

TENNESSEE SOYBEAN PRODUCTION HANDBOOK

CHAPTER 3:

Soybean Variety Development and Selection

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PLANT BREEDING

Breeders use a combination of both conventional and molecular techniques to develop improved soybean varieties. While genetic modification is the tool most utilized in developing herbicide resistance, techniques such as conventional breeding, marker assisted selection and genomic selection are mainstays for advancing yield, quality and disease resistance. In recent years, efforts have also increased in developing rapid phenotyping measures. These efforts take traits that typically have high labor and time requirements and utilize computer science, robotics, and remote sensing to collect data more efficiently. Soybean has a relatively narrow genetic base, with most current varieties tracing back to a small number of parents. This lack of genetic diversity can hinder improvement. Gene editing, a newer technique which allows precise modification of the genome, may provide a way to overcome this limitation and create greater advances in the future. Through these different methods, soybean breeders develop varieties with higher yield and quality, as well as reduced losses to disease and weed pressure.

Yield

Soybean yield in the U.S. has increased by approximately 370% since the 1920s (Viera and Chen, 2021). This dramatic change can be attributed partially to changes in production practices; however, a large proportion is also thanks to efforts by private and public (university or USDA) plant breeders. Because yield is controlled by many genes, conventional breeding and genomic selection have been most effective at producing large gains. While yield will always be a key trait for any variety destined for commercialization, other major traits of interest among soybean breeding programs include seed quality, disease resistance, and herbicide resistance.

Seed Quality

Soybean is a versatile crop, with uses for both oil, in human and industrial consumption, and meal, which can be fed to livestock and poultry. As such, breeding efforts have focused on improving both the total content and composition of soybean oil and protein. While oil content

and yield generally go hand in hand, protein has an inverse relationship with these variables. Because of this, among released cultivars, oil concentration and yield have tended to increase, while seed protein has decreased (Rincker et al., 2014). Protein is a critical component to soybean's use as animal feed, which accounts for the majority of its use, and cannot be ignored in favor of higher oil content and yield. Breeding efforts are underway to develop varieties that have increased amounts of both oil and protein, as well as to develop varieties that focus on either high oil or high protein.

The composition of soybean oil has also benefited from breeding efforts. Traditionally, soybean oil has required hydrogenation to increase stability; however, the hydrogenation process increases the amount of trans fatty acids (TFA). These are associated with increased risk of heart disease and, as such, are now no longer "Generally Recognized as SAFE" by the U.S. Food and Drug Administration (US-FDA, 2018). This ruling led to intensive work in the area of soybean breeding, which ultimately resulted in the development of a high oleic/low linolenic acid (HOLL) trait. Oil from soybeans containing this trait do not require hydrogenation, thus eliminating the TFA that would have been produced through the hydrogenation process.

Disease Resistance

Losses due to disease are a significant constraint on soybean production. Some of the most economically important diseases include soybean cyst nematode (SCN) (*Heterodera glycines Ichinohe*), charcoal rot (*Macrophomina phaseolina* (Tassi) Goid), sudden death syndrome (SDS) (*Fusarium virguliforme* O'Donnell and T. Aoki), Phytophthora root and stem rot (*Phytophthora sojae* Kaufmann and Gerdemann), and Sclerotinia stem rot (*Sclerotinia sclerotium* (Lib.) (Roth et al., 2020). Emerging diseases include root-knot nematode (*Meloidogyne* spp.), reniform nematode (*Rotylenchulus reniformis*), frogeye leaf spot (*Cercospora sojina* K. Hara), and *Diaporthe* diseases, such as Southern Stem Canker (*Diaporthe phaseolorum* var. *merdionalis*) (Roth et al., 2020). Disease resistance is typically controlled by a small number of genes, which makes marker-assisted selection

and genomic selection particularly effective. However, because resistance is conferred by a small number of genes, plant pathogen populations can quickly shift to develop resistance to these genes. Stacking resistance genes can help slow this, but breeding for disease resistance remains a constantly moving target.

Herbicide Tolerance

Much like breeding for disease resistance, breeding for herbicide tolerance continues to shift as weed populations develop resistance. The first herbicide tolerance trait introduced in soybean was Roundup Ready, which conferred resistance to glyphosate and was commercialized by Monsanto in 1996 (Vieira and Chen, 2021). Since that time, the number of available herbicide tolerance packages has expanded considerably, with single-herbicide tolerance traits making way for multi-trait stacks. The Tennessee Row Crop Trait Cheat Sheet provides an up-to-date summary of current trait package names and the herbicide tolerance they convey (Sykes et al., 2021).

VARIETY TESTING

Material that has reached advanced stages of a breeding program or has been commercialized subsequently moves into evaluation through a variety testing program. These include internal testing by seed companies, regional tests such as the Uniform Soybean Tests, coordinated by the USDA ARS, and state variety testing programs, coordinated by personnel at land grant universities.

The UT agronomic variety testing program is composed of two programs, the Official Variety Trials (OVT),

which consist of small plot replicated trials on research stations, and the County Standard Trials (CST), which are non-replicated on-farm strip trials (CST). These two programs combine to serve the needs of Tennessee producers, seed industry collaborators and public plant breeding programs. The variety testing program provides a head-to-head, unbiased comparison of soybean varieties for yield, disease resistance, quality and other important agronomic traits. The OVT and CST programs each provide unique perspective and information that, combined, give stakeholders important insight into which soybean varieties are best suited to Tennessee.

The OVT has trials at seven AgResearch and Education Centers across the state, as well as AgriCenter International in Memphis (Figure 3-1). Two locations, Springfield and Milan, have both irrigated and non-irrigated trials, allowing for direct comparison of irrigation impact on yield. The remaining locations are either irrigated or non-irrigated. Small plot trials allow for a larger number of entries, greater control over management and data collection on numerous traits. These trials look at yield, quality (oil and protein), disease, lodging, shattering and maturity. Often entries in the OVT are composed of both currently available varieties as well as material that is in advanced stages of the breeding process. In addition to tried-and-true varieties, these trials provide a view of what is coming down the pipeline for next year. Breeders and seed industry utilize these trials to determine what to advance or which regions are the best fit for their newest material.

The CST has demonstration plots in 41 counties across Tennessee in collaboration with 50+ county agents on over 90 Tennessee farms. Trials are broken up by

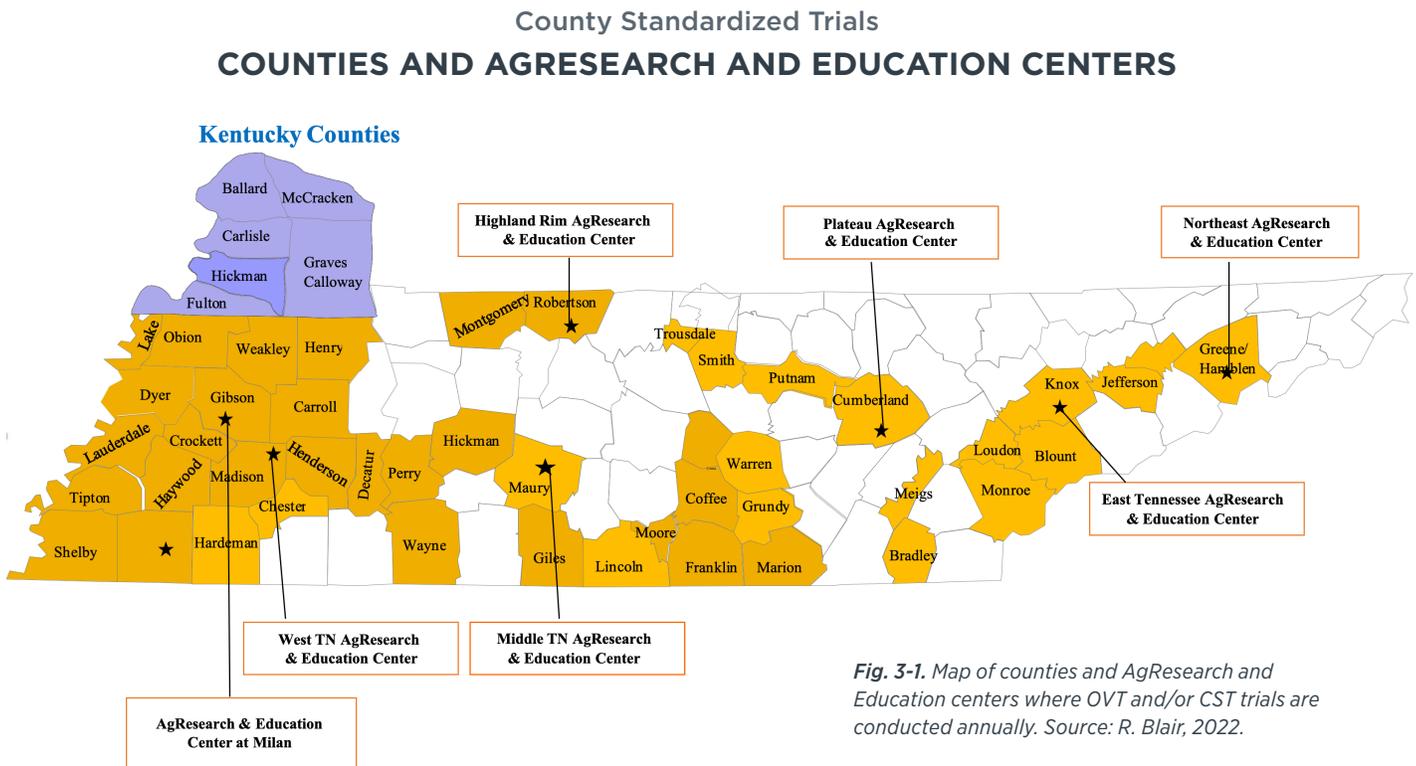


Fig. 3-1. Map of counties and AgResearch and Education centers where OVT and/or CST trials are conducted annually. Source: R. Blair, 2022.

management and maturity, with each trial represented at three to twelve county locations. Disease/fungicide trials are also conducted at two to three locations. Entries into the CST are all currently available varieties with a focus on yield. These trials give producers the unique opportunity of participating in the research process while engaging directly with their county Extension personnel.

Results from the variety testing program are made available each year through printed and web-based Extension publications and through search.utcrops.com. Results are also presented at in-service trainings, grain conferences and field days. Since variety selection and advancement decisions are often being made as soon as harvest wraps up, getting results to producers quickly is a top priority among UT's variety testing personnel.

The fastest way to access data is through search. [utcrops.com](https://search.utcrops.com), where data is posted as soon as locations are harvested and analyzed. There are two options for accessing data on search.utcrops.com, both of which can be found by first clicking on the soybean card from the search.utcrops.com homepage. The first option includes links to excel tables and a PDF-formatted version of the Soybean Variety Trials in Tennessee Extension publication. This is a good option if you like to download and have a printed copy on hand, before printed copies are available at county locations, and you want to see all the data.

An alternative option is to use the soybean variety database. This option provides a column of filter options for maturity group, brand, variety, herbicide tolerance, trial, year and disease tolerance. Selecting a combination of filter options will narrow down the database so that only data that fit your selected filter criteria are shown. This is a good option if you want to view very specific subsets of data. Development of an improved database option that allows consolidation of data across multiple states in the Southern region is currently underway and expected to be available in fall 2023.

CONCLUSION

Through plant breeding, new soybean varieties continue to be developed with improved yield, quality, pest resistance and herbicide tolerance. The "best" variety is highly dependent on region and the specific constraints of an agricultural system. Variety testing results are an important tool for identifying varieties that can maximize system sustainability and economic return.

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