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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:  | University of Arkansas |
| Project Lead Name: | Travis Faske |
| Report Date: | Jun 15 to Sep 15, 2023 |
| **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. To better understand resistance in soybeans and develop SRKN resistant lines three objectives were designed: determine how resistance is converged in resistant lines against SRKN, utilize molecular tools to identify lines with desired traits for resistance, and developing lines with resistance to the SRKN.
* Data from a time course study is being analyzed in LA and repeated in AR.
* Identify lines that have individual quality traits to better understand traits responsible for nematode resistance.
* Plant development of SRKN yield trails and progeny rows is ongoing uneventfully. Breeders’ notes and morphological trait evaluations are underway for all research plots. Early-generation materials have been assessed for desirable traits and will be monitored until they reach full maturity. Crossing block hybridizations were finalized, and harvest will commence in mid-September. Plots will be manually harvested when they reach full maturity.
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| 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)*** Data were analyzed from a time-course nematode development study with 2 newly identified maturity group 4 resistant lines (PI 438489B, NIL-PI 438489B x Magellan) a resistant control (Forrest), and two susceptible controls (Magellan, NIL-Mag). Fewer infective stage juveniles entered the roots of the 2 resistant lines and resistant control throughout the course of the study relative to that of the susceptible controls, resulting in more J3/J4-stage and adult female nematodes in the root system by 21 days after inoculation. Overall, data from this time-course nematode development study suggest that newly identified maturity group 4 resistant lines may suppress nematodes by reducing root invasion by infective stage juveniles and/or delaying post-penetration development from an infective J2-stage nematode to an adult female. (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 is underway. (Faske). These experiments take two months to complete and should be completed in the next quarter. Data analyses may be completed in the next quarter. Furthermore, thirteen entries from MO were rated for root galling in August and several had low galling compared to the susceptible control (Obj. 3).

**Obj. 2: Genetic characterization and development of functional markers for new sources of resistance to SRKN. (Nguyen)*** Seeds of the important RKN lines were shared with University of Arkansas and Louisiana State University to study the gall evaluation and understand the RKN resistance mechanism. Simultaneously, we are increasing the seeds of these lines in the field for future genotyping and phenotyping studies as well as to be share with collaborators to study resistance mechanism.
* Our long-term goal is to develop NILs for major (Chr. 10) and minor QTL (Chr. 13) for SRKN resistance and to achieve that we have identified 38 RILs generated from a cross of Magellan × PI 438489B using markers from Chr. 10 and Chr. 13. Currently, at least 10 plants from each RIL are growing in the field of University of Missouri, Columbia and DNAs were extracted from the contrasting RILs (with a combination of QTL on Chr.10 + Chr. 13, only Chr.13 QTL, only Chr. 10 QTL) and genotyping is in progress.
* After seed harvesting from these RILs, the RIL lines will be shared with breeders to include in marker assisted selection program for SRKN resistance and will be shared with pathologists to understand the underlying genetic mechanism of resistance.

**Obj. 3: Development of breeding populations and MG4 soybean varieties with resistance to SRKN.** University of Arkansas: Caio Vieira* Evaluation of morphological traits such as maturity, height, and flower color are being taken in selected yield tests. Yield trials and progeny rows are going through vegetative and reproductive stages without major concerns. Breeders’ notes are underway in all locations (Marianna, Pine Tree, Rowher, Stuttgart, DeWitt, Kibler, and Fayetteville) and will continue until full maturity is reached. Purity seed plots in Fayetteville have been continuously evaluated for off-type identification and removal.
* 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.
* Early generation materials F2 and F4:5 were planted in Fayetteville and Kibler, AR. Materials are growing uneventfully, and initial breeder notes were taken the last week of August. Visual selection will continue for pod load, uniformity, and desired agronomic traits and will be harvested for generation advancement in 2024.
* In-house southern root-knot nematode marker screening is currently ongoing in 43 of our pre-commercial materials (PCMs). Results are pending. In addition, approximately 1,200 breeding lines (2023 preliminary, finals, and pre-commercial) entries will be genotyped utilizing a proprietary marker panel by Corteva Agriscience. Results should be available by the end of October.
* Around 50 hybridizations between high-yielding and identified SRKN-resistant lines were performed during our 2023 crossing season. The first round of manual harvest of crosses will begin on September 15th and continue until all plods have reached full maturity. F1 seeds will be shipped to Puerto Rico and will be advanced until F4.
* Finally, 47 RILs developed by the University of Missouri breeding program continue growing in Stuttgart, AR, for seed increase purposes. Manual harvest of individual plots will take place at full maturity.
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| University of Missouri: Grover Shannon**2023 Releases**: Based on excellent performance over 30 to 40 environments of yield tests, two new conventional lines maturity group V (MGV) with resistant to multiple 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)** |
| **RM** | 5.2 | 5.0 |
| **Traits** | High Oil, SCN, RKN, SC, SDS, FLS, CRT, MET | HOLL, SCN, RKN, RN, PRR, SDS, SC, CRT, BSR, MET, Salt |
| **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, root knot nematode; SCN, soybean cyst nematode; 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. and HOLL, high oleic low linolenic acid oil. Mean: Weighted average across environmentsNXT: non Xtend commercial checkXT: Xtend commercial check**2. Promising lines in regional test:** Thirty-two (32) lines high-yielding breeding lines are in the 2023 regional trials from late group III to early group V. They will be screened for soybean cyst nematode (SCN) several SCN Hg-types; reniform nematode (RN), and SKRN. Each of the 32 lines has resistance to one or more nematode species for SCN, SRKN, and RN.**3. 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). Thel yield trials have reached the R4/R6 growth stages. Susceptible lines at the Clarkton, MO location with a history of infestations of both SCN and RKN are showing symptoms of root knot nematode injury. Because of the presence of SCN and RKN, performance of resistant versus susceptible genotypes can be accessed. The 72 breeding lines were genotypically characterized using molecular markers tightly linked to genes conferring resistance to soybean cyst nematode (SCN) and southern root knot nematode (SRKN). Results revealed that 11 soybean lines conferred resistance to the soybean cyst nematode with the r*hg1a* allele, while 14 lines exhibited the r*hg1b* gene. Two specific lines, namely S21-5901 and S21-17588, were identified to have both *Rhg1a* and *Rhg4* genes plus the root knot nematode resistance allele. Marker analysis indicated that 8 advanced lines had either ***Rps1a*** or ***Rps1b*** plus the root knot nematode resistant gene, Additionally, marker analysis identified 11 soybean lines with resistance to SRKN. In summary, nearly 40% of lines in the MO Delta Center AYT soybean breeding trials either have resistance to SCN, RKN or both nematode species based on genetic marker analyses. Based on satisfactory yield from local environments and other states, selected lines will be entered into the regional trials. **4. Preliminary yield trials:** A total of 1,224 late III to Late IV soybean breeding lines in our 2023 preliminary yield tests (PYT) were planted in Portageville, MO (3 local environments) and 4 locations in AR and MO where off-target damage to Dicamba is less of a problem. Yield trials have reached the R4 to R6 growth stages. More than 60% of the 1,224 lines have at least one nematode resistant parent. Selected lines will be placed in our advanced trials in 2024 AYT based on satisfactory yield results. **5. Progeny Rows:** A total of 208 bi-parental populations (~20,800 F4:5 lines) are being evaluated in progeny rows and compared to widely grown commercial ExtendFlex checks. Selected rows from different populations will be harvested based on yield potential and other agronomic traits. Then, advanced to 2024 preliminary yield tests. Most of these populations are derived from nematode-resistant pedigrees. **6. Breeding population advancement:** We have about 100 bi-parental populations derived from nematode-resistant pedigrees currently being advanced in off-season nurseries in Puerto Rico and Costa Rica and will return as progeny rows (F4:5) in summer 2024. |