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| Please use this form to clearly and concisely report on project progress. The information included should reflect quantifiable results that can be used to evaluate and measure project success. Comments should be limited to the designated boxes. Technical reports, no longer than 4 pages, may be attached to this summary report. |
| Project Number:  |  |
| Project Title:  | Southern Root-Knot Nematode in Maturity Group 4 Soybean: Characterization of Resistance Mechanisms and Breeding for Resistance |
| Organization:  | Univ. of Ark. System, Div. of Ag |
| Project Lead Name: | Travis Faske |
| Report Date: | Mar 15 to Jun 15 |
| **In the Progress Summary section below, please provide a brief summary of project progress in lay language that will be shared publicly in the** [**National Soybean Checkoff Research Database**](https://www.soybeanresearchdata.com/)**. Do not include any confidential or proprietary information. If no lay language is provided, the contents of this entire report will be published in the** [**National Soybean Checkoff Research Database**](https://www.soybeanresearchdata.com/)**.** |
| Progress Summary (in non-proprietary lay language suitable to be shared publicly): |
| The southern root-knot nematode (SRKN) is an important, yield-limiting pathogen of soybean in the Mid-Southern U.S. This project was designed to determine how different SRKN-resistance sources affect nematode maturity, reproduction, and galling and develop SRKN-resistant MG4 soybean varieties. A time course study on nematode maturity on PI lines is being investigated by individual labs in LA and AR. Recombinant inbred lines for major and minor QTL resistance to SRKN are be increased in the field to be used for marker genotyping and mechanism of resistance in SRKN maturity. The main goal by the genetics group is to develop near isogenic lines with high yield and resistance to SRKN. The breeding programs in MO and AR have advanced germplasm from SRKN-resistant pedigrees at various stages of development from recent crosses to variety release.  |
| Detailed Progress Status – Expand upon the above section. What key activities were undertaken and what were the key accomplishments during this reporting period? List each key deliverable from the proposal and describe progress made (or not made) toward achieving it, including metrics were appropriate. |
| **Obj. 1: Characterization of the mechanism of resistance to SRKN. (Faske and Watson)*** A time-course nematode development study is being repeated with 3 newly identified maturity group 4 resistant lines (PI 567516C, PI438489B, NIL-PI), a resistant control (Forrest), and two susceptible controls (Magellan, NIL-Mag). Overall, preliminary results from this time-course nematode development study suggest that newly identified maturity group 4 resistant lines may suppress nematodes by delaying the progression of nematode development from an infective J2-stage nematode to a J3/J4 nematode. (Watson)
* A second time course study is in progress with entries: Magellan, Forrest, PI 567516C, PI 567305, PI 438489B, two NILs for Chr. 10 QTL (R vs S) derived from Magellan x PI 438489B. (Faske) Furthermore, thirteen entries from MO and being screened for susceptibility to the southern RKN in a field screen near Kerr, AR (Obj. 3).

**Obj. 2: Genetic characterization and development of functional markers for new sources of resistance to SRKN. (Nguyen)*** Identification of RILs for Chr. 10 & Chr. 13 QTLs - In this quarter, we identified 38 RILs developed from a cross of Magellan × PI 438489B using two markers of Chr. 13 (BARC-010501-00676 and Sct\_033F) and two markers of Chr. 10 (BARC-065469-19494 and BARC-018101-02517). Contrasting RILs were selected with a combination of QTL on Chr.10 + Chr. 13, only Chr.13 QTL, only Chr. 10 QTL. These RIL lines were planted in the research field of University of Missouri for genotyping and to develop NILs for Chr. 13 QTL. We shared the seeds of contrasting RILs and parents to the University of Arkansas for further seed increase.
* Important RKN lines seeds were shared with University of Arkansas and Louisiana State University for gall evaluation and repeat the RKN mechanism study.

We planted seeds of the major RKN lines such PI 438489B, PI 567305, Forrest, PI 567516C, Magellan, and NILs at University of Missouri & Arkansas for seed increase**Obj. 3: Development of breeding populations and MG4 soybean varieties with resistance to SRKN.** University of Arkansas: Caio Vieira* Preparation of soybean breeding lines and populations for planting is fully completed (cleaning, packaging, and boxing seeds). Yield and research trials have been planted in Marianna, Pine Tree, Rowher, Stuttgart, DeWitt, and Fayetteville. Progeny rows have been planted in Kibler, AR, and all three dates of the crossing block have been planted in Fayetteville, AR.
* R18-10919 and R19C-1081 high-yielding advanced lines are being tested in Pre-commercial yield trials and the University of Arkansas System Division of Agriculture’s Variety Testing Program in 2023. Additionally, R19C-1081 is being evaluated in the UP4E USDA preliminary yield trials. These two lines were screened for SRKN resistance in 2022 in field and greenhouse conditions and have shown higher levels of resistance.

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| Name | Pedigree | Yieldbu/ac | Relative Yield% Check | Galling(0-5) | Root Galling Score(%) |
| R18-10919 | R11-2282/R12-3684 | 64 | 85 | 1.2 | 3.8 |
| R19C-1081 | S09-13635/R11-328:82 | 63 | 98 | 1 | 11.4 |

* Molecular marker evaluation identified 59 F1 individual plants derived from SRKN-resistant parents as true hybrids. Materials are currently in F2 and will be advanced until F4 generation in the off-season nursery in Puerto Rico.
* In total, 144 EG2 rows were planted in Fayetteville, AR. At maturity, rows will be visually selected based on pod load, uniformity, and desired agronomic traits and harvested using the modified pod pick method for EG3:EG4 generation advancement in 2024.
* A total of 304 F4:5 progeny rows were planted in Kibler, AR. At maturity, rows will be selected based on pod load, uniformity, and desired agronomic traits. Selected materials will be advanced to preliminary yield trials in 2024.
* Southern root-knot nematode marker screening is currently ongoing in 43 of our pre-commercial materials (PCMs). Results are pending.
* Between 30 to 40 new hybridizations between high-yielding and identified SRKN-resistant lines will be performed during our 2023 crossing season. A total of 19 SRKN-resistant parents were entered in our 2023 crossing block. These lines were developed in Arkansas, Missouri, Virginia, and North Carolina.
* Additionally, 47 RILs developed by the University of Missouri breeding program were planted for seed increase purposes in Stuttgart, AR. These RILs are going to be investigated for potential new genetic sources and mechanisms of resistance to SRKN.

Grover Shannon, University of Missouri* The planning and planting of all field trials have been successfully completed at the University of Missouri- Fisher Delta Research, Extension and Education Center. Two new soybean lines, S18-6013 and S19-19923HOLL were released, both possessing resistance to root-knot nematode. A total of 11 lines with resistance to RKN, including released lines and elite lines from the University of Missouri - Fisher Delta Research, Extension and Education Center (S09-13185C, S11-17025, S16-11644C, S16-12774C, S16-7922C, S18-6013C, S19-10701C, S19-12459C, S19-14797C, S19-6097C, and S19-7867RR), will be screened for their degree of resistance and virulence towards RKN in Arkansas.
* Root knot nematode resistant line S18-6013 with other desirable traits has shown very high yield potential. It ranked #1 in yield out of 30 plus entries in the Southern Regional Uniform Early Group V trials in both 2021 and 2022. It even yielded as well as commercial Xtend checks at several locations after exposure to off target dicamba in Mississippi, Arkansas, and Missouri.

**2023 Releases**: Based on excellent performance over 30 to 40 environments of yield tests, two new conventional lines maturity group V (MGV) with resistant root knot nematode, other nematodes, diseases, and other favorable traits were released in 2023 as follows:

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|  | **S18-6013** | **S19-19923HOLL****(80.7% Oleic and 2.0 % Linolenic)** |
| **Mean**  | 69.2 bu/ac | 58.8 bu/ac |
| **%NXT** | 117.5 | 99.7 |
| **% XT**  | 103.2 | 90.6 |
| **# Environments** | 42 | 33 |

Trait abbreviations confirmed by molecular markers are as follows: RKN, SCN, SC, stem canker; PRR, phytophthora root rot; CRT, charcoal rot; SDS, sudden death syndrome; FLS, frogeye leaf spot; BSR, brown stem rot; MET, metribuzin tolerant; HOLL, high oleic low linolenic acid oil. Mean: Weighed average across different environments NXT: non Xtend commercial checkXT: Xtend commercial check* **Promising lines in regional test: Thirty-two** (32) high-yielding breeding lines were entered into the 2023 regional uniform trials. They will be screened three species of root-knot nematode: *Meloidogyne incognita*, *M.* *arenaria,* and *M.* *javanica*.

**Advanced yield trials:** A total of 72 advanced breeding lines in our 2023 advanced yield trials (AYT) were planted in 4 local environments and 6-8 locations across different states (OH, IL, AR, LA, IN, MO, TN). Maturities vary from early Group IV to early group V. One of the test sites includes Clarkton, MO with an infestation of root knot nematode. Breeding lines were genotypically characterized using molecular markers tightly linked to genes conferring resistance RKN. The findings indicated that out of the 72 advanced soybean lines, 11 were identified as resistant to RKN. Furthermore, a majority of these 11 lines were resistant against SCN, specifically possessing the resistance genes *Rhg1-a*, *Rhg1-b*, and *Rhg4* as follows:

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| **Name** | **SCN** | **RKN** |
| S21-5391 | R(*Rhg1-b*) | R |
| S21-23988 | S | R |
| S21-5337 | R(*Rhg1-b*) | R |
| S21-23528 | S | R |
| S21-22067 | R(*Rhg1-b*) | R |
| S21-24201 | R(*Rhg1-a*) | R |
| S21-5901 | R(*Rhg1-a* and *Rhg4*) | R |
| S21-15672 | R(*Rhg1-a*) | R |
| S21-11972 | R(*Rhg1-a*) | R |
| S21-23086 | S | R |
| S21-17588 | R (*Rhg1-a* and *Rhg4*) | R |

* **Preliminary yield trials:** A total of 1,224 soybean late III to Late IV breeding lines were entered into our 2023 preliminary yield tests (PYT. They) were planted in Portageville, MO (3 local environments) and 4 other locations in AR and MO. At least half of the 1,224 lines have one root knot nematode resistant parent.
* **Progeny Rows:** A total of 298 bi-parental populations (~29,800 F4:5 lines) will be grown in progeny rows this 2023 summer. Most of these populations are derived from nematode-resistant pedigrees. The planting will be scheduled in the next couple of days as soon as the soil moisture is achieved.
* **Breeding population advancement:** We have 137 bi-parental populations derived from nematode-resistant pedigree currently being advanced in off-season nurseries in Puerto Rico and Costa Rica and will return as progeny rows (F4:5) in summer 2024.
* **New crosses in 2023 season**:Twenty-eight parents with RKN resistance were entered in our crossing block. We will attempt 120 new crosses between RKN resistant parents and elite breeding lines.
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