benefit plan, taking into consideration the review criteria which have been summarized as follows:

- Deliverables – appropriateness, in terms of potential to have impact on food safety, security and/or sustainable production; probability of being achieved by the end of the funding period
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- Expertise for realizing benefits – appropriateness, end-user involvement

This is a more long-term project where the benefits for agriculture and society will mostly be realized well after the project duration. However, generation of germplasm resources and phenotyping information for breeding is a long-term effort that is extremely important even in more fast-paced genomics times.
The deliverable central data mining and analysis resource is not sufficiently explained, but could potentially be transformative for sunflower breeding.
The plan for realizing benefits is appropriate and very well integrated with end users.
In the long term, this project will generate resources that will form the basis of breeding efforts that have very high potential of agronomic benefits.

C. i - MANAGEMENT AND FINANCE

Provide your assessment, including strengths and weaknesses, of the proposal’s Management and Financial plans, taking

into consideration the review criteria which have been summarized as follows:

- Management plans and expertise – including project governance, appropriateness of expertise, arrangements with technology service providers, experience in managing large-scale projects
- Budget and expenditure controls – including reasonableness, monitoring
- Financing from co-funders – including feasibility, link with project objectives

No issues.

C. ii - DETAILED BUDGET AND CO-FUNDING
(Lead Reviewer for the application ONLY - complete this section C. ii)
(Other Reviewers - skip to last section: Overall Summary/Rating)

- DETAILED BUDGET

Salaries

1. In terms of salary, is the proportion of the project total dedicated to salaries reasonable, considering the number and type of positions involved?
2. Is the level of resources proposed and the pro-rata of key positions (number of hours) appropriate for this project?

Appropriate

Consumables

3. Is the amount of consumables reasonable, considering the type of project and number of FTE?
4. Are consumables well justified and appropriate for the work being proposed?
5. Where a general rate per FTE (Full-time equivalent) has been calculated, is the estimate appropriately supported?

Comparable, but on the low side, to other projects

Equipment

6. Is the proposed equipment necessary and well justified?
   - For larger pieces of equipment, to what extent is this equipment necessary for this particular project?
   - Does the level of use justify a full purchase or are there other possible options that could be considered such as use and cost of sharing of equipment with others, or services from others through term contracts?
7. Are the associated equipment maintenance contracts (under the consumables category in the budget) appropriate?
8. Are the 'services from others costs' reasonable and appropriate for the work being proposed?

As far as I can see, equipment requested is reasonable

G&A (General and Administrative)

NOTE: Maximum costs, eligibility etc. will be looked at by Genome Canada.

- CO-FUNDING

Review of the co-funding component of all applications will aim to identify issues in the project's co-funding plan that should be pursued at the face-to-face meeting. <u>A written co-funding report for each project will be provided by KPMG analysts to the Committee one week before the end of the review period, on May 12th, 2015.</u>

9. After viewing this KPMG report, please discuss here any substantive co-funding issues raised in the report (KPMG analysts will not participate in the face-to-face meeting. The Lead Reviewer will be asked to raise any such issues identified

in the KPMG report, with the applicant team, during this meeting).

I agree with the report: Most cofunding is not problematic.
About the SAP contribution, I agree that it is not sufficiently clear what this entails (only access to the cloud instance? The workplan seems to say that there will be considerable input by SAP engineers/programmers). The cost for access to the cloud instance is indeed not justified, for this amount a dedicated server could be purchased which would serve for the whole duration of the project, so I assume licensing for SAP HANA or other things are factored in, but this should be clarified.

OVERALL SUMMARY STATEMENT

Please summarize your overall opinion of the application, highlighting its strengths and weaknesses. Please also comment on any additional issues not addressed in the sections above.

Strengths:
-important long-term efforts
-excellent phenotyping set up, adequate genomics
-excellent genome-wide data analysis
-GE3LS component with crop yield modeling

Weaknesses
-transcriptomic analysis not as well worked out
-unclear plans for central data mining and analysis resource

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(No response)

A. RESEARCH PROPOSAL, INCLUDING RESEARCH ON THE ETHICAL, ENVIRONMENTAL, ECONOMIC, LEGAL AND SOCIAL ASPECTS OF GENOMICS (GE3LS)

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The initial premise is that for cultivated sunflower, there is substantial variation in many of these stress resistant traits, and with no observable trade-off between yield potential and the yield of stressed crops. This is the basis of the project to identify genes/loci that can be incorporated to improve the performance of sunflower as a crop over a wide range of environmental conditions.

This derived data will include a knowledge of the genes, traits, and regulatory networks that are responsible for variation in resistance to the four focal stresses, and identification of genomic factors that influence the nature and extent of physiological trade-offs between stress resistance and performance (i.e., yield) under ideal conditions. Yield under the various growth conditions will be assessed in order to factor tolerance versus yield parameters.

This is a talented and experienced group of investigators who have an excellent productivity record. The distribution of tasks is logical, although some of the participants may be overstretched in their time commitments.

This is a wide-ranging comprehensive proposal. The response to the concern in the preliminary review that “too comprehensive for the resources and proposed timeline” was to reduce the number of samples included in the analyses and increase the funding request rather than refine the scope. I am not convinced that this modification fully addresses the original concerns.

The concern about the diversity of the 288 line population was addressed with preliminary data. However, the number of replicates have been increased, somewhat negating the reductions noted above. There was no indication of the numbers of genes/loci expected and what level of resolution would be available.

As far as I can tell from the proposal, all the alignments and SNP identifications will be done against the two assembled references. The proposal does not explicitly define the relationship between these two genomes and where they fit into the spectrum of c-value variation in sunflower taken from the Kew c-DNA database.

C Mean C Min. C Max. Standard deviation
1C (pg) 3.42 1.78 4.95 0.83

Although much of the DNA variation is in the form of transposable element families, data from other species demonstrates that no individual genome contains all the genes present in a species. The selection of the genomic references might have missed important loci ghat cannot be captured in the current proposal, so any contribution from novel genes and/or copy number variation would appear to be missed. I do not see a reasonable expectation that looking at the variation in the genes in the reference genomes will be sufficient. Thus, are there genes in wild populations not captured in the reference genome? Where in the data processing are unaligned reads incorporated?

Certainly it will be possible to map the loci in the experiments, but if the genes responsible are not included in the genome, interrogation of the regions will be uninformative.

For each stress, the most and least resistant lines (15 of each) will be replicated within treatments Are these lines defined on final yield or a complex algorithm of growth rates and recovery from intermittent stress?

What is the measure of success? Is it some yield under any conditions or high yield most of the time? Are growing conditions, selection and definitions of success sufficiently similar for Canada and Africa?

Whole seedlings will be harvested 24 hours after stress application to monitor expression changes due to acute stress, after 10 days to identify chronically expressed transcripts, and five days after recovery to assess whether stress-induced expression changes are fixed or plastic. Does the expression “whole seedlings extracted” include the roots? Are the likely determinants for tolerance the same across tissues? Would the same suite of genes be involved in maintaining leaf viability and meristem integrity for later recovery? In sampling while seedlings, would leaf tissue overwhelm any contributions form all other tissues? How will causal and consequential effects be distinguished?

Reference is made to allozyme studies that have shown an allele of ADH was associated with flooded habitats. Expression of the useful allele would be expected to be mainly in the roots in flooded situations. Can the proposed analysis identify this specific allele – an easy test could be performed using PCR based methods. If not then what resolving power will the methodology have for root-derived/influenced characters?

Activity 4.2 - Is the soybean section necessary – will the genes be identified in time to develop these lines? How many loci could be simultaneously modified and seed multiplied so evaluation can be made?

Research Support

The available facilities are extensive and suitable for the project.

The GE3LS research includes two activities, the development of crop models and involvement with the governance of the international transfer of germplasm.

The data derived from this project of plant performance of the new varieties under various well-defined stresses will provide a data set to test the robustness of models. The modeling may have importance in the long-term in decisions of which crops to plant where.

The activity focused on the Convention on Biological Diversity (CBD) and International Treaty for Plant Genetic Resources in Food and Agriculture (Treaty) connects the project with the treaty Secretariat. However, the concerns of Industry to the possible limitations of material subject to SMTAs makes this an important activity relative to the project. The understanding of any limitations for the output of the project is important, but it is still not clear how these will fold into the wider discussion of SMTAs. However, having an example of the complexities from this project should be important in informing the subsequent international discussions. The identified individual (Marden) is well qualified and positioned for this role.

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The appropriate deliverables in terms of data and new populations are well described and appropriate for this competition. The main socioeconomic benefit from this project will derive from the development and commercialization of new highly resistant and productive sunflower cultivars based on the information and germplasm developed. The ultimate deliverable in terms of new varieties of stress tolerant sunflower varieties will not appear until well after the end of the project. The project will interact with the industry to ensure informed consumers of their data so that the likelihood of it being used is high

C. i - MANAGEMENT AND FINANCE

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The management strategies and financial controls all appear appropriate.

The budget requested is reasonable considering the scope of the project.

OVERALL SUMMARY STATEMENT

Please summarize your overall opinion of the application, highlighting its strengths and weaknesses. Please also comment on any additional issues not addressed in the sections above.

This is a very ambitious project that is well described and coordinated. There is some concern of the basis for the identification of useful variation.

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The area of focus is highly relevant to the call for proposals. Sunflower is a viable crop in Canada and many developing countries. There is significant potential if they authors can deliver. The proposal addresses multiple agriculturally significant stresses. It involves an international collaboration, including end users. It most certainly uses genomics approaches to a problem. The scope of the research as defined by the authors is massive and certainly requires genomics to come up with answers. It is international in scope and competitive

with state of the art research being performed world-wide.

A. RESEARCH PROPOSAL, INCLUDING RESEARCH ON THE ETHICAL, ENVIRONMENTAL, ECONOMIC, LEGAL AND SOCIAL ASPECTS OF GENOMICS (GE3LS)

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The proposal is well written and the experiments are very well described. The genetic component is very strong with a decent sized, well characterized population. The authors logically go through all of the potential genetic challenges and describe methods to alleviate issues. The physiological characterization is very thorough. But I worry that this is a tremendous amount of work to perform on 30 lines for each stress, with replicates. There are just too many measurements on too many plants. I appreciate that if done well, there will be a massive amount of information – though in the end it comes down to humans digesting it all and integrating it into a coherent physiological snapshot. Similarly, the transcriptome work is a very large undertaking. I'm sure that they can collect the information. Beyond models, one needs to appreciate that it still comes down to one gene – one postdoc. This is going to end up being a massive data collection exercise but the next steps are vague. It's just the best 15 genes. It will be at least two years to transform, validate and assess T2 plants. CRISPR is all well and good. But today it only gives knockouts, not allele replacement. I really don't see how one initiates this activity in quarter 1 and has the first five genes completed by the end of year 2.

I do have a fundamental disagreement with the authors that one can select for stress tolerance and maintain yield. There is ample evidence arguing that pathogen defense is clearly an either-or situation. Likewise, drought stress is associated with an ability to stop growing under adverse conditions. In general, stress mechanisms are tuned to slow growth in times of adversity. There is reprogramming of gene expression with substantial energy diversion. I don't believe that you can have functional stress tolerance without a yield penalty. That said, there is significant benefit to understanding mechanisms of stress tolerance and having them in place. One can look, for example, at Monsanto's drought tolerant maize. The farmer is buying an insurance policy. There is an acknowledged yield hit and the farmer takes this on knowing that the alternative may be much greater loss. Similarly, chemicals that induce systemic acquired resistance to pathogens come with known yield penalties. Bottom line, it is worth understanding mechanisms of stress tolerance and they will have definite utility, especially in the developing world or in marginal growing areas. But I don't believe that these mechanisms, when deployed, will come with no yield penalty.
A related concern is that the PIs will identify multiple genes that simply slow down growth. How will they sort through candidates? There is a rich and infamous history of publications involving transgenic "stress" tolerance genes that simply act by slowing down plant growth. If it grows slower, it will inherently be more "resistant" to stress in most assays.

It is definitely not my area of expertise, but I am puzzled how one can generate crop models for new sunflower varieties that are not yet identified. With zero information on stress tolerance and yield penalties, how does one credibly model outcomes?
Goal 6 is interesting. These are important points for clarification. How does sequence information get handled? In an era of genome editing, does the genetic data carry forward to elite engineered varieties?

B. SOCIAL AND/OR ECONOMIC BENEFITS

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There is no way they will "deliver" stress tolerant lines in the time frame of the project, a point that is acknowledged. But they should easily be able to identify and validate markers linked to various stress responses. The population is such that they should be able to deliver elite breeding lines.

They will provide a massive amount of stress-related data that will no doubt be exploited by the larger community.

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The group appears to be well integrated. The research plan is well documented and the various labs in multiple countries appear to be well coordinated.

OVERALL SUMMARY STATEMENT

Please summarize your overall opinion of the application, highlighting its strengths and weaknesses. Please also comment on any additional issues not addressed in the sections above.

My main criticism of the pre-proposal was that it was extremely over-ambitious. The authors did scale back the amount of work. But there is still a vast quantity of information to be collected, and more importantly, analyzed. There is no question that the authors are highly skilled and productive scientists who are on top of the genetics. There is absolutely no doubt that a vast amount of ultimately useful data will be generated. I just don't think they will be able to do all that they proposed. That hesitancy prevents me from giving it the absolute highest rating. But I believe this is a highly meritorious proposal that should be funded. It's a really good system and the authors have an incredible opportunity to do genome-wide systems biology that may in the end yield useful products for Canada and the developing world. The physiology is in my opinion naive in that I don't think they will get stress tolerance without a yield penalty. But that's OK. Farmers in marginal areas will consider growing sunflowers. Monsanto makes money selling a stress-tolerant maize. So the model works.

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This proposal aims to use genetics- and genomics-driven approaches to investigate the basis of abiotic stress tolerance in sunflower. Sunflower is a major oilseed crop for which productivity is limited by lack of stress tolerance. It is an important crop in Canada and is also grown widely in developing countries. Wild reproductively compatible relatives of cultivated sunflower are adapted to a variety of extreme environments and so offer a reservoir of potentially useful genetic determinants for crop improvement. The proposed work builds on

previous Genome Canada-funded research that has enabled the reference genome sequence of sunflower to be determined, along with a host of other genetic and genomic resources for cultivated and wild sunflower genotypes, including whole genome sequence data for a mapping population of 288 inbred lines that contain around 90% of the allelic diversity in the sunflower gene pool. The PIs are world leaders in plant genomics and have generated most of the genomic resources available for sunflower. This proposal is timely and highly ambitious in scale, fully embraces genomics, and is directly relevant to Genome Canada's global food safety, security and sustainable production mission. The team is of high international calibre and the project if funded has considerable potential to have a major impact. The functional analysis section (Act. 4) is weak by comparison with the rest of the proposal.

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The proposed work builds on a massive amount of previous research on sunflower genetics and genomics and the team is exceptionally well positioned to undertake this project. Helianthus is a very attractive experimental system because of its genetic resources and the ability to cross cultivated and wild species. It has emerged as a model for evolutionary and ecological analysis and so offers considerable potential for both fundamental and strategic lines of investigation that will provide insights into the connectivity between genotypes and traits both in crop systems and in natural environments. The PIs plan to use complementary approaches (GWAS and population genomics) to investigate the genetic basis of tolerance to different abiotic stresses in these two different plant growth situations. The project is expected to identify genes and mechanisms for tolerance to different abiotic stresses that can be used for crop improvement. It should also shed light on the extent of overlap of the genes and mechanisms that determine sensitivity/tolerance to different types of abiotic stress. Advanced phenotyping methods will be used to evaluate plant performance in the field.

The methods for investigating abiotic stress tolerance in cultivated sunflower (greenhouse and field trials to assess performance under previously determined drought, flooding, salt and nutrient stress conditions) seem appropriate (Act. 1.1). GWAS will then be used to identify alleles associated with variation in abiotic stress resistance. The availability of high density markers coupled with low LD should apparently make it feasible to map functional variation down to the level of one or a few genes, although this reviewer does not have sufficient experience of mapping to make an independent evaluation of this likelihood. The aim is to identify abiotic stress resistance alleles that do not have severe antagonistic correlations, i.e. that are not anticipated to have significant effects on yield. Promising lines will be further tested using multiple phenological stages and multiple levels of stress and by automated phenotyping. Transcriptomic analysis will be carried out to investigate responses to the different stress treatments in lines that have high and low tolerance. This is expected to reveal differences in gene expression associated with low/high stress tolerance, enable co-expression networks to be developed, and the extent of overlap between different stress responses to be evaluated (the caveat being that two resistant and two susceptible lines will be used per stress treatment, and these are likely to differ for different stresses, i.e. comparison between stresses may be difficult).

In Act. 2 the plan is to search for associations between genotype variation (SNPs and haplotypes) and ecological variables (climate and soil characteristics) in natural populations of wild species corresponding to the multi-species mapping population used in Act. 1. to identify locally adapted alleles. This seems like a very exciting complementary strategy that has the potential to deliver important fundamental knowledge about mechanisms of stress tolerance and adaptation in natural populations although this reviewer is not positioned to

comment on the likely feasibility of this approach. Potentially though, it could offer a pioneering strategy to exploit such knowledge to inform and enable crop improvement.

The development and analysis of MAGIC populations (Act. 3) will provide higher resolution mapping compared with the association mapping population and will produce material that can be deployed into breeding programmes.

The parameters that will be used to identify ~15 candidate stress related genes for functional analysis are clearly defined in Act. 4.1. although the likelihood of finding this number of promising candidates is not clear. It is also not clear how the information generated by the transcriptional expression network analysis will feed into this part of the work. Until such candidates are available the PIs propose to focus on candidate genes identified in previous projects such as alcohol dehydrogenase (previously shown to be associated with tolerance to flooding). It would be good to know how many other candidates are on this initial list. Methods for sunflower transformation and RNAi-mediated gene silencing have been established in the Rieseberg lab. The focus here appears to be on gene silencing rather than expression of genes introduced in from other sunflower accessions. This part of the proposal is surprisingly brief and somewhat confused. There appear to be concerns about off-target silencing (can't this be predicted based on the reference genome?). The assumption is that loss of gene function in the reference cultivar will be informative. There is mention of testing alleles for complementation in knock-out lines of Arabidopsis where possible. How conserved are the genes of interest likely to be across these diverse species? Genome editing in Arabidopsis is also mentioned. Why is this a priority? It is reassuring to see that efforts are underway to develop genome editing methods for sunflower. Act. 4.2 (genome editing in soybean) is quite unrelated to the thrust of this project.

The GE3LS research is very well aligned with the project and has two goals – development of yield models for sunflower and other Canadian crops that will enable predictions of likely yields of new stress resistant cultivars under different soil and climate conditions across Canada; and designing strategies for addressing the challenges associated with international treaties on use of plant genetic resources. It is particularly good to see the latter issue being tackled directly as part of this proposed work.

The team has all of the necessary expertise to take on this project, from plant genetics, genomics, breeding and population genetics through plant physiology, phenotyping and agronomy to the inter-disciplinary expertise necessary to deliver the two GE3LS components. Access to the facilities, equipment and services needed for this project appear to be in place.

B. SOCIAL AND/OR ECONOMIC BENEFITS

Please provide your assessment of the strengths and weaknesses of the social and/or economic benefit plan, taking into consideration the review criteria which have been summarized as follows:

- Deliverables – appropriateness, in terms of potential to have impact on food safety, security and/or sustainable production; probability of being achieved by the end of the funding period
- Expected benefits – significance, feasibility, timeframe for realization after the end of the project
- Strategy for realizing benefits – persuasiveness, strength of plan, rationale for outcomes
- Expertise for realizing benefits – appropriateness, end-user involvement

The anticipated deliverables are next generation germplasm resources for uptake by breeders by Year 3, and new abiotic stress tolerant sunflower cultivars in the field within four years of the project end date; a data mining and analysis resource for sunflower that will be of general use for researchers and breeders (to be made available during the course of the project); crop yield models (by Year 4); and strategies for mitigating barriers to agricultural innovation resulting from international treaties (to be generated throughout the course of the project). These deliverables should have wide ranging value for plant science and crop improvement that extends well beyond the sunflower industry. The benefits to Canadian agriculture are clear. A well-developed plan for knowledge translation and delivery of impact is in place.

C. i - MANAGEMENT AND FINANCE

Provide your assessment, including strengths and weaknesses, of the proposal's Management and Financial plans, taking into consideration the review criteria which have been summarized as follows:

- Management plans and expertise – including project governance, appropriateness of expertise, arrangements with technology service providers, experience in managing large-scale projects
- Budget and expenditure controls – including reasonableness, monitoring
- Financing from co-funders – including feasibility, link with project objectives

The lead PI has previous experience in directing large consortia, as do several of the co-PIs. Clear plans are in place for project management including the budget. The reporting structure is laid out in a table on P53 of the proposal.

Financing from co-funders appears to be in place.

OVERALL SUMMARY STATEMENT

Please summarize your overall opinion of the application, highlighting its strengths and weaknesses. Please also comment on any additional issues not addressed in the sections above.

The proposed work builds on a wealth of previous research on sunflower genetics and genomics by the applicants and the team is exceptionally well positioned to undertake this project. I am not able to comment in any depth on the feasibility of the mapping work but the approaches proposed seem reasonable and well integrated. Act. 4 (functional analysis) is weak compared to the rest of the proposal and identification of candidate genes does not seem to draw on the outputs of the transcriptional co-expression network analysis.

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GENERAL INSTRUCTIONS

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* ELEMENTS WHICH YOU ARE UNABLE TO REVIEW *

Please review all sections of the Full Application (Scientific, Social and/or Economic Benefits, Management and Financial) to the best of your ability. If you have specialized expertise and are not comfortable commenting on a particular area (e.g., social and/or economic benefits reviewers may not be comfortable commenting on the research proposal) please enter N/A (not applicable) in the text box for the criteria that you are not reviewing.

ELIGIBILITY

Provide your assessment of the eligibility of the proposal. Does/Is the proposal:

- respond to the objectives of the Genome Canada competition;
- include genomic approaches as essential components in terms of importance to the overall outcomes of the project; *
- address challenges and opportunities related to global food safety, security and sustainable production;
- of a scale and scope such that it is able to address challenges requiring a genomics approach; and
- internationally competitive and has potential to have a major impact

*Genomics is defined by Genome Canada as the comprehensive study, using high throughput technologies, of the genetic information of a cell or organism, including the function of specific genes, their interactions with each other and the activation and suppression of genes. It also includes related disciplines such as bioinformatics, epigenomics, metabolomics, metagenomics, nutrigenomics, pharmacogenomics, proteomics and transcriptomics.

This project investigates the molecular and physiological basis of stress resistance in cultivated sunflower and reproductively compatible, stress-adapted wild species. Multiple genomic approaches are applied to identify exotic genes for integration into cultivated sunflower to improve stress resistance. Stress resistant cultivar development is projected to create ~$12 million USD annually within five years of the project end date and up to ~$230 million USD annually after ten years. Stress-resistant cultivars will afford an avenue to address food

security and nutritional issues in the developing world. The project is consistent with the eligibility requirements of the Genome Canada completion and addresses an area of potentially great impact.

A. RESEARCH PROPOSAL, INCLUDING RESEARCH ON THE ETHICAL, ENVIRONMENTAL, ECONOMIC, LEGAL AND SOCIAL ASPECTS OF GENOMICS (GE3LS)

Provide your assessment of the strengths and w eaknesses of the research proposal, including research on the ethical, environmental, economic, legal and social aspects of genomics (GE3LS), taking into consideration the review criteria w hich has been summarized as follow s:

- Research context and originality
- Research plans - methods, approach, feasibility
- Research expertise - appropriateness, integration
- Research support - access to facilities, equipment and services
- GE3LS research - alignment, integration, potential for know ledge advancement

The proposed research seeks to identify and characterize the genetic basis of stress resistance traits in sunflower leading to the development of stress resistant varieties exploiting novel stress resistance genes identified from wild relatives. The approach is well-developed and feasible with appropriate expertise well-integrated across project components. Conduct of phenotyping in both field and controlled environments serves as a check against unanticipated events to assure progress on very aggressive activities and timelines.

Characterization of stress response in cultivated sunflowers uses association mapping (GWAS) and transcriptional responses (activity 1). Identifying resources to enable development of stress resistant, high yield sunflower cultivars is accomplished by WGS re-sequencing of normalized libraries for collections of wild germplasm to provide SNPs for haplotype reconstruction (activity 2); conducting genetic analysis of complex trait variation and producing materials containing exotic alleles for deployment in breeding programs (activity 3); and, evaluating candidate genes for stress resistance using functional analysis through soybean transgenisis with RNAi constructs designed to silence the candidate genes, and evaluation of selected candidate genes following expression in soybean using CRSPR/Cas9 (activity 4).

GE3LS research will develop crop yield models for sunflower and other crops that will be used to gauge the opportunity for stress resistant sunflower cultivar adoption under diverse soil and climate conditions throughout Canada (activity 5). In addition, strategies to reduce international barriers to use of germplasm resources for R&D will be investigated with respect to the Convention on Biological Diversity (CBD) and International Treaty for Plant Genetic Resources in Food and Agriculture (Treaty). This will clarify potential impacts and opportunities for the outputs of this project and will engage relevant organizations in policy discussions.

B. SOCIAL AND/OR ECONOMIC BENEFITS

Please provide your assessment of the strengths and weaknesses of the social and/or economic benefit plan, taking into consideration the review criteria which have been summarized as follows:

- Deliverables – appropriateness, in terms of potential to have impact on food safety, security and/or sustainable production; probability of being achieved by the end of the funding period
- Expected benefits – significance, feasibility, timeframe for realization after the end of the project
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- Expertise for realizing benefits – appropriateness, end-user involvement

Projected deliverables are envisioned as next generation germplasm resources for sunflower breeders; a central data mining and analysis resource for the sunflower research community; crop yield models optimized for stress resistant sunflower which anticipate climate change impacts to Canadian agriculture; and strategies to address international trade and regulation as barriers to novel product adoption. Development of stress resistant sunflower cultivars through this effort is anticipated to expand sunflower production to marginal and

underutilized lands in Canada as well as to address nutritional needs in the developing world.

The ability to deliver improved sunflower cultivars to the field within four years following project completion is quite ambitious and will be governed by the approach used and the in-life progress made. Overall, the project is persuasive, well designed, uses appropriate expertise, and engages end users for planning, conduct and delivery of outcomes. The plan for knowledge translation and realization of benefits is very deeply considered and outlines multiple aspects – end user training and engagement; industry partnerships, and broad dissemination of results.

C. i - MANAGEMENT AND FINANCE

Provide your assessment, including strengths and weaknesses, of the proposal's Management and Financial plans, taking into consideration the review criteria which have been summarized as follows:

- Management plans and expertise – including project governance, appropriateness of expertise, arrangements with technology service providers, experience in managing large-scale projects
- Budget and expenditure controls – including reasonableness, monitoring
- Financing from co-funders – including feasibility, link with project objectives

The project has a logical and well-constructed approach to management and finance with a structure consistent with the scheme commonly represented in Genome Canada proposals. Project leadership and a project manager are specified and their expertise appears appropriate based on their prior experience in large scale research undertakings. Financial controls and management are outlined and can be rapidly implemented to allow for dealing with project finances in a timely, effective, and transparent manner. A co-funding plan is elaborated which relies on Genome BC and NSF for the majority of co-share. NSF funding is not secured at the time of this application and therefore needs to be clarified.

OVERALL SUMMARY STATEMENT

Please summarize your overall opinion of the application, highlighting its strengths and weaknesses. Please also comment on any additional issues not addressed in the sections above.

The proposed research investigates the genomic and physiological basis of stress resistance in cultivated sunflower and stress-adapted wild relatives. Substantial high quality genomic resources have been developed for cultivated sunflower. This research will utilize this resource and develop high density genetic maps and draft genome assemblies of two wild species (H. argophyllus and H. petiolaris), as well as the whole genome shotgun (WGS) sequencing of 486 cultivated and wild sunflower genotypes, including individuals from 13 wild Helianthus species and the full association mapping population. This work will involve genotypic and phenotypic characterization of a diverse collection of cultivated sunflower lines to enable genome-wide association studies (GWAS), detailed physiological and transcriptomic analyses to investigate the mechanistic basis of variation in stress resistance, and population genomic analyses of related species to identify natural variants that confer stress adaptation in the wild. Crop models will be used to forecast the opportunity for stress resistant sunflower to expand sunflower production in the face of climate change. The goal is improved systems-level understanding of plants and environment interactions for breeding environmentally resilient sunflower cultivars. In addition, multi-stakeholder interactions will seek to resolve ambiguities in interpreting the Treaty for Plant Genetic Resources in Food and Agriculture which are important to the use internationally of wild sunflower germplasm.

2014 Large-Scale Applied Research Project Competition: Feeding the Future

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ELIGIBILITY

Provide your assessment of the eligibility of the proposal. Does/Is the proposal:

- respond to the objectives of the Genome Canada competition;
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- address challenges and opportunities related to global food safety, security and sustainable production;
- of a scale and scope such that it is able to address challenges requiring a genomics approach; and
- internationally competitive and has potential to have a major impact

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This proposal certainly meets the eligibility criteria as it addresses the four key objectives laid down by Genome Canada. If successful the outcomes of the project will improve food safety and security as well as having an impact at an international level.

A. RESEARCH PROPOSAL, INCLUDING RESEARCH ON THE ETHICAL, ENVIRONMENTAL,

ECONOMIC, LEGAL AND SOCIAL ASPECTS OF GENOMICS (GE3LS)

Provide your assessment of the strengths and w eaknesses of the research proposal, including research on the ethical, environmental, economic, legal and social aspects of genomics (GE3LS), taking into consideration the review criteria w hich has been summarized as follow s:

- Research context and originality
- Research plans - methods, approach, feasibility
- Research expertise - appropriateness, integration
- Research support - access to facilities, equipment and services
- GE3LS research - alignment, integration, potential for know ledge advancement

Research Context

The project has identified several areas that can strengthen the Canadian sunflower industry, as well as having the potential at the international level. A more complete understanding of for key stress conditions can generate important phenotypic and molecular data. The approach to research is certainly creative and has the potential to achieve the desired outcomes. The end users identified in the project are breeders, in both the private and public sectors, and researchers. The outcomes of the research activities are targeted towards these end users.

Research Plans

The project is ambitious and may not complete all the tasks within the life time of the project. However, if the majority of the deliverables are achieved then this can have a significant impact on the sunflower industry. One possible concern is whether the starting material will have sufficient variation to address all the stress conditions to be studied. The project management committee should at least be aware of this possibility and have contingency plans in place should this be the case.

Research Expertise

The project team have great experience and expertise in areas such as genomics, phenotyping, association mapping etc. In addition, the GE3LS activities will also be led by an expert is this area. There seems to be good integration between the different activities to be undertaken by the project including that GE3LS activities.

Research Support

The research facilities and services are appropriate to successfully undertake the proposed research activities.

GE3LS

There are two aspects of the GE3LS activities; Development of crop yield models and an Analysis of International Treaties covering plant genetic resources.

The modelling activity generally fits in well with the research activities in that they will produce yield responses to existing varieties of sunflower as well as sunflower cultivars produced by the research activities. However, it appears that only three of the traits that the research activity will investigate, drought, flooding and low nutrient yield models will be produced. It’s unclear if this will be carried out for salt which is the fourth trait. One further aspect that is unclear is how the model will fully provide data that addresses issues of climate change. The proposal suggests that the new stress resistant sunflower cultivars will be able to produce higher yields and be grown on primary secondary and marginal lands. Yet it is unclear if the models used will be able to take into account issues such as direct and indirect land use and life cycle analysis which are key elements in assessing the suitability and sustainability of crops in addressing issues of climate change.

However the project has a clear idea of where they will obtain all the relevant data to input into the models and the link to economic models will be very useful to end users.

The second GE3LS activity is the analysis of international treaties covering plant genetic resources, namely the Convention on Biological Diversity (CBD) and the International Treat for Plant Genetic Resources for Food and Agriculture (ITPGRFA).
Although these instruments have been around for some time now the bilateral system under the CBD and the multilateral system under the ITPGRFA are underutilised. Arguably the CBD regime is cumbersome and unpredictable while the ITPGRFA system may be hindered by a lack of complete understanding of the implications of the standard material transfer agreements (SMTA). Therefore an in-depth study of the scope and impact of the SMTAs is undoubtedly a worthwhile undertaking. In addition, this study does have relevance to the research activities if, for example, sunflower material could be utilised through the multilateral system. A more complete understanding of the implications of SMTAs would be beneficial and increase understanding, certainty and clarity of the use of SMTAs. The stakeholder working group will also help achieve a better understanding of the scope and implications of SMTAs. Although the impact of policy papers generated by project such as this can be very limited, the project team seem well placed to maximise any impact. Although the focus of this GE3LS activity is looking at the scope and operation of SMTAs, no mention of the Nagoya Protocol seems a strange omission. However, the outcomes from this activity can certainly be a benefit to a range of end users.

B. SOCIAL AND/OR ECONOMIC BENEFITS

Please provide your assessment of the strengths and weaknesses of the social and/or economic benefit plan, taking into consideration the review criteria which have been summarized as follows:

- Deliverables – appropriateness, in terms of potential to have impact on food safety, security and/or sustainable production; probability of being achieved by the end of the funding period
- Expected benefits – significance, feasibility, timeframe for realization after the end of the project
- Strategy for realizing benefits – persuasiveness, strength of plan, rationale for outcomes
- Expertise for realizing benefits – appropriateness, end-user involvement

Deliverables
The project has clearly identified four key deliverables:

(1) “Next Generation” germplasm:
(2) A central data mining and analysis resource for sunflower:
(3) Crop yield models:
(4) Strategies for mitigating barriers to public and private breeding programs resulting from international treaties.

The project is certainly capable of producing the deliverables 2, 3 and 4 within the lifetime of the project. It is more difficult to predict whether the first deliverable, “Next Generation” germplasm can be achieved within the lifetime of the project. However, even if the majority of this deliverable is realised it will still be a major outcome and benefit to breeders and researchers.

Expected benefits
The expected benefits can have a significant impact on the targeted end users and beyond, contributing both in terms of food security and sustainability. The project can significantly contribute to the understanding of key abiotic stresses in sunflower and a better understanding of the international instruments that govern access and use of germplasm.

Strategy for Realising benefits
The strategy for realising the project benefits is clear and well thought out. There is very good involvement of end users from industry and from different markets, which will assist in moving the research from the lab to industry. However, the means of dissemination of the result outlined in the proposal is very ‘academic’, articles in journals, depositing data in GenBank, and perhaps consideration of other means of dissemination should be considered to ensure full impact of their projects deliverables.

Expertise for Realising benefits

The proposal has identified key end users and they have been integrated into the proposal in a manner that should aid the realisation of the expected benefits. In addition, the project team have the relevant expertise to achieve their goals and realise the benefits.

C. i - MANAGEMENT AND FINANCE

Provide your assessment, including strengths and weaknesses, of the proposal's Management and Financial plans, taking into consideration the review criteria which have been summarized as follows:

- Management plans and expertise – including project governance, appropriateness of expertise, arrangements with technology service providers, experience in managing large-scale projects
- Budget and expenditure controls – including reasonableness, monitoring
- Financing from co-funders – including feasibility, link with project objectives

Management plans

The management structure of the project seems clear and as does the roles and responsibilities of members of the project. There is also a clear process for who will make the key decisions on the direction of the project and the processes that will be used to inform the decision maker. However, is isn't fully clear how any conflict would be resolved although the project leaders do have experience in running large scale projects, so this may not be an issue.

OVERALL SUMMARY STATEMENT

Please summarize your overall opinion of the application, highlighting its strengths and weaknesses. Please also comment on any additional issues not addressed in the sections above.

The project is well designed and will produce worthwhile data and benefits to a range of end users. There is strong expertise within the project team in addition to experience of running large scale project. This should help ensure the deliverables are met within the time frame of the project. The expected benefits and the strategy for realising the benefits are clear and well thought out. The GE3LS component of the research is very focussed and is well aligned to the focus of the research activities of the project.

The project is very ambitious and there must be some doubt as to whether all the deliverables are achievable within the time frame of the project. The management committee may have to decide quite early in the project if there is a need to focus on once particular aspect of the research and get good data for that trait and focus on the major deliverables. The GE3LS component studying international treaties and the SMTAs should produce data useful to end users and to some extent the project itself. Although the GE3LS activities align quite well to realising the possible benefits of the research its unclear how the GE3LS activities will interact with the other project activities.