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| **Reporting Period** | Final Report   |
| **Proposal** | [9281 Rust Resistant Roundup Ready 2 Yield Soybean](http://moss.unitedsoybean.org/Lists/Proposals/DispForm.aspx?ID=730&RootFolder=*)   |
| **Committee** | Production   |
| **Target Area** | Supply   |
| **Project Start Date** | 7/1/2009   |
| **Project End Date** | 6/30/2010   |
| **Project Number** | 9281   |
| **Project Status**·    **Incorporate improved seed protein, low-phytate, Asian soybean rust resistance, and RR2Y traits into high-yielding mid-MG VI to early MG VIII varieties (University of Georgia).****Summary of what was accomplished or learned** Roundup (glyphosate) is a broad-spectrum herbicide that is highly effective against the major annual and perennial grasses and broad leaved weeds. Since 2008, we have had access to Monsanto second generation glyphosate tolerant technology– Roundup Ready2Yield® (RR2Y®) that provides increased seed yield of soybean. With SSPR grant support and by using Monsanto’s new RR2Ytechnology, we have developed two RR2Y lines with a trait package that will be released in 2014. We have advanced six RR2Y lines in our advanced yield trials, have had nine lines entered into USDA Preliminary Uniform Test in 2012 and have developed over 800 RR2Y lines as our pipeline materials in our soybean breeding program. These materials have laid a strong foundation for our future variety releasing and next cycle of soybean improvement. Recently, the control of glyphosate-tolerant weeds in RR soybeans (i.e., palmer amaranth) has become a production problem. In 2010, University of Georgia has obtained access to Bayer CropScience’s LibertyLink that provides soybean tolerance to glufosinate herbicide (Ignite) as an alternative weed control platform. We have incorporated the LibertyLink (PAT gene) trait into two elite lines through a backcrossing approach with aid of molecular markers. We have increased the seeds of these lines in our Puerto Rico nursery and will conduct yield test in the summer of 2013 for a targeted release in 2015.To meet the needs of livestock and poultry feeds, we have incorporated the traits of higher protein with improved levels of sulfur containing amino acids into our breeding materials. We have identified genomics regions controlling for increased protein and improved levels of sulfur-containing amino acids including methionine and cysteine. In addition, we have introgressed the two QTL, cqPha-001 and cqPha-002 that are responsible for low phytate in soybean seed into our elite lines to improve the nutrition value of soy meal and reduce environmental phosphorous pollution. Asian soybean rust (ASR) has become a problem in the Southeast. We have identified sources with high level of resistance and successfully developed some high yielding lines with high level of rust resistance in our pipelinesSoybean is a crop with many disease and quality traits that soybean breeders need to work on. During the project period (2010-2012), we have successfully utilized an integrated plant breeding approach along with a strategy of forward and backcrossing breeding in our breeding program. Molecular markers become very important tools to support soybean breeding and we have learned that continuous development of reliable, functional and high throughput DNA marker assays with low cost will greatly help improve our breeding efficiency. **Assessment of progress achieved**During the project period (2010-2012), we have incorporated the RR2Y trait into two of our elite lines, G00-3213 and G00-3880. In the tests at two locations in 2012 against four RR2Y commercial checks, the G00-3213 RR2Y and G00-3880 RR2Y yielded 7.8% and 5.6% over the check mean, respectively. These two RR2Y lines matured 1 and 3 days earlier than the check means, respectively. Both lines are resistant to Southern rook-knot nematode and SCN race 3. The seeds of two lines have been increased in Puerto Rico nursery this winter and are targeted to release in 2014.To provide soybean growers with the choice of herbicide tolerance, we have also incorporated the LibertyLink® trait (PAT gene) into our elite lines, G00-3213 and G00-3880. The seeds of LibertyLink version of G00-3213 and G00-3880 are being increased in Puerto Rico winter nursery and will be yield tested in the summer of 2013. Once approved, the lines will be available to the growers in 2015.We have achieved to advance six highest performing RR2Y lines into our advanced yield trials at 12 locations across the Southeast region. Of those, G10PR-56248 RR2Y have yielded 8.2% over the RR2Y commercial check means at 8 locations in 2011 and 7.3% at 5 locations in 2012 in cooperative tests with Private company. The line has similar performance to two RR2Y commercial checks in 2012 Georgia State Variety Test and has 6% yield advantage over the mean of two RR2Y commercial checks at four late plating locations at Georgia State Varity TestBased on the 2011 advanced yield tests, we have selected four RR2Y in Maturity Group VII and five RR2Y lines in Maturity Group VIII entered into 2012 USDA Preliminary Uniform Test, but we have not received the yield result yet. In 2012, we have entered 31 RR2Y breeding lines into replicated yield tests at four locations out of total of five locations (Athens, Plains, and Tifton, GA; Mt. Olive, NC; and Hartsville, SC). Of 31 RR2Y lines, 17 RRY2Y lines have at least 5% yield advantage over the check mean across the locations. We had five RR2Y lines with rust resistance included in the tests. Two RR2Y rust resistance lines, G11PR-418R2 and G11PR-407R2 have rust rating scores of 1.8 and 2.3 (1= best and 5= worst), and 17.9% and 9% yield increase over the RR2Y check mean, respectively. Both lines also have high level resistance of Southern root-knot nematode and SCN race 3We have also developed 883 RR2Y lines which were entered into our first year yield trials at two locations (Athens and Plains, GA) in 2012. Among these lines, 57 are rust resistance lines. Of 883 RR2Y lines, 379 including 10 ASR resistance lines had 10% yield advantage over the check means. Those lines have laid a strong foundation for our RR2Y soybean breeding. In addition, seven populations with LibertyLink trait have been advanced in our breeding program.One hundred and three high proteins, low phytate breeding lines were tested at two locations in 2012. Of 103 lines, six lines have yielded 5% better than the check mean. However, all these lines are RR1 lines. Due to the breeding process, we have not been able to yield test the RR2Y lines with a combination of high protein, low phytate, and ASR resistance traits during this project period yet. It is in our plan to develop such soybean varieties for southeastern growers.By using the SNP markers and chipping technology that we have developed, we are pyramiding the high protein and low phytate traits into RR2Y versions of elite lines, G00-3213 and G00-3880. Thus far, the third backcrosses to G00-3213 and G00-3880 have been accomplished. We have also used the markers to introgress low palmitic acid alleles from C1726 and N8702122-4, and low linolenic acid allele from C1640 along with two high oleic alleles (FAD2-1A and FA2-1B) into elite lines, G00-3213 (MG VII) and G00-3880 (MG VIII). The independent backcross introgression of RR2Y and Liberty Link will allow pyramiding the low palmitic/low linolenic/high oleic with two herbicide technologies. We have also used markers to select the genes Rpp4 and Rpp5 for rust resistance in four populations. **Leveraging of funding** With SSRP funding support and demonstrated progress to the project goals that we have made in our soybean breeding program, we have been able to leverage the funding from other sources to support our breeding program. Project “Rust Resistant RR2Y/Liberty Link Soybean Varieties for Georgia that Produce Superior Poultry Meal” was awarded $39,880 by Georgia Agricultural Commodity Commission for Soybeans and project “Development of Productive, Value-added Maturity Group VI and VII Soybean Cultivars” awarded $63,470 by the University of Georgia Research Foundation. **Plans**We plan to continue to use our new RR2Y lines as a platform to develop superior yielding, multiple pest resistant varieties with traits that enhance soybean’s value for the poultry and swine industries. We will also plan to use Bayer CropScience’s LibertyLink technology as an alternative platform for herbicide resistant variety development. We will utilize a combination of classical and molecular breeding approaches, and forwarding and backcrossing breeding strategies to improve the value of soybean grown in Mid-South and Southeastern region by increasing protein content and quality and decreasing phytic acid levels, and incorporating Asian rust resistance or SCN resistance into RR2Y varieties.Previous funding from SSRP for this project has resulted in the development of Roundup Ready® lines with improved quality and nematode and pathogen resistance and some of these RR2Y lines are targeted to release in 2014. The funding from this program has allowed us to utilize the Puerto Rican nursery for quick generation advancement and molecular marker tools for early generation selection and introgression of new traits in our elite pipeline materials. The funding also allowed expansion of our capacity of yield trials which has increased the rate of genetic gain by reducing one year of yield testing prior to cultivar release. Therefore, continued funding for this project will enable us to release our first round of publicly developed RR2Y soybean varieties and continue to develop southern-adapted high-yielding soybean lines with desired trait packages. **2.  Incorporate improved seed protein, low-phytate, Asian soybean rust resistance, and RR2Y traits into high-yielding MG V to early MG VI varieties (University of Tennessee)****Summary of What was Accomplished and Learned** The development of high yielding soybean lines with the RR2Y trait required testing of large numbers of progeny lines to identify candidate lines with yield levels comparable to or exceeding those of the commercial check varieties. Adding this RR2Y herbicide resistant trait to the program significantly expanded the size, scope, and resources of our operations. The Tennessee program accomplished submission of 10 advanced RR2Y lines to the 2012 USDA Southern Uniform Soybean Testing Program for evaluation in field trials throughout the region. This included material in the MG V, and MG VI tests, as well as in earlier maturity groups. That collaborative regional test provides opportunities to compare advanced lines with high yielding checks and the best new lines currently available by public breeders. Only breeders from three states (Georgia, Missouri, and Tennessee) had developed sufficiently advanced RR2Y soybean lines for that broad southern regional test. The SSRP project helped make that accomplishment possible. For the traits of improved seed protein, ASR, and low phytate, for combining with the RR2Y trait, during this project (2010-2012) we accomplished rapid generation advancement in winter nurseries, aided by molecular marker assisted selections of specific individual plants, using SNP technology. We learned specific SNP laboratory protocols for each trait in order to discern melting curve differences between the parental alleles. This enabled the accomplishment of direct selections of individual plants that captured the trait, based on their DNA melting curves. We learned that the aggregation of traits such as (RR2Y + yield + protein) or (RR2Y + yield + low phytate) or combinations of RR2Y and those traits + ASR resistance requires more than one breeding cycle and judicious selections of parental types in forming the desired populations. **Assessment of Progress Achieved** We achieved field testing of 10 new RR2Y lines in the USDA Southern Uniform Preliminary Test in 7 locations for the MG VI, 11 locations for the MG V, and 10-11 locations for the MG IV entries. We conducted further field tests in Tennessee. Three of our new RR2Y lines: TN09-45,309; TN09-48,343; and TN09-45,905 produced 72 to 74 Bu/A and ranked as the 2nd, 3rd, and 4th highest yielding test entries at 6.5 to 8.3 Bu/A above the mean in a test of commercial varieties and our advanced RR2Y lines conducted at a high yield environment at Milan, TN. Our new RR2Y MG IV line TN11-4510 produced 79 Bu/A , nearly 10 Bu/A above the test mean and it was among the three highest yielding entries; in the MG IV-Late test our RR2Y line TN09-48,552 produced 74 Bu/A, nearly 6 Bu/A above the test mean, and it was also among the three highest yielding entries. In the MG V-Late Elite Yield Test, evaluated over three locations in East, Middle, and West Tennessee, *seven* of our RR2Y lines exceeded the commercial check means. The top yielding entry in the test was our RR2Y line TN09-44,121, and the 2nd, 3rd, and 4th highest yielding entries were our RR2Y lines TN09-48,012, TN09-48,579, and TN09-44,420 respectively. Our new MG IV RR2Y line TN11-4510 was an entry in the MG IV Elite Yield Test and it performed as the 2nd highest yielding entry. In the MG IV-Late Elite Yield Test our RR2Y line TN09-45,368 produced 100% of the yield of the three commercial checks which ranked 1st, 2nd, and 4th for yield, with our line equivalent in yield to the commercial checks. Our Elite Yield Tests represent three years of field testing (2010-2012), during the complete duration of this project. The achievement of developing commercially competitive yielding RR2Y soybean lines was realized. However, we have not yet been able to test whether we have realized the accomplishment of combining the suite of all traits (RR2Y + high yield + higher protein + low phytate + ASR resistance) during the three years of this project. This is due to the amount of time it takes to converge traits through crossing to form a large population, and then to advance the population multiple generations to homozygosity in order to develop candidate pure lines. We have targeted 2-3 trait combinations in most RR2Y populations for this project and we have initiated single plant selections to begin the development of pure line progenies. The ability to select individual plants based on SNP marker technology was an achievement of the project. Seed stocks of single plants will need to be increased in order to conduct multi-location yield trials to determine which of the specific RR2Y soybean lines produce high yield and express the trait combinations. **Leveraging of Funding** The project ‘Soybean Breeding & Genetics’ awarded $62,440 by the Tennessee Soybean Promotion Board was approved after showing results including promising RR2Y yield performance of lines whose rapid development was facilitated with support with SSRP. Both projects co-leveraged support towards high yield, higher protein, and low phytate soybeans along with SNP genetic technology selections. The project ‘Product Testing and Commercialization - Low Phytate Soy’ awarded $61,100 by the Consortium for Plant Biotechnology Research was initiated prior to the inception of the SSRP project, thus SSRP project results had no influence on funding. However the knowledge and skills learned and the technical staff training that resulted from that project facilitated the objective of combining low phytate with RR2Y during the SSRP project. **Plans** We plan to target identification of high yielding RR2Y selections with >48% protein meal. This will help capture domestic and international market demand for soy meal.  |
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