Soybean (Glycine max L.) is an important crop in the US and worldwide. It has numerous health benefits because of its high contents of protein, oil, isoflavones, and other bioactive compounds. However, it is susceptible to many biotic stresses such as fungal, bacterial, and viral diseases and abiotic stresses such as drought and salinity. The objectives of this funded project were to map quantitative trait loci (QTL) for protein, oil, and isoflavones contents in three recombinant inbred line (RIL) populations of soybean. We have achieved 100% of the goals. We have constructed the genetic linkage maps based on the three recombinant inbred line (RIL) populations.

Final Report: Genetic Analysis of Seed Isoflavones, Protein, and Oil Contents in Soybean [Glycine max (L.) Merr.]

Approved for Public Release; Distribution Unlimited

The views, opinions and/or findings contained in this report are those of the author(s) and should not contrived as an official Department of the Army position, policy or decision, unless so designated by other documentation.

Abstract

Soybean (Glycine max L.) is an important crop in the US and worldwide. It has numerous health benefits because of its high contents of protein, oil, isoflavones, and other bioactive compounds. However, it is susceptible to many biotic stresses such as fungal, bacterial, and viral diseases and abiotic stresses such as drought and salinity. The objectives of this funded project were to map quantitative trait loci (QTL) for protein, oil, and isoflavones contents in three recombinant inbred line (RIL) populations of soybean. We have achieved 100% of the goals. We have constructed the genetic linkage maps based on the three recombinant inbred line (RIL) populations.

Subject Terms

Final Report
ABSTRACT

Soybean (Glycine max L.) is an important crop in the US and worldwide. It has numerous health benefits because of its high contents of protein, oil, isoflavones, and other bioactive compounds. However, it is susceptible to many biotic stresses such fungal, bacterial, and viral diseases and abiotic stresses such as drought and salinity. The objectives of this funded project were to map quantitative trait loci (QTL) for protein, oil, and isoflavones contents in three recombinant inbred line (RIL) populations of soybean. We have achieved 100% of the goals. We have constructed the genetic linkage maps based on the three recombinant inbred line (RIL) populations ‘PI 438489B’ by ‘Hamilton’ (PIxH, n=54) (Kassem et al., 2012), ‘Maryland 96-5722’ by ‘Spencer’ (MxS, n=100) (Akond et al., 2013), and ‘Hamilton’ by ‘Spencer’ (HxS, n=100) (Akond et al., 2014, under review). We also mapped quantitative trait loci (QTL) for protein, oil, isoflavone contents as well as other important agronomic traits in each of these RIL populations. The results have been disseminated through (1) high quality manuscripts published in well-respected international journals and (2) poster and oral presentations in local, regional, and international conferences. The results are summarized below.

Enter List of papers submitted or published that acknowledge ARO support from the start of the project to the date of this printing. List the papers, including journal references, in the following categories:

(a) Papers published in peer-reviewed journals (N/A for none)

Received            Paper


TOTAL: 1

Number of Papers published in peer-reviewed journals:

(b) Papers published in non-peer-reviewed journals (N/A for none)

Received            Paper

TOTAL:
(c) Presentations


Number of Presentations: 9.00

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**TOTAL:**
Number of Peer-Reviewed Conference Proceeding publications (other than abstracts):

(d) Manuscripts

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<td>ASM G. Masum Akond1, Bobby Ragin1, Richard Bazzelle1, Stella K. Kantartzi2, Khalid Meksem2, and My Abdelmajid Kassem1. Quantitative Trait Loci Associated with Moisture, Protein, and Oil Content in Soybean [Glycine max (L.) Merr.], Journal of Agricultural Science (06 2012)</td>
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<tr>
<td>08/25/2013 8.00</td>
<td>Masum Akond1, Bazelle Richard1, Bobby Regin1, Harmin Herrera2, Umerah Kaodi2, Cevdet Akbay2, Stella K. Kantartzi3, Victor Njiti4, Abdelali Barakat5, Khalid Meksem3, David A Lightfoot3 and My Abdelmajid Kassem*1. Additional Quantitative Trait Loci and Candidate Genes for Seed Isoflavone Content in Soybean, Journal of Plant Sciences (08 2013)</td>
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<td>08/25/2013 10.00</td>
<td>Masum Akond1, Melanie Boney1, Lauren Schoener1, Stella K. Kantartzi2, Khalid Meksem2, Nacer Bellalou3, David A Lightfoot2 and My Abdelmajid Kassem1*. Quantitative Trait Loci for Seed Isoflavone Contents in ‘Maryland’ by ‘Spencer’ Recombinant Inbred Lines of Soybean, Journal of Agricultural and Food Chemistry (09 2013)</td>
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<tr>
<td>08/25/2013 9.00</td>
<td>Masum Akond1, Lauren Schoener1, Stella K. Kantartzi2, Khalid Meksem2, Qijian Song3, Dechun Wang4, Zixiang Wen5, David A Lightfoot2 and My Abdelmajid Kassem1*. A SNP-Based Genetic Linkage Map of Soybean Using the SoySNP6K Illumina Infinium BeadChip Genotyping Array, Journal of Plant Genome Sciences (08 2013)</td>
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Masum Akond1, Shiming Liu2, Lauren Schoener1, James A. Anderson2, Stella K. Kantartzi2, Khalid Meksem2, Qijian Song3, Dechun Wang4, Zixiang Wen5, David A. Lightfoot2, and My Abdelmajid Kassem1*. A SNP-Based Genetic Linkage Map of Soybean Using the SoyS-NP6K Illumina Infinium BeadChip Genotyping Array, Journal of Plant Genome Sciences (09 2013)

Masum Akond1, Shiming Liu2, Melanie Boney1, Stella K. Kantartzi2, Khalid Meksem2, Nacer Bellaloui3, David A. Lightfoot2, My Abdelmajid Kassem1#. Identification of Quantitative Trait Loci (QTL) Underlying Protein, Oil, and Five Major Fatty Acids' Contents in Soybean, American Journal of Plant Sciences (10 2013)


Masum Akond1, Stella K. Kantartzi2, Khalid Meksem2, Nacer Bellaloui3, David A Lightfoot2, , My Abdelmajid Kassem1*. Genomic Regions Containing Quantitative Trait Loci (QTL) Underlying Sucrose, Raffinose and Stachyose Contents in the 'MD 96-5722' by 'Spencer' Recombinant Inbred Line (RIL) Population of Soybean, PLoS ONE (01 2014)

Laila Khandaker †, Masum Akond†, Shiming Liu§, Stella K. Kantartzi§, Khalid Meksem§, Nacer Bellaloui#, David A Lightfoot§, and My Abdelmajid Kassem. Seed Amino Acids QTL Detected by SNP Markers in the ‘MD 96-5722’ by ‘Spencer’ RIL Population of Soybean, Journal of Agricultural and Food Chemistry (02 2014)

TOTAL: 16

Number of Manuscripts:

Books

Received Book

TOTAL:
### Patents Submitted

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<td>Dec. 2013 “Excellence in Grant Proposal Submission Award”; Fayetteville State University; Board of Trustees Meeting on December 12, 2013.</td>
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### Graduate Students

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**Total Number:** 3

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**Total Number:** 1

### Names of Faculty Supported

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Names of Undergraduate students supported

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<td>Jonela Rogers</td>
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**Student Metrics**
This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period: ......

The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:......

The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:......

Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):......

Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:......

The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense ......

The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields:......

Names of Personnel receiving masters degrees

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<td>Melanie Boney (Fall 2014)</td>
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Names of personnel receiving PHDs

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Names of other research staff

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Sub Contractors (DD882)
Inventions (DD882)
The objectives of this grant were to genetically map quantitative trait loci (QTL) for seed isoflavones, protein, and oil contents in three recombinant inbred line (RIL) populations of soybean focusing on one RIL population per year (Table 1):

Table 1. A summary of the three-year period of the grant, its objectives, achievements, and evidences.

<table>
<thead>
<tr>
<th>Year</th>
<th>Objectives Achieved / In Progress</th>
<th>Evidence</th>
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</table>
Map QTL for Seed Protein Contents in ‘MD 96-7522’ by ‘Spencer’ RIL population. In Progress Manuscripts:


Abstracts:

Several abstracts will be presented at the International Plant and Animal Genome Conference XXII that will be held January 11–15, 2014 in San Diego, CA.

Map QTL for Seed Oil Contents in ‘MD 96-7522’ by ‘Spencer’ RIL population.
In Progress Manuscripts:


Abstracts:

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Map QTL for Seed Isoflavone Contents in ‘MD 96-7522’ by ‘Spencer’ RIL population.

In Progress Manuscripts:


Abstracts:

Several abstracts will be presented at the International Plant and Animal Genome Conference XXII that will be held January 11–15, 2014 in San Diego, CA.

Year 3:


Map QTL for Seed Protein Contents in ‘Hamilton’ by ‘Spencer’ RIL population. Achieved and In Progress


Map QTL for Seed Oil Contents in ‘Hamilton’ by ‘Spencer’ RIL population. Achieved and In Progress


Map QTL for Root Traits in ‘Hamilton’ by ‘Spencer’ RIL population. Achieved and In Progress


During the last period (Year 3), the following tasks were achieved:

1. Dr. Akond (Postdoctoral Fellow) and graduate student (Ms. Zenis Ambrocio) grew the ‘Hamilton’ by ‘Spencer’ RIL population both in the greenhouse and the field and they extracted DNA from the parents and RILs (96 samples). The DNA was checked for quality and was sent to Dr. Dechun Wang of Michigan State University for SNP genotyping.
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3. The RILs and parents have been harvested in the field around September-October 2013 and seeds have been sent to Dr. Nacer Bellaloui of USDA-ARS in Stoneville, MS. Dr. Bellaloui and his team performed the quantification of seeds isoflavones, oil, proteins, and sugars in the population and delivered the results to me late February-March 2014.
4. A preliminary QTL data analysis was performed after the genetic linkage map was constructed (Akond et al., 2014, unpublished). Dr. Akond and Ms. Ambrocio (Grad Student) did the QTL data analysis using WINQTL Cartographer and SAS Genomics software. A preliminary analysis revealed that we have discovered new QTL for seed isoflavones, protein, oil, sugar contents, and several other agronomic traits in this population. The following manuscripts are in preparation and will be submitted soon for publication:


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In summary (2011-2014), the PI, Co-PI, colleagues, and students published, submitted, and are preparing the following manuscripts:

**Published Manuscripts:**


**Submitted Manuscripts:**


**Manuscripts in Preparation:**


**Posters Presented at Conferences:**


Akond M, R Bobby, W Clark, SK Kantartzi, K Meksem, and MA Kassem. Row Spaces can affect Agronomic Traits in Soybean

Ragin B, M Akond, MA Kassem, Plant Densities Can Affect Isoflavone Accumulation in Soybean [Glycine max (L.) Merr]. Student Research Conference 2013, Fayetteville State University, April 12-13, 2013, NC, USA.


Students Working in the Lab and their Projects:

Graduate:

Melanie Boney: Variation in Agronomic Characteristics and Seed Components of Maryland by Spencer Recombinant Inbred Lines Soybean (Glycine max L. Merr.)

Bobby Ragin: Variation and genetic analysis of Seed Isoflavones Components in Hamilton by Spencer Recombinant Inbred Lines of Soybean (Glycine max L. Merr.)

Zenis Ambrocio: Phenotyping and quantitative trait loci mapping identify core regions of the soybean genome controlling root architecture.

Undergraduates:

Lauren Schoener: Genetic studies of soybean controlling isoflavones and other seed components.

Charity Bldwin: Genetic analysis of drought tolerance in soybean.

Technology Transfer
Abstract

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| \begin{itemize} 
| Map QTL for Seed Isoflavone Contents in PI 438489B by ‘Hamilton’ RIL population. | Achieved |
| \end{itemize} |
| **Manuscripts:** |
| **Abstracts:** |


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Submitted Manuscripts:


Bellaloui N, Y Hu, A Mengistu, MA Kassem, and CA Abel. Effects of foliar boron application on seed composition, cell wall boron, and seed δ^{15}N and δ^{13}C isotopes in soybean are influenced by water stress. Frontiers in Plant Nutrition, 2013. Submitted.


Manuscripts in Preparation:


**Posters Presented at Conferences:**


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