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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. Pengyin Chen |
| Other investigators: | Drs. M. Liakat Ali, Leandro Mozzoni, Daryl Chastain, Gurpreet Kaur, Tessie Wilkerson, and Blair Buckley |
| Report Period: | September 16 to December 15, 2021 |
| 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 39 breeding lines in two groups: MG-4 (20 lines) and MG-5 (19 lines) were tested for flooding stress tolerance and yield. Four MG 4 breeding lines (S19-17313, S19-17667, S17-1946 and S19-17693 displayed flooding tolerance score (FTS) from 1.0 to 1.3 on a scale of 1 to 5 (1=no apparent flood damage and 5=almost all plants dead) and yielded from 36.0 to 22.0 b/a under flooding stress condition while the commercial checks had FTS from 5.0 to 3.7 and yielded 4.0 to 12.0 b/a (Table 1). Seven MG 5 breeding lines (S17-1146, S19-17887, S19-17893, S19-14298, S19-14307, S18-9258, and S18-3616 displayed FTS from 1.0 to 1.3 and yielded 28.0 to 21.0 b/a under flooding stress condition while the commercial checks had FTS scores from 5.0 to 3.3 and yielded 3.0 to 12.0 b/a (Table 1). The sensitive check cultivar S99-2281 showed FTS score 4.7/4.8 and yielded 3.0/5.0 b/a under flooding stress condition (Table 1). These lines will further be tested in 2022 season. Table 1. Selected flood tolerant breeding lines from 2021 advanced yield trials (flood) and their flood tolerance  score (FTS) and yield performance.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  |  | Yield (b/a) | Yield % com checks |
| Maturity Group | Name | Pedigree | FTS | Flooded | Non-flooded | Flooded |  Non-flooded |
| MG-4 | S19-17313 | S14-16235 x S13-3851 | 1.0 | 36 | 53 | 445 | 79 |
| MG-4 | S19-17667 | S13-1955 x S16-16842 | 1.0 | 31 | 51 | 391 | 76 |
| MG-4 | S17-1946 | S11-16653 X S13-8585 | 1.2 | 26 | 55 | 330 | 82 |
| MG-4 | S19-17693 | S13-1955 x S16-16842 | 1.3 | 22 | 46 | 276 | 68 |
| MG-4 | S12-1362 (Tol Ck) |  | 1.3 | 22 | 56 | 275 | 84 |
| MG-4 | S99-2281 (Sus Ck) |  | 4.8 | 3 | 53 | 35 | 80 |
| MG-4 | AG 46X6 |  | 5.0 | 4 | 71 |  |  |
| MG-4 | AG 4835 |  | 3.7 | 12 | 63 |  |  |
|  | Com. Checks Mean |  | 4.3 | 8.0 | 67 |  |  |
| MG-5 | S17-1146 | S11-16653 x S13-10592 | 1.0 | 28 | 40 | 431 | 61 |
| MG-5 | S19-17887 | S14-16267 x V12-0045 R2 | 1.2 | 25 | 51 | 391 | 78 |
| MG-5 | S19-17893 | S14-16267 x V12-0045 R2 | 1.0 | 24 | 48 | 365 | 73 |
| MG-5 | S19-14298 | S12-1362 x S13-3851 | 1.3 | 24 | 58 | 363 | 89 |
| MG-5 | S19-14307 | S12-1362 x S13-3851 | 1.2 | 23 | 59 | 353 | 91 |
| MG-5 | S18-9258 | S11-17025 x LG13-3925 | 1.0 | 22 | 49 | 338 | 75 |
| MG-5 | S18-3616 | S12-1362 x S11-20337GT | 1.0 | 21 | 55 | 320 | 84 |
| MG-5 | S12-1362 (Tol Ck) |  | 1.5 | 22 | 52 | 338 | 79 |
| MG-5 | S99-2281 (Sus Ck) |  | 4.3 | 5 | 51 | 69 | 79 |
| MG-5 | AG 4835 |  | 3.3 | 12 | 58 |  |  |
| MG-5 | AG 49X9 |  | 4.7 | 7 | 71 |  |  |
| MG-5 | AG 52X9 |  | 4.5 | 5 | 74 |  |  |
| MG-5 | AG 5335 |  | 5.0 | 3 | 52 |  |  |
| MG-5 | P55A49X |  | 4.2 | 6 | 72 |  |  |
|  | Com. Checks Mean |  | 4.3 | 6.5 | 65 |  |  |

 **ii) Preliminary yield trial:** A set of 21 new breeding lines were subjected to flooding stress, and only 4 lines, S20-24517, S20-24243, S20-24521 and S20-24524 showed good flooding tolerance from 1.3 to 2.0 and yielded only 14.5 to 13.6 b/a while both commercial checks AG 52X9 and AG 5335 had FTS score of 5.0. AG 52X9 had yield of 3.6 b/a only and no yield was harvested from AG 5335 plots as all the plants died. In non-flooded field, the selected breeding lines yielded from 69 to 59 b/a which is 89 to 75% of the commercial checks yield.**2. Yield evaluation of selected tolerant and sensitive lines in flooded and non-flooded field:** A set of 19 lines were tested for flooding tolerance and yield under flooding stress condition and also tested for yield non-flooded field. The lines were categorized as tolerant (FTS from 1.0 to 2.7) and sensitive (FTS from 3.0 to 5.0). Tolerant group had average FTS of 2.2 and mean yield of 12.1 b/a, sensitive group had mean FTS of 3.5 and yield of 6.9 b/a and the commercial checks had mean FTS of 4.0 and yield of 6.2 b/a (Table 2). In non-flooded condition, the yields were 66.0, 67.0 and 61.0 b/a for tolerant, sensitive and commercial checks, respectively. The main objective of the test is to assess the impact of flooding stress on the seed quality and seed composition. Data collection on these traits are on-going and will be provided in the next quarterly report.  Table 2. Comparative yield of flood tolerant and sensitive lines under flooding stress condition.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Tolerant**  |  | Yield (b/a) |  | **Sensitive** |  | Yield (b/a) |
| Lines | FTS | Flooded | Non-flooded | Lines | FTS | Flooded | Non-flooded |
| S17-1146 | 1.0 | 28.4 | 68 |  | S13-1955C | 4.2 | 5.9 | 63 |
| S12-1362 | 1.0 | 20.2 | 61 |  | S99-2281  | 4.3 | 4.2 | 55 |
| R04-342 | 2.0 | 15.1 | 67 |  | S13-2743C | 4.0 | 8.6 | 67 |
| S16-7922C | 2.5 | 13.7 | 74 |  | S13-10592C | 3.3 | 6.8 | 58 |
| UA5615C | 2.0 | 13.6 | 67 |  | UARK-5896 | 3.3 | 5.6 | 67 |
| S16-15170C | 2.2 | 12.3 | 72 |  | R06-4433 | 3.7 | 5.4 | 69 |
| S16-14379C | 1.8 | 10.0 | 63 |  | S16-3739RY | 3.7 | 7.3 | 75 |
| R01-2731F | 2.3 | 9.9 | 64 |  | R11-6870 | 3.0 | 7.7 | 66 |
| UA5014C | 2.7 | 13.2 | 55 |  |  |  |  |  |
| **Mean** | **2.2** | **12.1** | **66** |  | **Mean** | **3.5** | **6.9** | **67** |
| **Commercial Checks** |  |  |  |  |  |  |  |
| AG 49X6 | 3.0 | 11.1 | 59 |  |  |  |  |  |
| AG52X9 | 4.0 | 6.1 | 78 |  |  |  |  |  |
| AG55X7 | 5.0 | 1.4 | 47 |  |  |  |  |  |
| **Mean** | **4.0** | **6.2** | **61** |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |

 **3. Screening of recently developed elite lines for flood tolerance:** A set of107 breeding lines, recently developed at the University of Missouri-Delta Research Center and at the University of Arkansas and five checks (4 commercial cultivars and one sensitive line) was subjected to flooding stress for 8 day with 4-5 inches of water at R1/R2 stage. The flooding stress tolerance (first round) was scored 11 days after removing the flood water on a rating scale of 1-5 and the second scoring was done after 2 weeks. Seven University of Missouri breeding lines, S17-1946, S18-3722, S17-20605, S18-9258, S17-1980C, S18-3463 and S12-1362 (tolerance check) and 4 University of Arkansas lines, R17-3393, R15-1587, R18-3250 and R18-10539 displayed very good flood tolerance with flooding tolerance scores from 1.0 to 1.8. In comparison, the sensitive check S99-2281 had tolerance score of 4.3 while the commercial checks, AG 42XF1, AG 4835, AG 52X9 and AG 5335, had tolerance scores ranging from 3.3 to 5.0. **4. Missouri commercial variety testing for flood tolerance:** A set of about 115 commercial varieties developed by 25 different seed companies were subjected to flooding stress at R1/R2 stage for 8 days with 4-5 inches of water. First round of flood tolerance rating was done 11 days after removing the water and second round of rating was done 2 weeks later. Seven commercial varieties, AgVenture 47V4LL, Delta Grow DG 48E59, DONMARIO DM46E62, Dyna-Gro S45ES10, MCIA S16-14730C, Midland Genetics 4880E3S, and NK Seeds NK45-V9E3 displayed good flooding tolerance with tolerance/injury scores ranging from 1.0 to 1.8 while the test mean flooding tolerance score was 3.6. In this screening test, University of Missouri breeding line S16-15170C displayed tolerance score of 1.3. These results indicate that some commercial varieties do have good flood tolerance although it was not the intended objective for the seed companies.**5. Selection of new breeding lines from progeny row testing**: **:** About 800 F4:5 progeny lines from 8 crosses were grown in progeny rows in 2021 season, and out of which only 25 lines were selected from 6 crosses. The selection was done based of visual high yield potential and good phenotypic acceptability. The selected lines will be yield-tested in preliminary yield trials under flooding stress condition and non-flooded field in 2022.**6. Breeding populations under generation advance:** Seven crosses made in 2020 to develop new flood tolerant high yielding soybean varieties from tolerant PIs/lines and elite breeding lines are being advanced in winter nurseries in Costa Rica (CR) and Puerto Rica (PR), and these are currently in F3 generation. The F4:5 seeds will return to home station for evaluation and line selection in 2022 season. The list of the crosses is given in Table 3.Table 3. List of the crosses made in 2020 that are in generation advance from F1 to F4 in winter nursery.

|  |  |  |  |
| --- | --- | --- | --- |
| **Cross** | **Pedigree** | **Generation** | **Year of evaluation** |
| S20-311 | S14-16267 (FT)x S12-1362 (FT) | F3 | 2022 |
| S20-312 | S12-1362 (FT) x R04-342 (FT) | F3 | 2022 |
| S20-313 | RIL 123 (FT) x R04-342 (FT) | F3 | 2022 |
| S20-314 | R11-6870 x S12-1362 (FT) | F3 | 2022 |
| S20-320 | S14-16267 (FT)x UA5814HP (Protein) | F3 | 2022 |
| S20-321 | S12-1362 (FT) x Osage (Protein) | F3 | 2022 |
| S20-322 | RIL 123 (FT) x R11-7999 (Protein) | F3 | 2022 |

**7**. **New crosses made in 2021 season**: Three new crosses between flood tolerant PIs/lines and elite breeding lines have been made with a view to develop new high-yielding flood tolerant varieties. The F1 seeds of these crosse have recently been sent to the winter nurseries in Costa Rica and Puerto Rico for generation advance. The F4:5 seeds will return to the home station at Portageville, MO in May, 2023 for progeny testing and lines selection.Table 4. List of the crosse made in 2021 season aiming at developing new flood tolerant cultivars.

|  |  |  |  |
| --- | --- | --- | --- |
| Cross | Pedigree | Generation | Year of evaluation |
| S21-806 | S12-1362 x S18-3460 | F1 | 2023 |
| S21-807 | S18-3555 x S12-1362 | F1 | 2023 |
| S21-808 | S16-3739RY x S12-1362 | F1 | 2023 |

**Arkansas:**1. **Evaluation of flood tolerance of high-yielding AR and MO breeding lines:** A total of 112 elite lines (five commercial checks) derived by AR and MO were evaluated for flood tolerance at R1/R2 stage in 5-reps test in Stuttgart, AR. Under 10-days flooding stress, these lines showed diverse responses with broad flood severity scores range from 1.6 to 3.8 (p<.0001). Twenty-eight lines (6 AR lines, 21 MO lines, and 1 commercial check AG 5335) exhibited high flood tolerance with flood damage score less than 4.0. These six AR lines (R18-10539, R17-3488, R18-10491, R18-14142, R18-14286, and R19-4328) will be further evaluated flood tolerance in 2022 season.

**2). Screening commercial varieties for yield and flood tolerance:** A total of 78 commercial varieties and AR elite lines (58 MG4 and 20 MG5) in the Official AR Variety Trials was screened for yield and flood tolerance in two Arkansas locations (Stuttgart and Pine Tree) in two strip-plot trials with 5-days flood at V3 growth stage and non-flood (irrigation) treatments side-by-side. In flooded treatment, plants in Pine Tree had less damage with lower test mean of flood severity score (FSS=0.9) comparing that of plants in Stuttgart (FSS=3.1). The results of seed yield and flood tolerance under both the flooded and non-flooded treatments showed that two AR MG4 lines (R18-14272 and R18-14502) displayed high flood tolerance and less yield losses under flooded treatment (Table 1). Additionally, several commercial varieties (Progeny P4970RX, Credenz CZ 4912XF, Local LS4806XS, Integra 54891NS, Progeny P4604XFS, and Progeny P4505RXS) also exhibited high flood tolerance and had good yield and less yield losses under flooding stress. These tests information will benefit soybean growers. Table 1. Yield and flood tolerance performance of lines R18-14272 and R18-14502 under irrigation and flooding treatments.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Line | Location | Yield Irrigation | Yield Flood  | Yield Loss  | Yield Loss  | Flood Severity Score |
|  |  |  (bu/ac) | (bu/ac) | (bu/ac) | (%) | (0-9) |
| R18-14272 | STU | 61 | 51.7 | 9.3 | 15% | 1.7 (test mean=3.1) |
|  | PTR | 58.5 | 57.4 | 0.9 | 2% | 0 (test mean=0.9) |
| R18-14502 | STU | 60.1 | 49.8 | 10.3 | 17% | 1.3 (test mean=3.1) |
|  | PTR | 69.6 | 60.1 | 9.5 | 14% | 0.3 (test mean=0.9) |

**3) Breeding for flood tolerance:** A set of 170 preliminary and intermediate breeding lines derived by high-yielding and flood-tolerant parents were evaluated flood tolerance and yield in 2021 season. Forty-eight lines were selected for 2022 intermediate yield test and flood screening. The thirty-seven lines were also selected from 1450 progeny rows for 2022 preliminary yield test and flood evaluation. In addition, a total of 25 genetic populations with flood-tolerant pedigrees were advanced and selected for next year flood breeding. Twelve new crosses for flood breeding were made and harvested in 2021 season.**Mississippi:**Mississippi OVT flood plots were harvested on October 15, 2021. Data is in process of being compiled and analyzed. Plans for continuing the flood OVT in spring 2022 are underway.  |