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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:  | Screening soybean germplasm and breeding soybeans for flood tolerance |
| Organization:  | University of Missouri-Fisher Delta Research Center |
| Principal Investigator Name: | Dr. Grover Shannon |
| Other investigators: | Drs. M. Liakat Ali, Jeff Edwards, Tessie Wilkerson, and David Moseley, Caio Canella Vieira |
| Report Period: | September 16, 2022 to December 15, 2022 |
| Project Status: On-going(What key activities were undertaken and what were the key accomplishments during this quarter? Please use this field to clearly and concisely report on project progress).  |
| **MISSOURI:****1. Evaluation of breeding lines for flooding tolerance and yield to develop commercial varieties.** **i) Advanced yield trials**: A total of 36 breeding lines in MG-4 (18 lines) and MG-5 (18 lines) along with commercial checks were grown for flooding tolerance and seed yield. The lines were exposed to flooding stress during R2 (mid-season) for 8 days.In advanced MG4 yield trial, four breeding lines (S19-14284, S19-10701C, S19-17693, and S19-17313) showed flood damage scores (FDS) from 1.0 to 1.5 on a scale of 1 to 5 (1=no apparent flood damage and 5=almost all plants are dead) while the commercial check had a FDS of 2.5. We could not evaluate the flooded field yield (of all tests) because after planting (delayed planting), there was a heavy rain and the soil remained wet (clay soil) for a prolonged period, which resulted in poor stands. Also, some late maturing lines were damaged by unexpected frost in October. However, these lines yielded 82 to 117 % of the commercial check under non flooded conditions (Table 1). It is important to note that there was extensive damage from volatile Dicamba herbicide spreading from adjacent farmer fields which resulted in yield reduction among these non-tolerant lines.In the advanced MG5 yield trial, five breeding lines5 (S17-1146, S19-14797, S19-17893, S19-18135L and S18-9258) had FDS from 1.2 to 1. while the check had a score of 2.0. These lines yielded 85 to 112 % of the check under non-flooded conditions and will further be evaluated under flooding during the 2023 season. The susceptible check S99-2281 showed a FDS score 2.8 and yielded 67 b/a under non flooded condition while the tolerant check S12-1362 had a FDS of 1.3 and yielded 67 b/a (Table 1). It is important to note that there was extensive damage from volatile Dicamba herbicide spreading from adjacent farmer fields which resulted in yield reduction among these non-tolerant lines.**Table 1**. Selected flood tolerant breeding lines from 2022 advanced yield trials (flood) and their flood damage score (FDS) and yield performance under non flooded condition

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Maturity** | **Name** | **Pedigree** | **Flood Damage Score(FDS)** | **Yield non flooded (b/a)** | **% Commercial Check** |
| MG4 | S19-14284 | S12-1362 x S13-3851 | 1.3 | 75.8 | 117 |
| MG4 | S19-10701C | S15-17108 x DA10x30-09F | 1.3 | 70.2 | 109 |
| MG4 | S19-17693 | S13-1955 x S16-16842 | 1.3 | 52.8 | 82 |
| MG4 | S19-17313 | S14-16235 x S13-3851 | 1.5 | 58.5 | 91 |
| MG4 | P45T88E | Commercial Check | 2.5 | 64.6 | 100 |
| MG5 | S17-1146 | S11-16653 x S13-10592 | 1.2 | 55.9 | 88 |
| MG5 | S19-14797 | S11-16653 x S15-11985 | 1.3 | 71.4 | 112 |
| MG5 | S19-17893 | S14-16267 x V12-0045 R2 | 1.5 | 56.7 | 89 |
| MG5 | S19-18135L | G13LL-44 x S12-4718C | 1.5 | 71.5 | 112 |
| MG5 | S18-9258 | S11-17025 x LG13-3925 | 1.5 | 54.6 | 85 |
| MG5 | P49T62E | Commercial Check | 2.0 | 63.9 | 100 |
| MG5 | S99-2281 | Susceptible Check | 2.8 | 67.0 |  |
| MG5 | S12-1362 | Tolerant Check | 1.3 | 67.0 |  |

**ii) Preliminary yield trial:** A total 28 MG-5 breeding lines were subjected to flooding stress during R2 stage for 8 days, of which, lines S21-4942, S21-4926, S21-21170 and S21-21192 showed FDS of 1.0 while the commercial check had a score of 2.0. The selected lines yielded 101 to 147 % of the commercila check under non-flood conditions. The susceptible check S99-2281 had a FDS score of 2.8 and yielded 33.3 b/a under non-flooded conditions while the tolerant check S12-1362 had a FDS of 1.0 and yielded 40.1 b/a (Table 2). It is important to note that there was extensive damage from volatile Dicamba herbicide spreading from adjacent farmer fields. The selected lines will be further evaluated in 2023.**Table 2**. Selected flood tolerant breeding lines from 2022 preliminary yield trials (flood) and their flood damage score (FDS) and yield performance under non flooded conditions

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Maturity** | **Name** | **Pedigree** | **Flood Damage Score (FDS)** | **Yield non flooded (b/a)** | **% Commercial Check** |
| MG5 | S21-4942 | R07-6669 x S15-3772RY | 1.0 | 51.8 | 147 |
| MG5 | S21-4926 | R07-6669 x S15-3772RY | 1.0 | 44.1 | 125 |
| MG5 | S21-21170 | S11-16653 x R04-342 | 1.0 | 35.7 | 101 |
| MG5 | S21-21192 | S11-16653 x R04-342 | 1.0 | 40.1 | 114 |
| MG5 | P49T62E | Commercial Check | 2.0 | 35.3 | 100 |
| MG5 | S99-2281 | Susceptible Check | 3.0 | 33.3 |  |
| MG5 | S12-1362 | Tolerant Check | 1.0 | 40.1 |  |

**2. Evaluation of selected tolerant and sensitive lines in flooded and non-flooded fields:** A set of 20 lines, one half of which have shown flood tolerance and other half of the lines are flood sensitive, were exposed to flooding stress during R2 (mid-season) for 8 days. The tolerant group had average FDS of 1.7 while sensitive group had mean FDS of 3.2 and the checks had a mean FDS of 3.5. The main objective of the test is to assess the impact of flooding stress on the seed quality and seed composition. Because of poor crop stand and frost damage under flooding, the flooded and non-flooded comparative yield among lines could not be done this year. Also, the effects of flooding stress on seed quality and seed composition could not be done this year. However, the whole experiment will be repeated in 2023.**3. Screening of recently developed elite lines for flood tolerance:** A set of97 breeding lines, recently developed at the University of Missouri-Fisher Delta Research Center and at the University of Arkansas and six checks (5 commercial cultivars and one sensitive line) were exposed to flooding stress during R2 (mid-season) for 8 days. Nine University of Missouri breeding lines, including S16-15896C, S17-1494C, S17-1695, S17-1980C, S19-14298, S19-17313, S19-17667, S19-17887, and S12-1362 (tolerance check) and 4 University of Arkansas lines, R18-3332, R18-9794, R18C-11127, and R18C-144 displayed very good flood tolerance with flooding damage scores from 1.0 to 1.2. In comparison, the sensitive check S99-2281 had damage score of 2.2 while the commercial checks, AG 43XF2, AG 46X6, AG 5335, AG 53XF2, and AG 54XF0, had damage scores ranging from 2.3 to 3.7.**4. Missouri commercial variety testing for flood tolerance.** During the 2022 season, a set of 63 commercial varieties developed by 14 different seed companies were evaluated under flood stress during R2 (mid-season). A total of 11 varieties had FDS from 1.0-1.5. They are DG 46E10, DG 48E49/STS, DG 48E60, and DG 48F33/STS from Delta Grow seed company; S45ES10, S46ES91, and S49EN12 from Dyna-Gro seed company; 40N02E and 43N04E from Nutech seed; AV47Y6E from AgVenture seeds and PL2E422 from FBN Paloma seeds. **5. Testing of new breeding lines in progeny testing** **nursery:** About 700 F4:5 single plant progeny lines were grown in single progeny rows in 2022. A total 85 lines high-yield potential from 12 crosses were selected and harvested for further evaluation for flood tolerance. These lines will be yield-tested under flooded and non-flooded conditions in 2023.**6. Breeding populations under generation advance:** Four breeding populations are being advanced from F1-F4 in Puerto Rico and Costa Rica. About 400 F4:5  breeding lines will be grown in progeny rows for selection in 2023. **7. New crosses in 2022:** Four new crosses between flood tolerant PIs/lines and elite breeding lines were made to develop new high-yielding flood tolerant varieties. The F1 seeds of these crosses were sent to the winter nursery in Costa Rica where the crosses will be advanced to F4 and F4:5 single plant selections will be return to Portageville to evaluate in progeny rows during the summer 2024.**ARKANSAS:****1.** **Evaluation of intermediated breeding lines for yield and flood tolerance:** In 2022 season, a total of 45 MG4 and 13 MG5 intermediated lines with diverse flood-tolerant pedigrees were evaluated along with commercial checks for yields and agronomic traits in four intermediate tests (FLM4E. FLM4M, FLM4L, and FLM5E) at five locations of Arkansas. Meanwhile, these lines were also evaluated flood tolerance at R1/R2 stages with 8-day flooding stress at Stuttgart, AR. Based on the data of yield and flood tolerance, 19 lines (R20-189, R20-262, R20-648, R20-203, R20-353, R20-417, R20-1429, R20-110, R20-216, R20-130, R20-342, R20-306, R20-371, R20-393, R20-1357, R20-1475, and R20-1482) with high yield or flood tolerance trait were selected for 2023 advances yield trials and flood screening tests.**2. Evaluation of preliminary breeding lines for yield and flood tolerance:** A total of 37 MG5 preliminary breeding lines derived from high-yield and flood-tolerant parents were evaluated for yields and agronomic traits in one preliminary test (FLP5E) at three Arkansas locations. At the same time, these lines were also evaluated flood tolerance under 8-days flooding stress at Stuttgart, AR. Based on both yield and flood screening data, eight lines (R21KB-05096, R21KB-05122, R21KB-05640, R21KB-05533, R21KB-05522, R21KB-04743, R21KB-01732, and R21KB-05083) were selected for next year advanced yield tests and flood screening trials.**3. Evaluation of Arkansas elite lines for yield and flood tolerance:** A set of 50 Arkansas elite lines with diverse traits such as yield, seed composition, drought tolerant, disease resistance, and food grade, were evaluated for yields and agronomic traits in four PCM tests (PCM4E, PCM4L, PCM5E, and PCM5L) at six Arkansas locations. Eleven lines (R18-14147, R19C-1081, R19C-1012, R19C-1035, R18C-13665, R18-14502, R18-14272, R18-10491, R19C-3194, R19C-3085, and R18-9782) with high yield, as potential release varieties/germplasm, were selected for 2023 regional trials. At the same season, these lines were also evaluated flood tolerance under 8-days flooding stress at Stuttgart, AR. Six lines (R19-43217, R18-11839, R18-14753, R18-13337, R18-13309, and R18-67F) showed high tolerance to flooding with low flood damage scores FDS = 1.3 to 3.7. **4. Yield evaluation of flood tolerant and sensitive lines:** Eighteen flood tolerant and sensitive germplasm/lines developed from AR, MO, and NC and two commercial checks were evaluated for flood tolerance and yield under two side-by-side flooded and non-flooded tests with three replications in Stuttgart, AR. The flooded test was treated 4-days flooding at R1/R2 stages. The test mean of non-flooded test (55.2 bu/ac) was significantly different that of flooded test (29.0 bu/ac) (p < 0.0001). The yields of four tolerant lines (R11-6870, S17-1146, R16-45, and N11-352) were higher than 40.0 bu/ac under 4-day flooding stress. Line R11-6870 showed the best flood tolerant with the highest yield 44.5 bu/ac and the lowest yield loss percentage 23.9%. The sensitive line S13-2743C had the largest yield loss percentage with 76.6% and two commercial checks AG49X6 and AG55X7 had the higher yield loss percentage with 49.2% and 59.6%, respectively.**5. Flood tolerance crossing and population advance:** In 2022 summer, 16 new crosses were made between flood-tolerant germplasm/lines and high-yielding germplasm/lines at Fayetteville, AR. The successful F1 seeds were harvested in full season and have been sent to winter nursery. Additionally, more than 10 breeding populations (F1 to F4 generations) with flood-tolerant pedigrees were advanced in Fayetteville, AR and winter nurseries in Chile and Puerto Rica. **6, Evaluation of Arkansas commercial varieties for yield and flood tolerance:** A total of 83 commercial varieties (58 MG4 and 25 MG5) developed from private companies were evaluated for yield and flood tolerance in the four strip-plot Official AR Variety Trials (VT4 non-flood, VT4 flooded, VT5 non-flood, and VT5 flooded) with 5-days flooding tests and non-flooding tests side-by-side at V2/3 growth stages. in Stuttgart, AR. For the VT4 flooded test, 58 commercial varieties showed significantly different response to 5-days flooding stress (p=0.0029) with flood damage score (FDS) range from 2.3 to 6.0. Two commercial varieties and line (Integra 74142NS and AG46XF3) exhibited high flood tolerance with the lowest FDS = 2.3 comparing 4.2 FDS test mean. For the VT5 flooded test, 25 commercial varieties showed significantly different response to 5-days flooding stress (p=0.0001) with flood damage score (FDS) range from 3.0 to 6.7. Three commercial varieties and line (DELTA GROW 52XF22/STS, Local LS5614XF, and Local ZS5429E3) had high flood tolerance with the lowest FDS = 3.0 comparing 4.5 FDS test mean. Meanwhile, the yield evaluations of these four tests were completed and the results will be reported in the next quarter report.**MISSISSIPI:**OVT, flood germplasm and hill planted plots located at the MSU-DREC were evaluated for flood severity and incidence after flooding period. Data is being organized and analyzed for presentation. Due to later planting and late season weather at maturity the plots have not been harvested to date. Plans are to still try and get some harvest data if possible.  Data integrity will be determined after collection.**LOUISIANA:****1. Flood tolerance evaluation of elite lines from AR and MO**: A total of 102 breeding lines including 96 MG4 and MG5 lines developed by the University of Arkansas and the University of Missouri, and 5 commercial checks and one flood-sensitive check were evaluated for flood tolerance at R1/R2 stages in 5-feet single-row plots with 3 replications at the Red River Research Station in Bossier City, LA. 11 varieties showed a flood damage score (FDS) from 2.0-2.33 from a 1 to 5 scale (1=no apparent flood damage and 5=almost all plants are dead) which was a lower score than the first check (P52A05X with a score of 2.5). The average FDS for all five checks was 3.17. **2. Evaluation of commercial varieties for flood tolerance** A total of 118 varieties from the 2022 Louisiana soybean OVT trial was screened for flood tolerance at R1/R2 stages in 5-feet single-row plots with 3 replications at the Red River Research Station in Bossier, LA. The plots were under flooded conditions for 17 days (From August 11 until August 28). The flood tolerance scores (FDS) were taken with a 1-5 scale (with 0.5 increments) and (1=no apparent flood damage and 5=almost all plants are dead). * 1. **MG 3.0-4.4 Varieties**
		1. 19 varieties from seed companies and the University of Missouri were screened for flood tolerance. The average FDS was 3.18 ranging from 2.67-3.75. AG40XF1 had the lowest FDS at 2.67. Four other varieties had a FDS lower than 3.0 (AG43XF2, Dyna-Gro S43XS70, NK43-Y9XFS, and Progeny 4202XFS).
	2. **MG 4.5-4.7 Varieties**
		1. 40 varieties from seed companies and the University of Missouri were screened for flood tolerance. The average FDS was 2.12 ranging from 1.33 – 3.33. There were 15 varieties with a FDS less than 2.0 (Dyna-Gro S47XF23S, LS4795XS, Progeny 4798XF, Dyna-Gro S47XF52, LS4727XF, Progeny 4775E3S, 47E35, Armor 46-F13, Progeny 4505RXS, S16-5540R, Dyna-Gro S46XF31S, Dyna-Gro S46XS60, P46A20LX, Progeny 4604XFS, Progeny 4691XFS).
	3. **MG 4.8-4.9 Varieties**
		1. 28 varieties from seed companies and the University of Missouri were screened for flood tolerance. The average FDS was 2.43 with a range of 1.5-3.17. There were three varieties with a FDS score less than 2.0 (Progeny 4844XFS, S16-7922C, LS4826XFS)
	4. **MG 5.0-5.3 Varieties**
		1. 20 varieties from seed companies and the University of Missouri were screened for flood tolerance. The average FDS was 2.48 with a range of 1.5 – 3.5. Four varieties had a FDS score below 2.0 (Progeny 5150XFS, S18-6328C, P52A14SE, S16-15170C)
	5. **MG 5.4-6.0 Varieties**
		1. 11 varieties from seed companies and the University of Missouri were screened for flood tolerance. The average FDS was 2.55 with a range of 1.67-3.5. There were two varieties with a FDS lower than 2.0 (Progeny 5554RX, P54A54X)

**3. Yield evaluation of flood tolerant and sensitive lines:** Twenty flood tolerant and sensitive germplasm/lines developed from AR and MO are being evaluated for flood tolerance and yield under two side-by-side flooded and non-flooded tests with three replications (two 20 foot rows per plot) at the Red River Research Station in Bossier City, LA. The trial was flooded at the R1/R2 stages for 18 days (July 20 until August 7). The flood resistance scores were taken on August 12 with a 1-5 scale (with 0.5 increments). * 1. The non-flood trial had a higher average yield (31.38 bu/A) than the flooded trial (27.98 bu/A)
	2. **Non-flood trial**
		1. There were significant differences in yield among the 20 varieties (p<0.0001; α=0.05). There were 11 varieties that did not differ from the highest yielding variety with a range of 45.28 bu/A – 35.19 bu/A)

| **Level** |  |  |  |  |  |  |  |  | **Least Sq Mean** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| UA5014C | A |  |  |  |  |  |  |  | 45.279468 |
| S19-17313 | A | B |  |  |  |  |  |  | 44.041548 |
| R04-342 | A | B |  |  |  |  |  |  | 43.072530 |
| R06-4433 | A | B |  |  |  |  |  |  | 42.909241 |
| R11-6870 | A | B | C |  |  |  |  |  | 40.641792 |
| R16-45 | A | B | C |  |  |  |  |  | 40.450374 |
| S19-17667 | A | B | C | D |  |  |  |  | 39.888839 |
| AG 49X6 | A | B | C | D | E |  |  |  | 36.521570 |
| AG55X7 | A | B | C | D | E | F |  |  | 35.428470 |
| S12-1362 | A | B | C | D | E | F |  |  | 35.266009 |
| R07-6669 | A | B | C | D | E | F |  |  | 35.192090 |
| R18-14272 |  | B | C | D | E | F |  |  | 31.247126 |
| S13-1955C |  |  | C | D | E | F |  |  | 29.446244 |
| N11-352 |  |  | C | D | E | F |  |  | 29.016896 |
| S17-1146 |  |  |  | D | E | F | G |  | 27.108533 |
| S99-2281 |  |  |  |  | E | F | G |  | 24.697374 |
| S13-2743C |  |  |  |  |  | F | G |  | 23.321695 |
| N16-9211 |  |  |  |  |  |  | G | H | 15.934596 |
| N05-7380 |  |  |  |  |  |  |  | H | 6.185332 |
| N10-792 |  |  |  |  |  |  |  | H | 2.043202 |

* 1. **Flood trial**
		1. There were significant differences in yield among the 20 varieties (p<0.0001; α=0.05). There were five varieties that did not differ from the highest yielding variety with a range of 44.82-37.36 bu/A)

| **Level** |  |  |  |  |  |  |  |  | **Least Sq Mean** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| R11-6870 | A |  |  |  |  |  |  |  | 44.819147 |
| S19-17313 | A | B |  |  |  |  |  |  | 42.752979 |
| R04-342 | A | B | C |  |  |  |  |  | 40.575546 |
| S17-1146 | A | B | C | D |  |  |  |  | 37.791643 |
| AG55X7 | A | B | C | D |  |  |  |  | 37.364977 |
| UA5014C |  | B | C | D | E |  |  |  | 31.794210 |
| R07-6669 |  | B | C | D | E |  |  |  | 31.771294 |
| S19-17667 |  | B | C | D | E |  |  |  | 31.694185 |
| S13-1955C |  | B | C | D | E |  |  |  | 31.211991 |
| S12-1362 |  |  | C | D | E | F |  |  | 29.922921 |
| R16-45 |  |  | C | D | E | F |  |  | 29.189631 |
| R06-4433 |  |  | C | D | E | F |  |  | 28.599884 |
| AG 49X6 |  |  |  | D | E | F |  |  | 27.314568 |
| R18-14272 |  |  |  |  | E | F |  |  | 25.057930 |
| N11-352 |  |  |  |  | E | F |  |  | 24.566238 |
| N16-9211 |  |  |  |  | E | F | G |  | 20.934257 |
| S99-2281 |  |  |  |  |  | F | G | H | 18.147746 |
| S13-2743C |  |  |  |  |  | F | G | H | 18.054612 |
| N10-792 |  |  |  |  |  |  | G | H | 5.166877 |
| N05-7380 |  |  |  |  |  |  |  | H | 2.940353 |

* 1. Seed samples were collected and will be shipped to the University of Arkansas for protein/oil analysis.

**4. Screening of recently developed elite lines for flood tolerance:** A set of96 breeding lines, recently developed at the University of Missouri-Fisher Delta Research Center and at the University of Arkansas and six checks (5 commercial cultivars and one sensitive line) are included in the screening test. These lines are planted in 5-feet single-row plots in 3 replications. There were two sets on screening, including flooding at the V2 and R1/R2 growth stages. Flood tolerance score (FDS) were taken with a 1-5 scale (with 0.5 increments). * 1. **Flood tolerance screening at the V2 growth stage**
		1. **MG4**
			1. The average FDS was 3.24 with a range of 2.33-3.83. There were six breeding lines with a FDS under 3.0.
		2. **MG5E**
			1. The average FDS was 3.25 with a range of 2.75-4. There were five breeding lines with a FDS under 3.0.
		3. **MG5L**
			1. The average FDS was 3.05 with a range of 2.67-3.33. There were two breeding lines with a FDS under 3.0.
		4. **MG6/7**
			1. The average FDS was 3.14 with a range of 2.5-3.5. There were four breeding lines with a FDS under 3.0.
	2. **Flood tolerance screening at the R1/R2 growth stage**
		1. **MG4**
			1. The average FDS was 2.46 with a range of 1.5-3.25. There was 1 breeding line with a FDS under 2.0.
		2. **MG5E**
			1. The average FDS was 2.67 with a range of 1.83-3.25. There was 1 breeding line with a FDS under 2.0.
		3. **MG5L**
			1. The average FDS was 2.40 with a range of 2.17-2.83. There were 0 breeding lines with a FDS under 2.0.
		4. **MG6/7**
			1. The average FDS was 2.81 with a range of 2.33-3.5. There were 0 breeding lines with a FDS under 2.0.
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