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| Project Number:  | 1720-172-0129 |
| Project Title:  | Genetic improvement of flood tolerance and best management practices for sustainable soybean production |
| Organization:  | University of Missouri together with University of Arkansas, Mississippi State University, Louisiana State University, and USDA-ARS, Raleigh, NC |
| Principal Investigator Name: | Henry T. Nguyen |
| **National Soybean Checkoff Research Database** [**https://www.soybeanresearchdata.com/**](https://www.soybeanresearchdata.com/) **(visible to public)****Please choose only one option (if no option is selected, this report will be posted to the website):**[x]  I agree to allow the information contained in this report to be published in its entirety.[ ]  I have included, at the end of this report, a brief non-technical report that can be posted to the website.[ ]  I DO NOT agree to allow the information contained in this report to be published. |
| Project Status - What key activities were undertaken and what were the key accomplishments during the life of this project? Please use this field to clearly and concisely report on project progress. The information included should reflect quantifiable results (expand upon the KPIs) that can be used to evaluate and measure project success. Technical reports, no longer than 4 pages, may be included in this section.  |
| Through USB support for the past several years (USB #1920-172-0129), we have key accomplishments below:1. We developed a flooding tolerance breeding pipeline and established flooding field-screening sites in all the 5 participating states. We screened >15,000 plots for flooding tolerance for germplasm evaluation and gene mapping annually. In the past 3 years, we screened >10,000 plots of commercial varieties requested by the major soybean seed companies.
2. At the University of Missouri, Nguyen group has built 2 flooding channels with high-throughput phenotyping ability in the new greenhouse to evaluate impacts and tolerance of flooding at seedling stages.
3. New flooding tolerant lines were identified, including 12 exotic and 14 wild soybean lines, across different location. 3 drought tolerant lines, such as N11-10295 were also found to be flooding tolerant and can be used for both drought and flooding prone areas.
4. 6 novel flooding tolerance genes were identified. The associated DNA markers were developed for molecular breeding and made available for soybean community.
5. 6 populations were developed or are under development for gene mapping and breeding, utilizing the newly identified genetic resources.
6. Early- and mid-season flooding tolerances were found to share some common mechanisms and genetics; however, many differences were also indicated. A low correlation of genotypic means was observed between early and mid-season flooding stresses.
7. New flooding-tolerant germplasm: a flooding tolerant and high-yielding line (R16-45) at MG V is being tested in the USDA Uniform Preliminary test MG5L.Pre-foundation seeds of this line were grown in 2019. Some other promising lines, such as lines of S12-1362, R04-342 and R07-6669, are in the process of being validated and released as conventional high-yielding germplasm with flooding tolerance.
8. One breeding population is being advanced (F4 generation) to incorporate the 4 identified flooding-tolerance genes into an elite high yielding MG V breeding line. The final products (high-yield and flooding-tolerant lines) will be selected in 2021.
9. Created 4 large F3 populations derived from elite domesticated soybean × flooding-tolerant wild soybean accessions for large scale (multiple acre) grow-out and selection of desirable F3 plants (flooding tolerant and acceptable agronomic traits) in 2020.
10. A new gene (*WLT1*) was cloned to regulate flooding tolerance through modification of soybean roots and was successfully incorporated into an elite soybean cultivar by marker-assisted backcrossing by Nguyen group at the University of Missouri. The new gene incorporation line was found to have >40% more yield under flooding stress in the elite background. This line will be released as flooding-tolerant/high-yielding germplasm. This gene was also found to improve yield by 30% and 35% under drought and low-phosphorus conditions.
11. Effects of flooding on yield were quantified for the Delta region and >27% yield reduction can be expected for 2-day of flooding.
12. Best management practice was recommended to farmers: raised-bed production strategy can protect yield of 10-15% than the flat-bed.
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| Did this project meet the intended Key Performance Indicators (KPIs)? List each KPI and describe progress made (or not made) toward addressing it, including metrics where appropriate.  |
| Proposed Key Performance Indicators:1. At least five flood tolerant soybean germplasm lines are identified for early-season flood stress in 2020. These lines will be used for improving flood tolerance for early-season flood stress and in gene discovery.

WE identified 12 exotic and 14 wild soybean lines across different location. 1. At least two new genes are identified for flood tolerance and the associated DNA markers will be developed for marker-assisted selection in 2020.

We identified 6 genes for flooding tolerance and developed the DNA for marker-assisted selection.1. At least one soybean line is released as flood-tolerant and high-yielding (within 90% of the commercial checks under optimum conditions) germplasm line in 2021.

We released 1 germplasm line (R16-45) as flood-tolerant and high-yielding to the soybean community in 2019. We have 3 lines are being validated and released in near future.1. The benefit of best management practice (raised beds) in flood tolerance at the early-season is confirmed by the end of 2020 and recommendations for farmers are made.

Best management practice was recommended to farmers: raised-bed production strategy can protect yield of 10-15% than the flat-bed. 1. Incorporation of flood tolerance genes into high-yielding soybean germplasm using the developed DNA markers by the end of the project in 2022.

1 breeding population is being advanced (F4 generation) to incorporate the 4 identified flooding-tolerance genes into an elite high yielding MG V breeding line. The final products (high-yield and flooding-tolerant lines) will be selected in 2021.1. At least two advanced flood tolerant and high yielding soybean germplasm lines are transferred to industry and used as parental stock to develop commercial varieties by 2025.

Currently, we are in the discussion with the major seed company (BASF) for flooding-tolerant germplasm transfer and application of gene-editing technique in a major gene to improve flooding tolerance. |
| Expected Outputs/Deliverables - List each deliverable identified in the project, indicate whether or not it was supplied and if not supplied, please provide an explanation as to why. |
| 1. New genetic resources from exotic and wild soybean to increase genetic diversity for flood tolerance (**Supplied**)
2. DNA markers for molecular breeding (**Supplied**)
3. Improved high-yielding and flooding-tolerant germplasm with stable flood tolerance (>8 bu/ac advantage under moderate to severe flooding) (**Supplied**).
4. Quantification of yield loss and seed quality reduction from flooding to aid in field planning and replant decisions (**Supplied**)
5. Best management practices to mitigate soybean yield loss for flooding-prone areas (**Supplied**)
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| Describe any unforeseen events or circumstances that may have affected project timeline, costs, or deliverables (if applicable.) |
| The 2019 severe flooding event ruined experiment in MS. We need repeat evaluation of the effects in yield protection of raised-bed practice for the newly developed flooding tolerant/high yielding lines in 2020. |
| What, if any, follow-up steps are required to capture benefits for all US soybean farmers?Describe in a few sentences how the results of this project will be or should be used. |
| The Team will engage private breeders in collaborative activities to utilize the new materials. We will publish findings, report activities at stakeholder meetings/workshops, host field days to communicate findings. Currently, we are in the discussion with the major seed company (BASF) for flooding-tolerant germplasm transfer and application of gene-editing technique in a major gene to improve flooding tolerance. Unlike disease resistance, flooding tolerance cannot protect yield 100% under the stress. It only allows plants to yield relatively more under the stress. Thus, efforts in long-term are needed to identify more genetic resources and stack them into the current elite germplasm pool to develop stronger tolerance. With continued support by USB, this technology would become available to USA farmers up to 10 years ahead of other soybean growing countries. |
| **List any relevant performance metrics not captured in KPI’s.** |
| 1. We cloned 1 major flooding tolerance gene and help us understand the regulatory mechanism of flooding tolerance in soybean, which will allow us to precisely edit the soybean genome to develop better flooding tolerant lines.
2. We started a new breeding strategy to utilize wild soybean lines, which will allow us to incorporate better genetic resource (wild better than cultivated in flooding tolerance) into elite lines in a much faster pace.
3. We found that some drought tolerant lines showing very good flooding tolerance and the major flooding tolerance gene can improve yield under drought. It suggests drought tolerance and flooding tolerance interact with each other and breeding for tolerance to either trait may have benefit for the other.
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| **Non-technical report (this information will be posted to website in place of above report):** |
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