GEORGIA SOYBEAN PRODUCTION GUIDE

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UNIVERSITY OF GEORGIA
College of Agricultural & Environmental Sciences

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Crop and Soil Sciences

UGA SOYBEAN WEBPAGE **www.caes.uga.edu/commodities/fieldcrops/soybeans/**

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AGRONOMIC PRACTICES FOR SOYBEAN

(***Corey Bryant***)

Field Selection and Rotation

When considering fields for soybean production make sure to account for factors such as yield potential, crop rotation, and soil type. Soybean production fields should have at least a 35 bu/a yield potential and should be planted to something other than soybean in 2019, preferably cotton or corn. Planting soybeans year after year in the same field can increase incidence of disease, nematode, and soil borne insects. Furthermore, rotating soybean with other leguminous crops such as peanut can also increase these risks. It is recommended to avoid planting soybean on deep sands or eroded clays which may yield potential of only 15 to 20 bu/a.

Land Preparation

Land preparation for soybean should provide deep rooting channels and a moist seed-bed at planting. Soybean grown on sand-textured Coastal Plain soils respond positively to in-row subsoiling to a depth of 12 to 14 inches. However, so long as soils are not re-compacted by roto-tilling, disking, or other seed-bed preparation operations deep turning or chisel plowing are also acceptable tillage practices. To date, soybean grown on fine-textured and red soils of the Upper Coastal Plain, Piedmont, and Limestone Valley have not expressed positive responses to in-row subsoiling. These soils can often be prepared by deep disking and turning, or chisel plowing.

Planting Dates

Proper planting date is one of the most critical decisions a grower can make to obtain maximum soybean grain yields. Optimum planting dates for full-season soybean in Georgia range from May 10th to June 10th. Planting as early as May 1st is possible, so long as soil temperatures are above 70^{o} F and tall-growing MG V or VI varieties are used. Planting determinate varieties prior to May 1st can cause premature flowering, plant stunting, reduced seed quality, and overall lower yields. Similarly, planting after June 10th reduces plant growth, auxiliary limb branching, root nodulation, and yield. Expect soybean yield of suitable varieties with proper management to decline ½ to ¾ bu/a, for each day planting is delayed after June 10th. **Should planting need to occur after June 10th ensure well adapted, tall growing, late maturing varieties are planted.** These plantings should also consider adopting other late planting practices such as increased populations and narrower rows. If soybean planting is not completed by July 1st yield may not be economical. **These recommendations are only for full season soybean production and must be adjusted for Early and Ultra-Late Soybean Production Systems as described in the corresponding section.**

Row Spacing

Generally, top soybean yields are obtained from narrow row production systems. It is commonly agreed that row widths between 20 and 30 inches are optimum. However, most soybean varieties will give near top yields with row spacing ranging from 30 to 36 inches so long as planting occurs in the proper planting window. Shorter soybean varieties will perform better than taller varieties when planted in May often resulting in less lodging and greater yields. **In general, the benefits of narrow rows increases as planting dates becomes later.**

Research in Georgia has demonstrated a yield benefit of 0.7% for every inch that the row is narrowed, compared to 36 inch or wider rows. Therefore, decreasing row spacing from 36 to 20 inches could increase soybean yield up to 11%. Row-spacing alterations, however, will require growers to make significant investments in new equipment and changes to an existing operation. It must also be noted that if proper maturity group and planting date decisions are not made and in-row subsoiling is not performed then the benefits of narrow rows may not be attainable.

One approach to modifying row spacing without having to make significant investments in multiple new implements is planting in a twin-row configuration. Most notably, many peanut growers currently have twin-row peanut planters which would require minimal adjustment to plant soybean. Research conducted in the mid-south has demonstrated the potential to increase soybean grain yield up to 11% in twin-row plantings, compared to single-row plantings. Research in Georgia evaluating twin-row soybean configurations in 2009 and 2010 showed an average yield increase of 3.5%, compared to 36 inch single-row configurations. This is not near the 11% yield increase shown in other regions and is attributed more to planting date and variety architecture, meaning positive yield effects from twin-row configurations were observed more in later planting dates and more “columnar” varieties. The advantages identified in this research are not thought to equal the advantages of conventional row spacing alterations.

Plant Population & Seeding Rate

Target plant populations should range from 85,000 to 100,000 plants/a in early and full season soybean production in Georgia. Early and Ultra-Late Soybean Production system plant populations will be discussed in depth in the respective section. Final plant stands as low as 60,000 plants/a can produce reasonable yields if plants are evenly distributed without large gaps between plants. When selecting seed care should be taken to select varieties with at least 80% germination. If you are planting late or in a dry or trashy seedbed consider increasing the seeding rate by 10% to 20%. As soybean is planted on varying row spacing configurations in Georgia, the following table provides information specific to numerous spacings. Growers must recognize that seeding rate suggestions are based on obtaining a certain number of plants per acre, regardless of row spacing utilized.

Row Spacing (in.)	Row Feet/Acre	Seed/Row Foot	Plants/Row Foot
36	14,520	9 – 11	5 – 6
30	17,424	8 – 10	4 – 5
20	26,146	5 – 7	3 – 4
15	34,484	4 – 6	2.5 – 3.5
7	74,674	2 – 3	1 – 1.5

Planting

Planters should be set so that seed are placed 1.0 to 1.25 inches deep in moist soil. If surface soil moisture is limited, set planters to push aside dry soil and plant in a shallow seed furrow. **Postpone planting when seed cannot be placed in moist soil.** Closing wheels should be adjusted so as to firm the soil around seed but not so firm as to induce soil crusting as poor emergence can result. If soil crusts do form, rotary hoe within one to three days to help ensure adequate stands.

Soybean germination is best when soil temperature ranges from 70º F to 90º F and can be very poor at temperatures above 95º F. When peak daily temperature at the two-inch soil depth exceeds 100º F postpone planting until peak daily temperatures decrease. Soil surface temperatures can be reduced by utilizing stubble-mulch planting. If irrigation is needed for soybean establishment, considerable effort should be made to maximize soil moisture prior to planting. Therefore, irrigation should be applied ahead of, not immediately after planting. Applying irrigation after planting can increase incidence of soil crusting and seed rot.

CONSERVATION TILLAGE

(*Corey Bryant*)

Conservation tillage can offer distinct advantages but requires increased management activity to attain sufficient crop stands and weed control. Management practices for conservation tillage vary depending on the crop, soil type, and weed pressure. Listed below are some basic principles which apply to all conservation tillage systems.

Cover Crops

Winter cover crops are often used with conservation tillage to prevent top soil erosion, conserve soil moisture, modify soil temperature, suppress winter weeds, and N additions. If a cover crop is planted prior to soybean it is recommended to select a grass. Grass cover crops are easier to establish and have fewer adverse effects on soybean stands and growth. Soybean planted into growing cover crops often results in poor stands. Therefore, it is optimal to desiccate the cover crop at least 14 days prior to planting. Early desiccation will allow for potential allelopathic chemicals produced by the cover crop to be leached from the rooting zone prior to soybean planting.

Seeding Rates and Row Spacings

Good soybean stands are more difficult to obtain with conservation tillage than with clean tillage. To help reduce this problem, soybean conservation tillage seeding rates should be increased 10 to 15 percent. Conservation tillage seeding depths should be about the same as clean tillage. Some conservation tillage planters tend to make a furrow when planting. These should be adjusted so that the furrow depth is as shallow as possible. Deep furrows should be avoided since high intensity rains can wash excessive amounts of soil over the seed or concentrate herbicides near the seed and cause injury or stand reduction.

Soybeans do not normally accumulate quite as much vegetative growth with conservation tillage as clean tillage. Therefore, in late plant situations close rows could be especially important for conservation tillage. Row spacings of 36 inches are common for soybeans, but soybeans could benefit from more narrow spacings of 20 to 30 inches. Narrow rows help insure full canopy development which can reduce soil moisture loss and suppress late emerging weeds. Drill planting can be successfully used with conservation tillage but soil compaction can be a problem and getting acceptable crop stands is not easy. The soil compaction problem may be corrected by deep chiseling in the fall ahead of planting wheat or a cover crop. Winter grazing can fully reestablish soil hardpans on Coastal Plain soils. As such, drill planting is generally not a good planting behind winter grazing.

Stand problems with conservation tillage drill planting are usually associated with getting litter in the seed furrow and poor seed-soil contact. The litter problem can sometimes be reduced by using a smooth coulter instead of the normal fluted coulters on drill planters. To get uniform seeding depth, conservation tillage drills should be equipped with double-disk furrow openers and disks that have bands for depth control. Good seed-soil contact is essential so special narrow press wheels will usually be needed. Extra weights on the planter are often needed to help get adequate soil penetration and seed coverage.

No-Till Soybean Production

An ever increasing amount of the state's double crop soybean acreage is cultured by conservation tillage. Some farmers burn or remove wheat straw residue, others plant directly into this residue. This practice is discouraged for several reasons. Removing straw can facilitate use of machinery and often allows for better and/or less expensive weed control, but planting directly into wheat residue is encouraged whenever suitable no-till planting equipment is available. This reduces soil surface temperatures, conserves soil moisture and increases soybean yield. In years with hot May-June temperature this practice often allows for better soybean stands. Surface crop residues also reduce soil erosion and water runoff, benefits that are often not immediately recognized. Getting adequate soybean stands and weed control are the biggest challenges with conservation tillage when planting into wheat residue. Wheat straw contains chemicals which reduce soybean germination and growth. Soybean planting must be done in such a way that wheat straw is kept out of the seed furrow. Wheat straw in the seed furrow also prevents good seed-soil contact and reduces germination. Modern conservation tillage planters have adjustments to pull wheat straw away from the seed furrow. Careful straw management can also help aid chemical weed control efforts. Cut wheat as high as practically possible to allow more herbicide penetration to the soil surface - the area where it is needed most for performance. When applying post-emergence directed herbicide sprays, rig equipment with press bars to push standing wheat stubble down and to the side so that it does not deflect herbicide sprays, injuring soybeans or reducing weed control effectiveness.

SOYBEAN GROWTH AND DEVELOPMENT

(*Corey Bryant*)

Proper identification of growth stage is essential for proper soybean management throughout the year. Generally, soybean development can be divided into vegetative (V) and reproductive (R) stages. The beginning of each stage starts when at least 50% plants are at that stage. Vegetative growth stages start with soybean emergence and reproductive growth stages start with the first flower.

Vegetative Growth Stages

The vegetative stages begin with emergence (VE stage). Prior to germination, soybean seed absorbs water equal to approximately 50% of its weight. The elongation of hypocotyl brings the cotyledons out of the soil, which starts the soybean emergence.

After emergence, unifoliate leaves on the first node unroll in addition to cotyledons and start the VC stage. The following vegetative stages are designed numerically from V1, V2, V3, through V(n), based on the number of nodes with trifoliate fully developed leaf which is unrolled. A fully developed trifoliate leaf is one that has unrolled or unfolded leaflets. For example, the V1 stage starts when one unrolled fully developed trifoliate leaf on the second node is visible. The (n) represents the number of the last fully developed trifoliate leaf.

Vegetative Stages		Description
VE	Emergence	Soybean emergence; cotyledons and the growing point are above the soil surface, unifoliate leaves are still folded.
VC	Cotyledons Expanded	Unifoliate leaves have unfolded and expanded.
V1	1st Node Stage	The first trifoliate has developed and the margins of the leaflets are no longer touching.
V2	2nd Node Stage	The second trifoliate has developed and the margins of the leaflets are no longer touching.
Vn	nth Node Stage	nth number trifoliate has developed and the margins of the leaflets are no longer touching. Continue counting development as Vn until the first bloom appears.

Reproductive Growth Stages

The reproductive stages in soybean start when at least one flower is present on the plant (R1). These stages refer to bloom development (R1 and R2), pod development (R3 and R4), seed development (R5 and R6), and maturity (R7 and R8). Proper identification of reproductive growth stages plays an important role in timing fungicide applications to manage Asian soybean rust. Recommendations for both initiation and termination of fungicide applications are most often described by growth stage. Soybean should be safe from the effects of soybean rust when they are near or have reached full seed, or at the R6 stage. Fungicide labels also have restrictions on application based on soybean growth stages (see Nematodes and Diseases for specific recommendations).

Reproductive Stages		Description
R1	Beginning Bloom	One open flower at any location on the plant; indeterminate varieties will generally begin blooming near the bottom and progress upwards while determinate varieties will begin blooming in the middle and progress up and down the main stem.
R2	Full Bloom	An open flower at one of the two uppermost nodes on the main stem with a fully developed leaf.
R3	Beginning Pod	One pod approximately 3/16 of an inch long at one of the four uppermost nodes on the main stem with a fully developed leaf.
R4	Full Pod	One pod approximately ¾ of an inch long at one of the four uppermost nodes on the main stem with a fully developed leaf.
R5	Beginning Seed	Seeds in the pods at any of the four uppermost nodes on the main stem with a fully developed leaf is 1/8 of an inch long. May be able to feel the seed but is easily identifiable by removing a pod and holding it up to the sun.
R6	Full Seed	One pod contains a green seed that completely fills the seed cavity at one of the four uppermost nodes on the main stem with a fully developed leaf.
R7	Beginning Maturity	One normal pod on the main stem has reached its mature pod color; usually brown or tan. Soybean is now at physiological maturity.
R8	Full Maturity	95% of pods have reached mature color and are drying down for harvest.

Acknowledgements: This section was adapted from the 2009 edition of the South Carolina Soybean Production Guide (Soybean vegetative and generative growth stages, Pawel Wiatrak) published by Clemson University Cooperative Extension Service, the 2004 edition of PM 1945 Soybean Growth and Development published by Iowa State University Extension. Original descriptions of soybean growth stages were developed by Fehr, W.R., C.E. Caviness, D.T. Burmood, and J.S. Pennington. 1971. Stage of development descriptions for soybeans, Glycine max(L.) Merr. Crop Science 11:929-931.

VARIETY SELECTION

(***Corey Bryant***)

Variety Selection Process

Making proper variety selections is extremely important to the overall success of a soybean crop. Variety selection is a process, and growers need to seek out varieties which have high yield potential and high yield consistency, while not forgetting the characteristics of varieties which can and often do impact the number of bushels that make it to the bin at the end of the season. Each year there are a tremendous number of varieties that can be potentially grown in Georgia, and new varieties are released quite often.

Remembering that all soybean varieties are not created equally can help narrow choices. Knowing what makes varieties different and what characteristics are needed in a particular situation can greatly impact overall production and assist in making this daunting task more manageable.

Listed below are a few important ideas and steps which can help narrow down choices and hopefully assist in making proper variety selection. By no means is this the absolute way to go about it, but it's a start.

Planting date/Maturity Group – The large majority of soybean varieties planted in Georgia are maturity group V, VI, or VII. Based upon planting date and desired harvest timing, growers can potentially narrow their search. In both irrigated and dryland systems, it's a good idea to spread out varieties based on maturity groups. This not only spreads out harvest, but also spreads the risk of drought and heat stress effects during flowering and seed development.

Yield Potential and Yield Stability – Once the correct maturity group has been determined the next step in choosing a variety is to look at yield data to determine a variety's yield potential and that variety's ability to produce high yields across multiple locations. The University of Georgia Official Variety Testing Program conducts variety trials at many of the University's agricultural experiment stations. When looking at OVT data it is best to look at data from locations near you as well as the overall statewide results. A summarized chart of variety data can be found later in this chapter.

Weed Control – Some growers may be able to narrow their search based on herbicide traits (or lack thereof). Most commercial varieties have the Roundup Ready® trait, which allows for glyphosate use. Some varieties have been commercialized with the Liberty Link® trait, which allows for post-emergence use of Liberty®. There are also many selective herbicides which can be used on conventional, Roundup Ready, or Liberty Link varieties. Knowing the weed issues in a particular field can help growers decide on which trait they should be utilizing for maximum production.

Auxin Technology – Within the last three years the availability of high yielding varieties with tolerance to dicamba have greatly increased. Growers may also see yield information from varieties planted by the UGA-OVT group. Please read the Weed Control chapter for more in depth information on the use of these technologies.

Irrigation – When soybeans are grown in irrigated situations, a couple of things can be considered. Lodging is sometimes a problem which can reduce yield, and this is more likely to occur in irrigated situations. Therefore, selecting varieties with low lodging potential may help irrigated yields. Also, there may be an opportunity to attempt to select varieties with the highest yield potential. By examining yields from state-wide variety testing results, growers may be able to find varieties which have performed best in higher yield situations.

Nematodes – Nematodes can dramatically impact yield, and the occurrence of these pests along with species present can affect variety selection. If a grower is aware of nematode species and pressure in a field, planting a variety with resistance to those nematodes will almost certainly increase yield.

Roundup Ready Trait Patent Expiration

The first generation Roundup Ready® trait in soybean expired in 2014. Questions exist aboutsaving seed with this technology in 2015 and beyond. A few comments on this situation:

1. Only the first generation Roundup Ready® trait (RR1) has expired. The Genuity Roundup Ready 2 Yield (RR2Y or RY) trait is protected under a different patent. Therefore, varieties with RR2Y trait are still protected.
2. Soybean varieties are often protected by other forms of intellectual property which may be used to enforce certain stewardship practices associated with saving seed.
3. CONTACT SEED SUPPLIERS TO FIND OUT DETAILS ABOUT SPECIFIC VARIETIES.

Farmer Saved Seed Soybeans

A few words of caution when considering the use of bin run or farmer-saved seed beans:

1. Be aware of stewardship or technology agreements for particular soybean varieties. The use of farmer-saved seed is specifically forbidden by some of these agreement and can result in large fines or legal action.
2. With conventional varieties, remember the eye cannot detect seed viability; therefore, germination tests are essential. Germination should be 80% or above. Plump seed with high percent germination, good color, and no visible damage will generally develop into good stands.

Buying **certified seed** is an excellent way to ensure that seed is true to variety, of high quality, and of good germination. Contact the Georgia Crop Improvement Association at 706-542-2351 for a list of certified seed suppliers in your area.

EARLY AND ULTRA-LAGE SOYBEAN PRODUCTION SYSTEMS IN GEORGIA

(*Corey Bryant*)

Early Soybean Production System

Researchers have examined an Early Soybean Production System (ESPS) that allows for earlier than usual soybean planting and harvesting. ESPS involves planting a maturity group IV or indeterminate MG V soybean variety and planting it between in April or early May. The ESPS system has become popular in the Delta and Mid-south but is still fairly uncommon in Georgia. The ESPS system appears to have the most merit for productive soils in the Middle/Upper Coastal Plain and the Limestone Valley regions of Georgia.

MG IV or early MG V indeterminate varieties are used in the ESPS system because they grow better with early planting (April 20 – May 10) than determinate varieties. The critical moisture period for ESPS is July and early August. Therefore, the ESPS system can be used to escape September/October drought and/or to further spread drought risks when grown in addition to regular soybean varieties. Performance of ESPS varieties can be improved by planting in close-row widths (7 to 30 inches) and at high seeding rates (10 to 20% above normal). ESPS varieties will mature by mid-September. Harvest must be made by 10 to 14 days after maturity to avoid shatter and seed quality problems. The use of a harvest aid is recommended in the ESPS. The harvest aid can assist in maintaining seed quality with a more timely harvest. It is critical for harvest aids to be applied at the correct time as severe yield loss may occur if applied too early. For more information on harvest aid application, call your location UGA County Extension Agent.

ESPS varieties are ideal for soybean trap crops. They are, for the most part, susceptible to root knot nematodes. Therefore, they should be planted only on select soils. ESPS varieties have high yield potential but have slightly higher production risks than regular varieties.

There are three major risks which must be managed when growing ESPS soybean:

- These varieties attract stink bugs during early pod-fill (July). Therefore, stink bug scouting and control measures are essential.
- ESPS seed quality declines rapidly in the field after maturity. Harvest within two weeks of maturity to prevent possible severe seed quality problems.
- Maturity of ESPS soybeans can coincide with late August and early September rains and hurricanes, such as those encountered in 2015. Thus a large portion of one's soybean crop should not be planted in this manner. It is always best to spread risk over planting dates and maturity classes.

ESPS is not well adapted to Georgia for the above three reasons. Getting good seed quality is the biggest concern for ESPS. As such, ESPS soybean seed quality is expected to be fair in north Georgia but only fair to poor in southern Georgia counties.

Ultra-Late Soybean Production in Georgia

For several years, growers in the most southern parts of Georgia have planted soybean behind either corn cut for silage or traditional corn that is harvested early in the season. These growers have likely implemented planting soybean in this traditionally "too late" window for a couple of reasons. When corn is harvested in July or early August, the period of time before frost is long enough that weed control may be an issue to contend with in these fields. The evolution of glyphosate-resistant Palmer amaranth, which has ample time in this situation to germinate and produce seed, further complicates this issue. Another factor in the adoption of ultra-late planted soybean is the fact that soybean prices are very attractive, and when planted behind a successful corn crop, this situation could more easily provide an economic incentive. Nevertheless, these insightful growers have used ultra-late planted soybean to help with weed control and add another crop within one growing season. The relative success of these growers, paired with high soybean prices, have tremendously increased interest in planting soybean in this window across the state.

For growers interested in planting soybeans in this window, there are several things to consider which may dramatically impact the relative success or failure of this system.

1. **Planting Date** – Likely the most significant factor in this system. Traditional research has indicated a loss in yield potential of 0.75 bu/day when planting soybean after the middle of June up to the end of July. Initial work in this system indicates that yields are dramatically diminished as planting dates reach into August; therefore, all efforts should be made to plant as early as possible (and in most cases not planted after the first week of August). The actual date in which a grower should consider not planting soybean will be variable (depending on latitude and fall weather). At this time, recommendations are to avoid planting after the first week of August unless you are in the very southern regions of Georgia.
2. **Irrigation Capabilities** – Irrigation is a must for the Ultra-Late production system to be successful. Irrigation water will be needed to supplement growth and ELIMINATE stress from dry soil conditions. The amount of vegetative growth that can be produced is important when producing soybean this late. Irrigation water may also help increase the overall height of the soybean crop and potentially help increase the height of pods produced on the bottom of the plant (often in this system pods are produced on the lower nodes and may be located too low to be practically harvested). Irrigation will also likely be needed to ensure adequate germination (which would include irrigating prior to planting to potentially cool soils and provide better soil seed contact.
3. **Planting Capabilities (Row Configuration/Seeding Rates)** – Narrow rows and high seeding rates are likely needed to successfully implement the Ultra-Late Production system. Growers with experience in this system have adopted planting high seeding rates with narrow-row equipment (most often a grain drill). Seeding rates of at least 175,000 seed / A should be considered however recent research at UGA indicates that seeding rates above 200,000 may increase yields over that. Higher seeding rates help ensure optimum populations. When planting this late, each additional stalk could increase yield and help to increase overall crop height (when planted in narrow rows, soybean often compete against each other and ultimately grow taller than wide-row soybean). Higher populations and narrow rows also decrease the time in which the crop needs to close the canopy, which certainly helps with weed control and may provide benefits in yield.

4. **Planting Equipment/Tillage** – Tillage and planting equipment can impact yields and the overall program by helping to maximize stands and speeding up the planting process. There is also a likely benefit to plant with a no-till drill for at least three reasons. One is the time after corn harvest to planting, when utilizing a no-till drill soybean could potentially be planted the same day as corn harvest. Another potential benefit is that by leaving corn stubble, soil temperatures will likely be much cooler than bare soil (soybean emergence can be dramatically lower with higher soil temperatures). Some growers have found that the corn stubble can improve harvestability (by helping lift the soybean plant onto the harvest grain table). Although planting the crop as soon as possible is important, recent research at UGA indicates that mowing the remaining corn stubble with a rotary mower prior to planting may help improve yields. This may improve overall stand counts by distributing the corn stover more evenly across the field.
5. **Soybean Variety/Maturity Group** – A lot of discussion has occurred about what variety and maturity group is best in this system. There are a couple of things to consider when making this variety selection. Maturity group does play a role in the soybean growth and development in Georgia during "traditional" planting windows. In general, later maturing varieties are more attractive than earlier maturing varieties because of the shorter period of time in which earlier maturity soybean has to grow vegetatively prior to shifting to reproductive growth. This phenomenon is still true for soybean planted in this system, however most varieties planted in Georgia (MG V – MG VIII) will initiate flowering within a day or two of each other when planted in late-July or early-August. Therefore, maturity may not be the most important factor in the selection of a variety in this system. If fact, one MG V variety is widely planted in this system and it has been successful. However, it doesn't mean that one should choose a MG V, one should consider other characteristics of a variety. Characteristics of varieties that may be important when planting this late are good early season vigor and large plant stature, especially considering limited time for vegetative growth. Since 2013, the UGA Official Variety Testing program has tested soybean varieties in the ultra-late system. For current yield data please refer to the UGA OVT website or contact your UGA County Extension Agent.
6. **Fertility (additional N)** – Most growers who have been successful in this system also apply additional N fertilizer prior to or close to planting. This additional N potentially increases early-season growth rate. Traditionally, soybean do not need supplemental N (if properly inoculated); however, the ability to produce enough N to maximize growth rate may be diminished with the decreased window for growth. Initial research in 2013 has indicated that additional N (30 units/a) applied at planting can increase plant height and increase soybean yield.
7. **Soybean Prices** – This factor is likely the most important when considering whether or not to utilize this system. Since yields are compressed and can vary, the price in which the crop can be sold can greatly impact the profitability of this system. Prior to planting, a grower should consider the economic risk of this system.

Again, it should be emphasized that this system is much more risky than planting in traditional windows, and although relatively successful for some growers for the past couple of years, it has yet to be proven successful in other parts of the state on larger acreages. It should also be pointed out that planting soybean in this window requires extremely timely management, whereas a missed insect infestation or missed irrigation may dramatically impact yields.

FERTILIZATION AND LIMING

(*Glenn Harris*)

Soybean removes a relatively large amount of nutrients from the soil. The approximate pounds of primary and secondary nutrients contained in a 40 bushel per acre soybean crop are shown in the following table.

Approximate Nutrient Utilization of 40 bu/a Soybean[1]

	Plant Nutrients Absorbed				
Plant Part	**N[2]**	**P_2O_5**	**K_2O**	**Mg**	**S**
	lb/a				
Total Uptake	224	38	144	16	14
Seed Only	160	32	56	17	11

[1] Amounts may vary with variety, soil type, and fertilization
[2] All N fixed from the atmosphere

While these quantities are high, this should not be interpreted to mean that this amount of fertilizer should be added. Nutrient additions will vary according to soil type, residual nutrient status, soil pH, and past crop management. For these reasons, fertilizer needs should not be second-guessed, but based on soil test results.

Soil Testing and Recommendations

Soil tests are valuable for predicting fertilizer needs and monitoring soil nutrient status. But soil tests and the resulting fertilizer recommendations are not miracle workers. The soil test is a helpful diagnostic tool requiring common sense and experience to interpret and use in managing your fertilizer programs.

Method of Sampling

The weakest link in soil testing is the sampling procedure. Samples must accurately represent the conditions of the field or the results will be meaningless. Also, be sure to take soil samples to plow depth.

Interpreting Soil Tests

Soil pH

Low soil pH can limit soybean yields. **Liming soils for a pH near 6.0 is desirable for producing optimum soybean yields.**

Liming acid soils improves soybean yield potential by reducing toxic quantities of aluminum and manganese, favoring the growth of nodule-forming bacteria, increasing the availability of molybdenum and phosphorus, supplying calcium and/or magnesium, and improving the soil physical condition.

Limestone additions should always be based on soil test results. Adding limestone without a soil test may increase pH excessively (above pH 6.5), causing micronutrient deficiencies. The somewhat poorly drained soils of the Flatwoods in the Coastal Plain region are particularly susceptible to Mn deficiencies as soil pH increases above 6.3.

When limestone is needed, it is most effective when applied at least three months prior to planting soybeans. Since limestone is fairly insoluble and will not leach downward, it should be thoroughly incorporated throughout the plow-layer. Surface applications will have little effect on soil acidity beyond the surface two or three inches.

Fertilization

A profitable response to fertilization is more likely on a soil that tests low for a given nutrient than on one that tests high. This does not rule out the possibility of a profitable response from a fertilizer application at a high level of fertility if yield factors other than fertility are optimum. Likewise, a profitable response on soils with low fertility is not assured when other factors such as adverse climate, poor management, or pest problems occur.

An example of soil test recommendations for phosphate and potash fertilizer for both full season and double-crop situations is given in the Fertilizer Recommendations for Soybeans table. Pulling a soil sample between the small grain and soybean double crop may be helpful in confirming fertility is sufficient in this system.

Fertilizer Recommendations for Soybeans

	Full Season		**Small Grain – Soybean**	
Plant Part	**P_2O_5**	**K_2O**	**P_2O_5**	**K_2O**
	lb/a			
Low	70	100	150	180
Medium	40	80	80	120
High	0	60	40	60
Very High	0	0	0	0

Nitrogen

The soybean plant is a legume, so nitrogen can be supplied by nitrogen-fixing bacteria contained in nodules located in the plant roots. These bacteria convert atmospheric nitrogen into forms usable by the soybean plant. Total nitrogen needs can be supplied through the symbiotic nitrogen-fixation process. **For soils where soybean has not been successfully grown within three years, an inoculant containing nitrogen-fixing bacteria should be applied at planting.** Some helpful hints concerning soybean inoculation include:

- Purchase a proven soybean inoculant from a reputable dealer.
- Check the expiration date to assure viability at planting.
- Store inoculant in a cool, dry place prior to planting.
- Do not buy inoculant that is prepackaged with fungicide treatments.

- Do not mix inoculant and fungicide treatments far in advance of planting.
- Apply inoculant at rates and in the manner according to manufacturer recommendations.

Many producers use small amounts of nitrogen fertilizer for soybeans. While there appears to be no yield advantage under most conditions to this practice, an early season growth response may be observed. In some cases, this could permit more efficient use of early season directed herbicide applications. Nitrogen in excess of 20 pounds per acre can seriously inhibit the symbiotic nitrogen-fixation process.

Phosphate and Potash

The phosphate and potash recommendation for soybeans are based on the soil test levels as shown in the Fertilizer Recommendations for Soybeans table. Fertilization without a soil test is an unsound agronomic practice.

Soybeans are known to produce best on soils with good residual fertility. On most Georgia farms, it is desirable to maintain soil P index at a “High” test level and soil K index at a “Medium” or “High” test level. **Use soil test recommendations to determine the rate of P and K to apply to each field.**

In double-cropping systems, the phosphate and potash requirements for soybeans can be applied to the crop proceeding soybeans. On deep sands (depth to clay layer greater than 18-20 inches), the potassium application should be split, with half applied in the fall, and half applied prior to planting in the spring. The quantities recommended for a small grain and soybean systems are given in the Fertilizer Recommendations for Soybean table.

Secondary Nutrients (Calcium and Magnesium)

For most situations, adequate levels of calcium and magnesium can be maintained by using dolomitic limestone. In situations where soil pH is above 6.0 and soil Mg tests low, it is advisable to use a magnesium fertilizer rather than additional limestone.

Micronutrients

Direct application of micronutrients to soils is seldom required for soybeans in Georgia, but should be applied when soil test results indicate levels are low. When Mn levels are low and pH is above 6.0, apply 10 lbs Mn/A as manganese sulfate or manganese oxide. Liming to pH levels greater than 6.5 can induce deficiencies of manganese, zinc and copper on some soils. The most frequent occurrence of such deficiencies has been in the Ocilla, Pelham, Leefield, and similar soils in the Flatwoods area. Under these high pH conditions, foliar applications of micronutrients during the growing season are more effective than soil applications. Soil applied micronutrients are rapidly converted to unavailable forms in soils with high pH. A foliar spray of boron (1/4 to 2 lb/A) at soybean bloom often gives a slight soybean yield increase especially on sandy soils. Adding boron to insecticide sprays (wherein compatible) at R3 soybean growth stage can be a way of improving the economics of this treatment.

It is recommended to apply 2 oz/A Dimilin plus 1/4 to 2 lb/A boron at early podding (R2-R3) to (1) increase soybean yields, (2) control velvetbean caterpillar, (3) suppress soybean looper, (4) increase insecticide effectiveness if looper develops and (5) increase potential profitability y o f soybeans.

Poultry Litter

Poultry litter contains significant amounts of plant nutrients and is a valuable source of fertilizer for crop production. The nutrient content of poultry litter varies depending on a number of factors. These include moisture content, type of bird, feed rations, and handling / storage methods. The average value for N-P-K analysis of chicken litter reported by the University of Georgia Agricultural Services Laboratory is 3-2- 2. Therefore, on average, a 1 ton/A application of chicken litter will supply 60 lbs of N, 40 lbs of P_2O5 and 40 lbs of K_2O.

Remember, these are average values. Having litter tested for nutrient content by a reputable laboratory before calculating application rates is highly recommended.

In addition to the primary elements, poultry litter also contains significant amounts of calcium and magnesium (around 30 lbs of Ca and 5 lbs of Mg per ton of litter). This will not only supply these secondary elements for crop uptake, but may also maintain or even increase pH of the soil. Maintaining adequate soil levels of micronutrients such as Zn Mn, B, and Cu is another potential benefit of using poultry litter, since small quantities of these nutrients are contained in litter. An additional benefit of applying poultry litter to soil is a potential increase in soil organic matter. This could result in improved soil physical properties, such as tilth and water holding capacity.

The basic strategy for using poultry litter as fertilizer is to: 1) soil test, 2) test the litter for nutrients, then 3) match the nutrient requirements of the crop with nutrients in a corresponding amount of litter.

Fertilizer recommendations are normally based on the nitrogen requirement of the crop to be grown. Nitrogen is not recommended for soybeans because soybean is a legume, and nitrogen needs are met through fixation of atmospheric nitrogen by symbiotic bacteria. However, nitrogen still needs to be considered since excessive amounts can cause pollution of surface water and groundwater with nitrates. In addition, excessive N in litter applications can cause lodging. Planting shorter stemmed soybean varieties may reduce the risk of lodging in this situation. Another consideration is that not all of the nitrogen in the applied litter will be available for uptake by the soybean. The soybean plant will have to rely on symbiotic fixation to fulfill the total nitrogen demand. Therefore, inoculating soybeans with nitrogen-fixing bacteria is still recommended if soybeans haven't been grown successfully within three years.

Disease and Nematode Control

(*Bob Kemerait*)

Disease and Nematode Outlook for 2020

Soybean producers in Georgia should begin preparation now to protect their crop against fungal diseases and nematodes in the upcoming season. Climatic conditions during the winter of 2019-2020 have been unseasonably warm. Because of the warm conditions, both kudzu and Asian soybean rust have survived the rust in some locations in the deep southern parts of the state. The survival of soybean rust into the upcoming season will greatly increase the risk of the disease during the growing season. Growers should be prepared to deploy and appropriate fungicide program, if justified, as early as the R1 bloom stage. Soybean rust sentinel plots, funded by the Georgia Commodity Commission for Soybeans, will be established again in 2020 and will give growers advanced warning for the development and spread of this disease across the state.

Our mild winter and warmer soils into the growing season will greatly affect the potential for damage from nematodes. Growers should recognize that there is a greater urgency to protect this year's soybean crop from nematodes, either by planting resistant varieties or by use of nematicides, whether fumigation, in-furrow products, or seed treatments.

In 2020, especially if rainfall is abundant during the growing season, growers should remain vigilant and prepared to manage Asian soybean rust and other diseases like frogeye leaf spot, anthracnose and Phomopsis pod and stem blight. Rainfall is a critical factor for many fungal diseases. Growers should note that there is increasing risk of fungicide resistance issues for frogeye leaf spot to strobilurin products used alone (examples would be Headline, Quadris, Abound, Aproach, and generic formulations of azoxystrobin and pyraclostrobin). For this reason, growers applying fungicides specifically to manage frogeye leaf spot are encouraged to use products with mixed modes of action.

Nematodes continue to affect soybean production in Georgia. In addition to resistant varieties, growers can also consider use of familiar nematicides like Telone II and AVICTA seed treatment. In 2020, growers will also have access to Ag Logic 15G (aldicarb) and ILeVO seed treatment (active ingredient fluopyram) from BASF.

Charcoal rot, caused by the soilborne fungal pathogen *Macrophomina phaseolina*, has been increasingly problematic in recent years, especially when a soybean crop is under environmental stress. This disease is characterized by poor growth and even plant death in specific areas of the field. It can be diagnosed by splitting the lower stem with a knife and observing gray discoloration and small, black, pepper-grain-like structures imbedded in the tissue. We have not management options for charcoal rot other than efforts to minimize stress, especially drought stress.

The Soybean Rust Sentinel Plots will continue in 2020. We in UGA Extension are grateful for support of such an important program from the Georgia Commodity Commission for Soybeans. This program continues to provide an effective tool for early notice of the development and spread of ASR. By effectively managing rust, growers may achieve better control of other diseases as well, such as anthracnose, Phomopsis pod and stem blight, frogeye leaf spot, and Cercospora blight. A list of fungicides currently labeled for control of Asian soybean rust and other diseases of soybeans is presented later in this section.

Newer fungicides available for soybean producers include Aproach and Aproach Prima from DuPont, Fortix and Zolera FX from Arysta LifeScience, Priaxor and Revytek from BASF, Miravis Top (not for rust) from Syngenta, Lucento from FMC, and Affiance from Gowan. More specific discussion on use of fungicides in soybeans will follow; however growers are reminded that best management practices for protecting the crop from disease include the following. 1) Follow reports from Soybean Rust Sentinel Plots through your county agent. 2) Use the late-bloom-to-early pod development growth stages as a potential target for initial fungicide application. 3) Recognize that fungicides that include a mixture of products, e.g., SDHI, strobilurin and triazole chemistries, provide both a broader spectrum of activity against disease and a longer protective window than do fungicides like propiconazole (Tilt, Bumber) and tebuconazole alone. Trivapro (propiconazole, azoxystrobin and solatenol) is also labeled for use on corn and soybeans by Syngenta.

Azoxystrobin (the active ingredient in Quadris fungicide and a component of Quilt, Quilt Excel and Quadris TOP) went "off-patent" in June of 2014 and there will be an increase of generic "Quadris" products on the market. Azoxystrobin is also a component of Affiance and other fungicides. Related strobilurin fungicides can also be found in products like Fortix, Zolera FX , Headline, Priaxor and many other fungicides.

Growers are reminded that it remains critically important to use these products carefully and according to label. Fungicide resistance occurs when a fungicide that was used to control a fungal pathogen becomes ineffective, often times from overuse. It is important that growers are careful with use of strobilurin fungicides. The pathogen causing frogeye leaf spot has already developed resistance to strobilurin fungicides in some areas of the United States; there is concern that it could be present in Georgia as well.

Southern stem blight ("white mold" in Georgia) was severe in peanuts in 2010, 2011 and 2012; the disease was also commonly observed in fields planted to soybean. The unusually high soil temperatures throughout much of the 2010 and 2011 seasons were largely to blame for the outbreak of southern blight. Southern blight was less of a problem in 2013 when cooler temperatures were observed over much of the growing season. Though no research has been conducted at the University of Georgia on management of southern blight in soybeans using fungicides, fungicides may prove to be an effective management tool where the disease is severe. Fungicides labeled for use in management of southern blight on soybeans include Quadris, Headline, and EVITO.

Nematodes are an important threat to soybean production in Georgia. Soybean yields in the state are routinely compromised by root-knot, reniform, Columbia lance nematodes, and perhaps sting and cyst nematodes as well. From a survey of 107 soybean fields from across Georgia, root-knot nematodes were present in at least 36 fields, cysts nematodes in 10 fields and reniform nematodes in five fields. The root-knot nematodes were found in fields across the state; cyst and reniform were found in much more localized areas. For example, cyst nematodes were found most commonly in Washington, Burke, and Screven Counties; reniform nematodes in Calhoun and Sumter Counties.

The first line of defense for protection from plant-parasitic nematodes is crop rotation; however crop rotation is difficult for management of nematodes that affect soybeans. This is because one or more of the important nematodes affecting soybeans will also affect most of our suitable rotation crops (e.g. cotton, corn, and peanuts). The second line of defense will be the use of soybean varieties with some level of nematode resistance. Though none of our soybean varieties are immune to nematodes, growers can plant varieties with improved resistance to the cyst and the southern root-knot nematodes. (Note: resistance to the peanut root-knot nematode and the reniform nematode is rare in our soybean varieties.) This resistance, as a part of an over-all nematode management plan, will help to minimize losses in yield and also reduce nematode populations in a field compared to populations when a susceptible variety is planted. The third line of defense in management of nematodes on soybeans is the use of appropriate nematicides. Growers have the opportunity to use the soil fumigant Telone II (3 gal/A). The seed-treatment nematicide AVICTA Complete Beans from Syngenta is also available to soybean producers. For 2017, AgLogic 15G (aldicarb) is also now labeled for use on soybeans.

Tebuconazole fungicide. Tebuconazole, the active ingredient in products such as Folicur, Orius, Muscle, Tebustar, Tebuzol, etc., remains a popular fungicide used on soybeans grown in Georgia. The popularity of this product is based on its proven efficacy in management of rust, its cost per application (3-4 fl oz/A), and because delays in natural defoliation are not attributed to this fungicide. There is no doubt that tebuconazole is an attractive choice of fungicide for these reasons. HOWEVER, growers must recognize that tebuconazole is NOT a perfect fungicide. Growers should consider other fungicides when deciding what to spray on their beans as a) there are better fungicides for management of soybean rust, b) there are more effective fungicides for the management of anthracnose and other important diseases, and c) there are fungicides, typically strobilurin fungicides, that offer a longer protective window, e.g. three weeks as opposed to two weeks.

Phomopsis pod and stem blight (*Diaporthe phaseolorum* var. *sojae*) and **anthracnose** (*Colletortrichum* spp.) have been devastating in some fields in Georgia in recent years, for example in Terrell and Marion Counties. In such fields, the effects of these two diseases were much more severe than losses to Asian soybean rust. Inoculum (spores) from these fungal pathogens can survive in the field amongst the crop debris and the pathogens can also be born on infected seed as well. Although little research has been conducted in Georgia to assess management of these diseases, timely applications of effective fungicides has been reported as an important control measure for at least anthracnose. Reports of these diseases were much more common in 2009 than in 2010 or 2011. This was likely due to the abundance of wet weather experience across much of the production region in 2009. Both diseases are easily spread by wind and splashing rain that helps to move the fungal spores within a field. CRITICAL POINT: Where fields have been affected by Phomopsis and/or anthracnose in the past, growers should choose a fungicide that is proven effective both in the management of these diseases and in control of Asian soybean rust. Also, growers should ensure that the timing of the fungicide application is appropriate for all of these diseases.

Cercospora blight. Late in the season growers often begin to observe that upper leaves exposed to the sun turn a purple color and is followed by significant defoliation. The petioles (leaf stems) on many plants also develop deep purple lesions and seed from these plants are frequently stained a purple color. The fungal pathogen *Cercospora kikuchii* is the likely causal organism for all of these symptoms and can lead to a reduction in yield and quality. In field studies at the University of Georgia, less Cercospora leaf blight is frequently observed in plots which have been treated with a fungicide to protect against soybean rust than in unsprayed plots.

Crop rotation. If the acreage planted to soybeans increases in Georgia, the time between soybean crops in a field will likely decrease (i.e. shorter rotation) and also peanuts and soybeans are more likely to be planted in shorter rotations with each other. Should shorter rotations occur, growers can expect greater problems with Cylindrocladium black rot (CBR)/Red crown rot, as this disease affects both peanuts and soybeans, and possibly the peanut root-knot nematode. Increased plantings of soybeans may also increase problems with southern root-knot nematodes, reniform nematodes, and Columbia lance nematodes on future cotton crops.

Asian Soybean Rust

Asian soybean rust remains of important concern to soybean producers across Georgia. Growers should remember that if timely applications of fungicides to control Asian soybean rust are needed in 2020, these applications will also help to control other diseases as well, e.g. frogeye leaf spot, Cercospora blight, Phomopsis pod and stem blight, and anthracnose.

Bottom-line comments for managing Asian soybean rust in Georgia:

1. Asian soybean rust can (and does) limit yields in some soybean fields in Georgia most years.
2. Asian soybean rust has occurred in every county in the state at some time or another over the past 10 years. Soybean rust is most likely to be found on soybeans and kudzu.
3. Soybean producers are advised to protect their crop with a fungicide IF a) the crop has reached reproductive growth, b) Asian soybean rust has been detected locally or is likely to be found locally, c) environmental conditions are favorable for development and spread of rust, e.g. adequate rainfall or storms, and d) the grower's crop has the potential to make a satisfactory crop.
4. Asian soybean rust is less likely to be a problem in a field with poor growth and plants stunted by drought or other factor than in a field with good growth, heavy foliage, and a closed canopy of foliage.
5. Some growers plan to apply fungicides to their soybean crop automatically as the crop reaches the R3/pod formation growth stage. They reason that since they will already be applying Dimilin and boron during this time period and because the crop is susceptible to rust, it just makes sense to tank-mix the fungicide for good timing and to save a trip across the field later. **This is a good strategy**, especially when other diseases may occur during this time as well. However if soybean rust does not develop until much later, the R3 fungicide application may not have been needed.
6. In some studies, a single, well-timed application of an effective fungicide may be all that is needed to adequately protect a grower's crop from soybean rust. However, depending upon the timing of arrival of the soybean rust pathogen (earlier versus later) and the impact of weather, e.g. tropical storms, it may be necessary (an profitable) to make a second fungicide application 2-4 weeks after the first application.
7. To determine where soybean rust is known to be present in Georgia, growers should consult their county agent (University of Georgia Cooperative Extension).

Spread of Asian Soybean Rust
Soybean rust is spread from infected plants to non-infected plants by spores. Spores germinate in approximately 6-7 hours with suitable leaf wetness and temperatures between 59 and 86ºF. Pustules form in 5-10 days and new spores are formed in 10-21 days. Spores are spread by wind-blown rain and can be carried great distances in upper air currents.

Resistant Soybean Varieties
Currently, we have no commercial varieties that are resistant to the soybean rust.

Alternative Hosts
Phakopsora pachyrhizi (the fungus that causes Asian soybean rust) infects other plants in addition to soybean. These include kudzu, snap beans, lima beans, cowpeas, and more than 90 other species of legumes (the bean family). In 2008 Asian soybean rust was confirmed on kudzu, Florida beggarweed, and iron clay pea in Georgia . **NOTE: peanut is NOT a host for the Asian soybean rust.** Alternative hosts are important because they allow the disease to survive and spread even in the absence of soybean. Thus, the disease may spread into regions where soybean does not occur and survive when soybean is not planted.

Survival of the Asian Soybean Rust
Survival of the rust pathogen is an important component in determining the threat of soybean rust in the coming season. The soybean rust pathogen does not survive for long without a living host. As most kudzu freezes back in Georgia each winter, it is very unlikely that soybean rust will survive in Georgia or in northern Florida to any appreciable amount during the winter. However, the rust pathogen will survive in central and southern Florida, provided that alternative hosts are present. The disease can then be reintroduced into Georgia as it is spread up the peninsula.

Detection of Asian Soybean Rust
Early detection of symptoms of the soybean rust is an important tool in the management of this disease. The initial symptoms begin on the under surface of the leaves and as gray lesions that change to red or tan. These early symptoms can be quite difficult to detect because they are fairly non-descript; however, it is essential to find the disease as early as possible in order to most effectively treat it. Lesions can spread from the foliage to the petioles, stems, and pods. Spores are produced in the mature lesions on the undersides of the leaves. Once these spores are visible, it is very likely that many other infections also exist which have yet to form lesions.

Lessons from the field: It is very difficult to identify the very early infections of soybean rust in a field and early detection can be likened to “finding a needle in a haystack.” Based upon our efforts since 2004, effective detection of the earliest infections will require patience and use of a dissecting microscope. It is highly doubtful that growers, consultants, or county agents will find the earliest introductions of soybean rust in a field. **Therefore, soybean rust sentinel plots (funded by the Georgia Soybean Commission) will be carefully monitored again in 2017 to provide advanced warning to growers.**

In 2017, growers, consultants, and agents should continue to monitor the soybean crop and kudzu carefully. Suspicious samples should be submitted to the Plant Disease Diagnostic Clinic in Tifton. Any finds of soybean rust in 2017 by researchers at the University of Georgia will be immediately passed along to the County Agents and also reported on the national USDA website at www.sbrusa.net.

Management of Asian Soybean Rust with Fungicides
There are currently a number of fungicides that are labeled for the management of Asian soybean rust. Those fungicides are likely effective in the management of other diseases of soybean as well. Fungicides labeled for the management of Asian soybean rust are presented in Table 1.

Strobilurins versus Triazoles

The most important classes of chemistries that growers will use to manage soybean rust are the strobilurins (azoxystrobin, pyraclostrobin, and trifloxystrobin) and the triazoles (tebuconazole, tetraconazole, flutriafol, flusilazole, metconazole, myclobutanil, propiconazole and cyproconazole). Here are some notes on these fungicides:

1. Strobilurin fungicides, unless tank-mixed with a triazole, are for use as protectants only and must be applied before rust infection occurs.
2. Strobilurin fungicides are reported to remain active in the field longer than triazole fungicides after application (3 weeks versus 2 weeks), though we do not have clear data on this.
3. Triazole fungicides have both protectant and limited curative properties. "Curative properties" refers to their ability to eliminate or reduce some infections that have happened in the very recent past.
4. Propiconazole (i.e. Tilt, PropiMax, and Bumper) is a weaker fungicide against rust than are other triazoles such as tebuconazole (Folicur et al.), myclobutanil (Laredo), tetraconazole (Domark) cyproconazole (Alto), flutriafol (Topguard), metconazole (Caramba) and flusilazole (Punch).

NOTE: Fungicides like MIRAVIS TOP, LUCENTO, PRIAXOR and TRIVAPRO also contain fungicides of the "SDHI" class which increases efficacy and reduces risk for resistance to develop.

Lessons from the field: Based upon fungicide trials conducted in Georgia since 2005, we have learned the following lessons:

1. Asian soybean rust can be effectively managed with the fungicides currently available to soybean growers in Georgia.
2. Producers who protect their crop with timely applications of fungicides do not need to worry about spores coming to their fields from kudzu or a neighbor's field where fungicides were not applied. In field trials, rows of soybeans that were treated with fungicides remained nearly disease-free for extended periods of time despite devastated, unsprayed, plots next to them.
3. In UGA fungicide trials, chlorothalonil products were less effective than were other fungicides for the control of rust. Although chlorothalonil is labeled for the control of soybean rust, the University of Georgia's Cooperative Extension advises growers that the optimum timing for application of this fungicide to control rust is unclear and to use the product cautiously. Chlorothalonil remains an effective tool against diseases such as frogeye leaf spot.
4. **NOTE: Headline and likely other strobilurin fungicides such as Quadris, Quadris Xtra, Quilt, EVITO, Stratego, etc. produced what we refer to as a "greening" effect. Foliage in plots sprayed with these fungicides remained greener longer than in plots sprayed with other fungicides and took considerably longer to defoliate. This did not seem to affect the**

% moisture of the soybeans at harvest; however the delay in defoliation did make harvest more difficult. Some growers have used harvest-aides such as paraquat to defoliate the crop and hasten harvest. It should also be noted the greening effect seems to be more pronounced where some fungicides (e.g. Headline) have been used and less pronounced (sometimes much less pronounced) where other strobilurin fungicides mentioned above have been applied.

5. Where tebuconazole products were applied in our studies, we sometimes observed striking foliar symptoms described as "interveinal chlorosis". This effect was more severe in 2005 than in later years. The foliage on these plants looked like plants that have been affected by nematodes or by sudden death syndrome. NOTE: We did not find any yield reductions associated with these symptoms; tebuconazole provides excellent control of Asian soybean rust.

Application Timing

The timing for application of fungicides to manage soybean rust is **critical**. It is unlikely that growers in Georgia can afford to spray fungicides on soybean without the imminent threat of Asian soybean rust or some other disease such as frogeye leaf spot. However, we have learned that soybean rust can be a very unforgiving disease if fungicide applications are delayed too long once it threatens. Where applications were delayed in our fungicide trials, significant reductions in yields often occurred.

Based on field studies conducted in Georgia, it appears that early reproductive growth (for example early bloom (R1-R2) through early pod (R3) stages) is an important time for rust management. To date, we have never detected rust in plots or fields prior to early bloom and typically began to find rust as the soybean crop reached early pod set and beyond. However, based upon a variety trial in the fall of 2005, **we know that soybean rust can infect soybeans prior to bloom!**

Lessons from the field: Listed below thoughts about the timing of fungicides applications for management of soybean rust.

1. Timing fungicide applications ahead of introduction of Asian soybean rust into a field is critical in the successful management of the disease.

2. From field observations, it appears that early reproductive growth is a critical period in the management of soybean rust. From both seasons, it appears that a well-time fungicide application with an appropriate fungicide during this period is CRITICAL for maximum rust control IF the disease is threatening.

3. **If rust has not been detected in the local region (as assessed with sentinel plots and careful scouting)**, it is recommended that soybean growers delay application of a fungicide for control of soybean rust until the threat from the disease is more imminent, UNLESS the grower is protecting against some other disease, such as frogeye leaf spot, anthracnose, or Phomopsis blight. **If growers want to take a more conservative approach, they may choose to apply their first fungicide at the same time as a Dimilin application timed at the R2-R3 growth stage.**

4. **If rust has been detected in the local area, or is thought to be likely,** growers are advised to initiate fungicide applications once the crop reaches first bloom.

5. **A second fungicide application should be considered within 2-4 weeks after the first application UNLESS the crop has reached harvest maturity or weather has been unfavorable for disease spread.**
6. From field studies, it is clear that the **FIRST** fungicide application is more important than the second. In 2006, a single, well-timed application of our best fungicides was at times as effective as two fungicide applications, and sometimes better than two applications of a lesser effective fungicide. Growers should not miss the opportunity to achieve excellent control of rust by using a less effective product in the first application, if rust threatens.

"Plant Health Benefits" of Fungicides

Many soybean growers in Georgia are aware that at least one fungicide, Headline, is noted not only for its fungicidal qualities, but also for its reported "plant health" benefits. There is no question that applications of Headline on soybeans keep the leaves greener longer and delays natural defoliation. However, it is not clear that this "greening" effect actually improves yields consistently enough, in the absence of disease, to justify the expense. In Georgia we have not seen an increase in yield where Headline was used in the absence of disease. Growers who wish to apply Headline with anticipation of improved yields simply from better "plant health" should do so with caution.

Steps to manage Soybean Rust in 2020

1. Early detection is critical. Once a grower or consultant finds a sample that could be Asian soybean rust, they should take it to their local county Extension agent. The agent will send it immediately to Mr. Jason Brock at the Disease Diagnostic Lab at 2360 Rainwater Road, Tifton, GA, 31793. The phone number at the Diagnostic Lab is 229-386-7495.
2. Sentinel crops. Sentinel soybean plots will be planted in April and monitored around the state to provide a means for early detection and warnings of the disease to the growers. Kudzu sentinel plots will also be monitored.
3. Fungicide programs to effectively manage rust will be developed and disseminated through the Cooperative Extension Service to the growers.
4. In using a fungicide program, growers must recognize that improper use of fungicides will increase the risk for the development of fungicide resistance by the pathogen.
5. Fungicides currently labeled for management of foliar diseases of soybean are included below in Table 1.

Table 1. Fungicides labeled for management of foliar diseases of soybean. **NOTE: Always read and follow the official label for use of these fungicides.**

CHEMICAL AND FORMULATION	RATE PER ACRE	REMARKS AND PRECAUTIONS
Quadris 2.08F (azoxystrobin)	6.2-15.4 fl oz/A (to include frog eye leaf spot and soybean rust)	**Note 1**: Prior to the discovery of Aisan soybean rust in Georgia, foliar fungicides were not generally recommended on soybeans in the state. Result s of Georgia research on foliar fungicides have been extremely erratic. Before deciding to apply a fungicide, a grower should consider the current yield potential in the field and the potential for further disease spread. **Note 2:** The presence of the Asian soybean rust in Georgia has greatly affected disease control recommendations. **Note 3:** Asian soybean rust can develop vary rapidly in a field when enough spores are present and environmental conditions are favorable. Once a soybean crop reaches reproductive growth stages, growers should be prepared to treat with fungicides very quickly as soon as the disease is likely to be present in the area. **Note 4:** The key to successful management of Asian soybean rust is use of an effective fungicide in a timely manner before the disease becomes established in a field. **Note 5:** Higher rates of a product provide greater residual activity and may reduce the need for later sprays to manage rust. **Note 6:** Although, "Headline SBR" is no longer available commercially, growers can tank-mix3.1 fl oz tebuconazole with 4.7 fl oz Headline to create a similar product.
AzoxyStar (azoxystrobin)	6-15.5 fl oz/A	
Quadris Xtra	4.0-6.8 fl oz for management of soybean rust; 5.0-6.8 fl oz for other foliar diseases.	
Quilt (azoxystrobin + propiconazole)	14-20 fl oz (for management of foliar diseases to include soybean rust.)	
Cover XL (azoxystrobin + propiconazole)	10.5-21.1 fl oz	
Quadris TOP SBX (azoxystrobin + difenoconazole)	8-14 fl oz/A (for management of foliar diseases to include soybean rust.)	
Alto (cyproconazole)	2.75-5.5 fl oz. For control of Soybean rust use 2.75-4.0 fl oz/A. For other foliar diseases use 4.0- 5.5 fl oz/A.	
Domark 230 ME (tetraconazole)	4.0-5.0 fl oz (for management of foliar disease to include soybean rust.)	
Affiace (azoxystrobin + tetraconzole)	10.0-14.0 fl oz/A (for management of foliar diseases to include rust.)	
Tebuconazole	3.0-4.0 fl oz (for management of foliar disease to include soybean rust.)	
Headline (pyraclostrobin)	6.0-12.0 fl oz (for management of foliar disease to include soybean rust.)	
Priaxor (pyraclostrobin +fluxapyroxad)	4.0-8.0 fl oz/A (for management of foliar diseases to include soybean rust and target spot)	
Revytek (pyraclostobin + fluxapyroxad + mefentrifluconazole	8 fl oz/A	
Propiconazole (Tilt or Bumper)	4.0-6.0 fl oz (for management of soybean rust and other foliar diseases.)	
Stratego (trifloxystrobin + propiconazole)	10.0 fl oz/A (for management of soybean rust and other foliar diseases.)	
Stratego YLD (trifloxystrobin + prothioconazole)	4.0-4.65 fl oz (for management of soybean rust and other foliar diseases.)	
FORTIX (fluoxastrobin + flutriafol)	4.0-6.0 fl oz/A (for management of soybean rust and other diseases of soybean.)	
EVITO (fluoxastrobin)	2.0-5.7 fl oz/A	
EVITO T (fluoxastrobin tebuconazole)	4.0-6.0 fl oz/A	
Topguard (flutriafol)	7.0-14.0 (for management of soybean rust and other foliar diseases).	
Aproach (picoxystrobin)	6.0-12.0 fl oz/A (for management of soybean rust and other foliar diseases.)	
Aproach Prima (picoxystrobin + cyproconazole)	5.0-6.8 fl oz/A (for management of soybean rust and other foliar diseases to include target spot.)	

Zolera FX (fluoxastrobin + tetraconazole) TRIVAPRO benzovindiflupyr (solatenol) + azoxystrobin + propiconazole MIRAVIS TOP adepidyn + difenoconazole LUCENTO flutriafol + bixafen	4.4-6.8 fl oz/A (for management of soybean rust and other foliar diseases to include target spot.) 13.7-20.7 fl oz/A 9.0-13.7 fl oz/A (for soybean rust, use Trivapro rather than Miravis Top) 3.0-5.5 fl oz/A	
Topsin-M 70WP (thiophanate methyl)	Rate: ½ -1 lb/A (controls frog eye leaf spot and other foliar diseases but NOT soybean rust)	
Topsin-M 4.5 FL (thiophanate methyl)	10-20 fl oz/A (controls frog eye leaf spot and other foliar diseases but NOT soybean rust)	
Bravo Weather Stik	1-2 ¼ pts/A (for management of foliar disease including suppression of rust)	
Echo 720	Rate: 1-2 ¼ pts/A (for management of foliar disease including rust)	
Equus 720	1-2 ¼ pts/A (for management of foliar diseases including rust).	
Bravo Ultrex	0.9-2.2 lb/A (for management of foliar diseases including rust)	
Equus DF	0.9-2.2 lb/A (for management of foliar diseases including rust)	
Echo 90DF	0.875-2.0 lb/A ((for management of foliar diseases including rust)	

Seedling Diseases and Seed Treatments

Over the years, seedling diseases have reduced soybean yields 0.5 to 1%. *Rhizoctonia* or *Pythium* are usually the pathogens responsible, but *Rhizoctonia* damage is far more common than *Pythium* damage in soybean fields. Non-uniform stands and/or death of plants soon after emergence are the problems caused by these diseases. Typical symptoms are reddish to dark brown lesions at the base of the stem or on the roots.

Seedling diseases are usually associated with poor quality seed and cool, wet soils. Seed rots and seedling diseases are rarely a problem if high quality seed are planted in well drained, warm soils. However, the increased incidence of seed-borne diseases such as anthracnose shows a need for general fungicide treatment of soybean seed. Commercial treatment of seed is the most effective, but on-farm treatment is acceptable. Rotation should be used in combination with seed treatment for control of these diseases.

A good stand is essential to ensure maximum production. See the "Cultural Practices" section of this guide for information about proper soybean stands.

Soybean Seed Treatments

Common Names (Compounds)	Remarks and Precautions
Dynasty (azoxystrobin, Syngenta) Trilex (trifloxystrobin, Bayer CropScience) Captan Thiram Thiabendazole Molybdenum Carboxin PCNB Metalaxyl *Bacillus subtilis*	Use according to label recommendations.

Fusarium Wilt

Symptoms: Fusarium wilt occurs in midseason during hot weather. The disease is rarely found in seedlings and is more common in sandy soils. Initial aboveground symptoms include a general wilting. The disease may progress rapidly with leaves becoming chlorotic (yellow) then withering. Unlike many soybean diseases, Fusarium wilt can kill plants. Fusarium wilt can be identified in the field by cutting into the stem just above the soil line to observe the condition of the vascular tissue: Fusarium wilt causes tan or brown discoloration in the vascular tissue whereas healthy tissue is white. Fusarium wilt is often exacerbated by root-knot nematode or soybean cyst nematode damage though the presence of the nematodes is not necessary for Fusarium wilt to occur. Drought can enhance disease development.

Control: In fields with a history of Fusarium wilt, crop rotation may help reduce disease pressure. If soybean cyst or root-knot nematodes are present, varieties resistant to those nematodes should be grown. Genetic resistance to Fusarium wilt has been documented, but varieties are not routinely screened and Fusarium wilt resistance information is rarely reported. If a variety is reported to have Fusarium wilt resistance, it should be grown in fields with a history of Fusarium wilt.

Stem Canker

Symptoms: Symptoms of stem canker are first evident when the soybean plant is in the early reproductive stage. Symptoms appear as small, reddish brown lesions at the base of a petiole on the lower stem. If conditions favor disease development, these lesions elongate laterally along the stem and may, or may not, girdle the stem. Generally, there is a distinct border between the lesion and healthy stem tissue. Foliar symptoms (similar to red crown rot and/or sudden death syndrome) can appear as the season progresses and are expressed as an interveinal chlorosis (yellowing) which becomes necrotic (brown with dead tissue). This disease can cause premature death of plants which significantly reduces yields.

Control: Use crop rotation, resistant varieties, and destruction (plowing under) of infected crop residue to reduce stem canker incidence and severity. Even in fields where stem canker has never occurred, resistant varieties should be grown. All Georgia recommended varieties have fair to good resistance to stem canker. Do not plant susceptible varieties (refer to the variety table in previous section). Some weeds can serve as hosts for the stem canker fungus, so when incorporating fallow into a rotation, it should be as "weed free" as possible.

Pod and Stem Blight

Symptoms: The fungal pathogen of pod and stem blight remains latent in the plant throughout most of the growing season, and symptoms are usually not evident until near harvest. There may be evidence of small black dots along the stems and pods as plants reach maturity. The dots are pycnidia (a fungal reproductive structure) of *Diaporthe phaseolorum* var. *sojae*, the causal agent of pod and stem blight. These pycnidia are more abundant during periods of wet weather.

Control: Rotate with corn and plow down residues. Plant high quality, treated seed. Plant late or during a time that allows maturation during a dry period. Plant resistant varieties may be available. Do not delay harvesting. Maintain adequate potash to minimize moldy seed.

Anthracnose

Symptoms: The plant is susceptible to the fungus at all growth stages, but initial symptoms usually appear during the early reproductive stages. Symptoms are predominantly on the stems and pods in the form of brown to black blotches. As the disease progresses the lesions (blotches) contain black fruiting structures of the fungus. These structures (acervuli) produce minute spines that are easily seen with a hand lens and are very good diagnostic characteristics of this disease. Foliar symptoms are rare, but occur after prolonged periods of high humidity. They include necrosis (browning) of the laminar veins, leaf rolling, petiole cankering, and premature defoliation.

Control: Use disease-free seed and a fungicidal seed treatment. Plow under infected crop residue and rotate the field to something other than soybean.

Red Crown Rot

Symptoms: Symptoms of red crown rot usually appear during the early reproductive stage. The symptoms are expressed as an interveinal chlorosis in the foliage. Prior to harvest, a close examination of the base of the stem may reveal the presence of brick red perithecia, which are fungal fruiting structures that look like clusters of small, red balls. These structures allow the fungus to survive and spread.

Control: Red crown rot is caused by the same fungal pathogen responsible for Cylindrocladium black rot (CBR) in peanut. Therefore, DO NOT rotate soybean with peanut in fields that have problems with red crown rot. This disease is favored by moderate soil temperatures (70 to 85°F) and wet (field capacity) soil. Disease severity is often greater in heavy soils. Management practices reducing red crown rot are as follows: 1) rotate (3-5 years) with any crop except peanut (peanut is highly susceptible), and 2) delay planting. After working in fields infested with this fungus, remove soil from equipment before moving to another field.

Foliar Diseases other than Asian Soybean Rust

Grower complaints for Frogeye leaf spot and downy mildew are common in some years. Many growers who felt they had a good soybean crop were concerned about losses that could be associated with the foliar diseases and called the Extension Service for recommendations on fungicides for the control of this disease. Our recommendations are as follows:

1. In most situations, control of Frogeye leaf spot with a fungicide will not be economically justified. Growers should focus on using a resistant variety.
2. Currently, it is not economically justified to control downy mildew with fungicides.
3. Growers who want to use a fungicide for managing the disease should use the fungicide on irrigated land and only when they expect exceptional yields, typically 45 bu/A or greater.
4. Fungicide spays should begin when the symptoms first start to appear or in the range of the R3 (1/4 inch pod) to the R5 (1/8 inch seed) growth stages.
5. If a growers waits too long to begin spraying (i.e. the diseases is rampant in the field), the fungicides will not help him.
6. In addition to many of the fungicides that are labeled (Section 3) for the control of Asian soybean rust, Topsin-M (thiophanate methyl) is labeled for control of foliar diseases such as frogeye leaf spot.

Nematodes

Take soil samples prior to harvest (typically August or September) to determine if economically damaging nematodes are present. Nematode populations decline following harvest, so do not delay sampling or you may fail to identify nematode problems. Do not sample overly dry soil and protect samples to keep them from getting too hot or dry. Several species of nematode can damage soybean, but root-knot nematodes and soybean cyst nematode are the most common problems in Georgia. In some parts of Georgia, reniform and Columbia lance nematodes are common and cause significant damage to soybean. Sting nematodes are not common and are limited to very sandy sites, but they can be extremely damaging where they occur.

For some nematode species, damage can be determined by examining soybean roots prior to harvest. Root-knot nematode damage can be identified by the presence of root galls. Root galls differ from nitrogen nodules by the fact that galls are caused by swelling of the root tissue and cannot be removed from the root, but nodules are located on the side of the root and can easily be broken off. If roots are gently washed free of soil, soybean cyst nematodes can be seen as small white specks on the roots (they are much smaller than nodules). As cysts age, they get darker and may appear golden, tan, or brown.

Root-knot nematode is the most commonly occurring nematode problem in soybean in Georgia, and three different species (Southern, Peanut and Javanese root-knot) cause damage here. Many fields in the Coastal Plain region of Georgia are infested with one or more species of these nematodes, and heavy infestations can cause severe damage and, in extreme cases, even plant death. The most common and widespread is the Southern root-knot nematode, which is found in all counties where soybean is grown. For predictive purposes, assume that root-knot nematodes detected in cotton or corn fields are southern root-knot. Peanut root-knot is common in areas with significant peanut production. Javanese root-knot is found less commonly in some areas of south Georgia. Many soybean varieties have genetic resistance to one or more of these root-knot species. The level of resistance to these three species is given in variety recommendations. It is critical to select varieties with resistance to the root-knot species present in your field. Anyone using the early soybean production system should be aware that few varieties in early maturity groups have root-knot nematode resistance. An example of a soybean variety with resistance to the southern root-knot nematode is 'Prichard RR'.

Soybean cyst nematode is present in almost all counties where soybean is grown in Georgia. In the midwestern US, soybean cyst can cause significant yield losses with no above-ground symptoms. It seems unlikely here, but Georgia soils typically have much lower fertility and organic matter; however, it may be possible. Sixteen different races of soybean cyst nematode are theoretically possible, but there are only three races of significance currently widespread in Georgia. Race 3 is the most widespread race of soybean cyst nematode in Georgia. Much less commonly, race 9 or 14 is identified. In Georgia, populations often shift readily between races 9 and 14. University of Georgia variety recommendations include a rating of the level of resistance to the species of root-knot and the races of soybean cyst nematode common in Georgia. Even if you do not have a soybean cyst nematode infestation, rotation with crops other than soybean is extremely helpful in reducing losses from other diseases.

Columbia lance, reniform, and sting nematodes cause economic damage in some counties. Nematicides can provide good control, but they are expensive. Rotation with peanut is an excellent control for these nematodes, but peanuts are susceptible to many of the same soilborne fungal disease problems.

The reniform nematode is a growing problem in Georgia and can cause significant yield loss in soybean and cotton. Corn and peanut are non-hosts for the reniform nematode. Most soybean varieties are very susceptible to the reniform nematode, but some soybean varieties have extremely effective reniform nematode resistance and others have moderate resistance. If reniform nematodes are present, a highly resistant variety should be chosen to minimize soybean losses and to reduce reniform levels in the field. A highly resistant soybean variety can reduce reniform populations as effectively as a non-host crop such as corn. An example of soybean varieties with reported resistance to reniform nematodes include 'Santee', 'Motte', 'DP 5806 RR', 'DP 5644 RR', and 'Delsoy 5710'. Reniform nematodes are not believed to have races, but a population may be able to overcome reniform resistance in soybean if resistant soybeans are grown for several consecutive years. Crop rotation can be used to minimize this possibility.

Both fumigant and non-fumigant nematicides are registered for use on soybeans and either type can provide effective nematode control. Resistant varieties are available for root-knot, soybean cyst, and reniform nematodes, and those varieties should be grown if these nematodes are present. Nematicides may be necessary if sting or Columbia lance nematodes are present, though it is probably better economically to avoid such fields. Root-knot resistant soybean still suffers some yield loss in heavily infested fields, and research shows that yields of root-knot resistant varieties may be increased by nematicides.

Historically, nematicides have not been economically feasible in most situations, but they may be an option in high profit potential situations such as production of foundation or certified seed. Given better prices for soybeans in the recent past, more growers may consider use of nematicides to manage nematodes and to increase yields. Nematicides are not recommended as a general soybean production practice unless production potential is excellent and the price for soybeans makes this added expense worthwhile.

SOYBEAN NEMATODE CONTROL ALWAYS READ AND FOLLOW THE OFFICIAL LABEL				
Chemical and Formulation	Rate/Acre (36" Row Basis) Amount of Formulation	Pounds Active Ingredient	Ounces/1000 Feet of Row Any Row Spacing	Remarks and Precautions
Preplant Injected				
Telone II	3 to 5 gals		30 to 50 fl ozs	Inject 8 inches deep beneath future row. Wait seven days between application and planting when using Telone II.
Preplant or At Planting				
AgLogic 15G	Granular in-furrow insecticide/nematicide	7 lb/A		
ILeVO	Seed Treatment			ILeVO can contribute to the management of nematodes and Sudden Death Syndrome
AVICTA Complete Bean	Seed treatment			AVICTA Complete Bean is a combination of abamectin and thiomethoxam + additional fungicides. Research continues to develop more specific recommendations for this product on soybeans grown in Georgia.

Soybean Weed Control

(*Eric Prostko*)

One of the most important aspects of soybean production is weed management. Uncontrolled weeds not only reduce soybean yields through their competition for light, nutrients, and moisture, but they can also severely reduce harvest efficiency. Before implementing a weed management plan for soybeans, several factors need to be considered including weed species, rotational crops, and cost/A.

Soybean Weed Management Strategies

The most effective weed management programs in soybeans use a combination of cultural, mechanical, and chemical control strategies. Cultural practices include such factors as planting date, planting rate, and row spacing. Cultural practices improve weed control by enhancing the competitive ability of the soybeans. Mechanical practices, such as cultivation, are a non-chemical method for controlling weeds between rows. A multitude of herbicides are labeled for use in soybeans and can be applied preplant incorporated, preemergence, postemergence, and post-directed. A complete update on the herbicides recommended for use in Georgia can be found in the latest edition of the ***Georgia Pest Control Handbook – Special Bulletin 28***. Because there are an extensive number of herbicides labeled for use in soybeans, just about any weed problem that arises can be controlled. It is just a matter of how much money can be economically justified for weed control in soybeans.

Row Spacing Effects on Weed Control and Soybean Yield

A review of soybean row spacing trials revealed that narrow row spacing (i.e. < 30”), has provided significant reductions in the late-season density of weeds in the majority of experiments conducted across the U.S. Additionally, research in Georgia has shown that narrow row spacing can increase soybean yields as follows:

Table 1. Soybean Row Spacing/Yield Research in Georgia

Year	Location	Row Spacing Comparison	Yield Increase With Narrower Row (%)
1979	Athens	38” to 19”	11
1981	Tifton	36” to 18”	4
1982	Plains	36” to 20”	17
1989	Plains	30” to 20”	8
		30” to 10”	11
		20” to 10”	3
2007/2008	Camilla	36” to 24”	8
2015	Midville	22” to 15”	19
		22” to 7.5”	30

Georgia's Soybean Weed Problems

The following table lists Georgia's most common and troublesome weeds of soybean:

Table 2. Common and Troublesome Weeds in Georgia Sobyeans.

Rank	Common	Troublesome
1	Palmer amaranth	Glyphosate + ALS-resistant Palmer amaranth
2	Texas millet (panicum)	Glyphosate-resistant Palmer amaranth
3	smallflower morningglory	Benghal dayflower (tropical spiderwort)
4	*Ipomoea* morningglory species	Palmer amaranth
5	Florida pusley	*Ipomoea* morningglory species
6	crabgrass species	Florida pusley
7	Florida beggarweed	nutsedge species
8	nutsedge species	spreading/Asiatic dayflower
9	sicklepod	smallflower morningglory
10	bristly starbur	Texas millet

Weed Competition in Soybeans

If a weed management program in soybeans is going to be successful and economical, a thorough understanding of the competitive effects of weeds is important. In regards to this area, two things must be considered: 1) When do the weeds need to be controlled in order to prevent significant yield losses? and 2) How much yield loss are they actually causing? Research has shown that weeds that emerge just prior to or at the same time as the soybeans cause greater yield losses than later emerging weeds. Consequently, effective weed control during the initial 2 to 4 weeks after soybean emergence usually prevents yield losses due to weed competition. However, later emerging weeds can have a negative influence on seed quality and harvest efficiency. Other research has shown that soybean plants can tolerate a certain level of weed pressure and that control strategies should only be implemented when the potential yield losses caused by the weeds exceeds the cost of control (*i.e. economic threshold concept*). The following table illustrates the influence of various weed species on soybean yield:

Table 3. Number of Weeds/100 Row Feet that Cause Yield Reductions in Soybeans.

Weed	Soybean Yield Loss (%)					
	1	2	4	6	8	10
cocklebur or giant ragweed	1	2	4	6	8	10
pigweed or lambsquarters	2	4	6	10	15	20
morningglory or velvetleaf	8	16	24	32	40	50
smartweed or jimsonweed	2	4	6	10	15	20

However, recent concerns about herbicide-resistant weeds have caused many growers to re-consider a ***zero-tolerance*** policy for weeds with the goal of reducing seed-rain back into their fields.

Metribuzin in Soybeans

Metribuzin is an older herbicide that at one time was very popular in soybeans. Back in 1990, nearly 20% of the soybean acres in the U.S. were treated with metribuzin. Many seasoned soybean growers likely remember when metribuzin was sold under the trades names of Sencor or Lexone. Over the past few years, UGA weed scientists have encouraged the use of metribuzin in Georgia for various reasons (i.e. can be applied PPI or PRE, a non-PPO herbicide, good on ALS-resistant pigweed, residual control of sicklepod). However, the use of metribuzin is not without complications. Growers must be aware of many factors before considering the use of metribuzin. These include soil pH, soil organic matter (%), soil texture, application rate, planting depth, and variety. Generally, metribuzin injury is more likely to occur when higher rates are used on sensitive varieties that are shallowly planted in lighter soils.

Examples of commercial herbicides that contain metribuzin are as follows: Authority MTZ (Spartan + metribuzin); Boundary (Dual Magnum + metribuzin); Canopy (Classic + metribuzin); Intimidator (Dual Magnum + Reflex + metribuzin); Mauler (metribuzin); Metri (metribuzin); TriCor (metribuzin), and Trivence (Valor + Classic + metribuzin).

Roundup Ready (RR) Soybeans

It has been estimated that 94% of the soybeans planted in the U.S. during 2019 were herbicide-resistant varieties. Since 1996, producers rapidly adopted the Roundup Ready (glyphosate) soybean system because of its ease of use. In the early days of this system, it was very common for growers to apply 1 or 2 applications of glyphosate and to not use any other herbicides or weed control strategies. Consequently, glyphosate-resistant weeds have become a serious problem. It is now recommended that **every** acre of Roundup Ready soybeans *(and any other type of soybean)* in Georgia should receive at least 1 application of a residual herbicide. **In most cases, 2 residual herbicides may be required for optimum weed control, especially when heavy populations of Palmer amaranth exist.** Additional information about the control of herbicide-resistant weeds in soybeans is discussed later in the chapter.

Tank-Mixes with Glyphosate for Improved Morningglory Control in RR Soybeans??

One of more common weeds that glyphosate has not provided consistent control of is morningglory. Single applications have rarely been adequate to control this weed complex. Split applications of glyphosate will provide better morningglory control than single applications but many producers are reluctant to pay the additional application and herbicide costs. Tank-mixes with other broadleaf herbicides can help to improve the control of morningglory at a reduced cost compared to split applications. However in most cases, the addition of these herbicides has only resulted in a 5 to 10% increase in morningglory control. Morningglory control with glyphosate can also be greatly improved by making a timely application **before** the weed exceeds 2" in height.

Growers who continue to struggle with annual morningglory control in RR soybean systems may want to consider growing Liberty-Link (LL) soybeans. The active ingredient in Liberty, glufosinate, is generally known to be more effective on morningglories than glyphosate. The LL soybean weed control system is discussed later in this section.

Table 4. Potential tank-mixes with glyphosate to improve morningglory control in RR soybeans.

Herbicide	Rate/A
Classic 25DF	0.25 - 0.33 ozs
FirstRate 84WDG	0.15 - 0.30 ozs
Resource 0.86EC	4 ozs

Glyphosate/Boron/Dimilin Tank-Mixes

A common soybean production practice in Georgia is to apply a combination of Dimilin (diflubenzuron) + boron at the R2 to R3 stage of growth. Numerous inquiries have been made about the potential for adding glyphosate to this treatment. Research conducted in Georgia and South Carolina indicated that the 3-way combination of glyphosate + Dimilin + boron can be used in soybeans without concern for compatibility problems or excessive soybean injury.

However, it has been demonstrated in numerous studies that the best time to apply glyphosate is between the V2 and V3 stages for soybeans grown in 30" rows and between the VC and V4 stages for soybeans grown in 7.5" rows. Thus, single applications of glyphosate made at the R2 to R3 stage of growth are ***too late*** to provide the best level of weed control and optimal yields. The 3-way combination of glyphosate + Dimilin + boron would be much more effective when used following an earlier application of glyphosate applied at the appropriate time. If the 3-way combination is used, the rate of boron should not exceed 0.25 lb ai/A.

Glyphosate/Manganese Tank-Mixes

Growers with soybeans that are exhibiting foliar manganese (Mn) deficiency symptoms should be cautious when considering tank-mixing Mn fertilizers with glyphosate. Research has shown that certain formulations of Mn, particularly Mn-EAA, Mn-LS, and $MnSO_4$, applied in combination with glyphosate, can significantly reduce weed control. Consequently, split-applications would be preferred if these formulations of Mn are used. Mn-EDTA (chelated) formulations of Mn have not reduced weed control when applied in combination with glyphosate.

$MnSO_4$ has not reduced the weed control performance of other herbicides such as Basagran, Ultra Blazer, Classic, or Pursuit.

Nutsedge Management in RR Soybeans

Potential nutsedge control strategies in the RR soybean production system include the following:

1. Two postemergence applications of glyphosate (14 days apart). This treatment will be more effective on purple nutsedge than yellow nutsedge.
2. Classic tank-mixed with glyphosate. This treatment will control yellow and suppress purple.
3. Pursuit tank-mixed with glyphosate. This combination will be more effective on purple than yellow. A pre-mixed combination of Pursuit + glyphosate is sold under the trade names of Extreme or Tackle.

Soil-applied herbicides that have fair to good activity on yellow nutsedge include the following: Canopy/Cloak, Dual Magnum, Envive, Prefix, Pursuit, Reflex, Scepter, and Warrant.

Liberty-Link® (LL) Soybean System

Liberty-Link® soybean varieties were introduced into the market in 2009. These varieties are resistant to postemergence applications of Liberty (glufosinate). Generally, Liberty is very effective on numerous broadleaf weeds, particularly morningglory species. With proper management, the Liberty-Link system can also be used to help control glyphosate and ALS-resistant Palmer amaranth. Before using the Liberty-Link soybean system, consider the following:

1) Liberty is not necessarily a direct replacement for Roundup (glyphosate). There are many differences in weed susceptibility to these herbicides
2) It is strongly recommended that a **residual** herbicide be used with the Liberty-Link system! The use of residual herbicides in the Liberty-Link system will improve the control of herbicide-resistant weeds and help delay the development of resistance to Liberty.

3) Liberty must be applied in a minimum of **15 GPA.**

4) Liberty should be applied using nozzle and pressure combinations that generate **medium to coarse** spray droplets (VMD_{50} = ~236-403 microns). Refer to spray nozzle tip manufacturer guidelines for more information about droplet size.

5) Liberty is most effective when applied between the hours of 9:00 am and 6:00 pm.

6) Liberty tank-mixes with grass herbicides (Assure, Fusilade, Poast, and Select) may result in reduced grass weed control.

7) Liberty will not consistently and effectively control Palmer amaranth that exceeds **3”** in height.

8) Refer to the latest UGA Soybean Variety Tests for more information about the agronomic performance of Liberty-Link soybeans. These results can be accessed from the following web-site: https://swvt.uga.edu/summer-crops/soybeans.html

9) Some Liberty-Link soybean varieties have exhibited **poor** tolerance to metribuzin herbicides. Refer to the most current list of metribuzin-tolerant soybean varieties in the 2020 Edition of the *Georgia Pest Control Handbook – Special Bulletin 28*. Herbicides that contain metribuzin include the following: Authority MTZ, Boundary, Canopy, Intimidator, Mauler, Tricor, and Trivence.

Enlist™ Soybean Production Systems (2,4-D Choline Tolerant Soybeans)

Corteva™ Agriscience (formerly DowAgroSciences) has developed soybeans that are tolerant to glyphosate, 2,4-D choline, and glufosinate (Liberty). Collectively, the trait and herbicides are marketed as the Enlist™ Weed Control System. Deregulation of the Enlist™ soybean trait occurred in September of 2014. **Enlist Duo®** herbicide (glyphosate + 2,4-D choline) was registered in October 2014. **Enlist One®** (2,4-D choline) was registered in September 2017. China approved the import of Enlist™ soybeans in January 2019. Enlist Duo® and Enlist One® have numerous requirements for application including but not limited to the following:

1) Apply POST in soybeans no later than the R2 or full flowering stage. A total of 2 POST applications can be made (12 days apart)
2) Only used approved tank-mixes and nozzles.
3) Clean sprayer before using Enlist™ herbicides to avoid contamination from a previous application.
4) Apply Enlist™ herbicides when wind speed is between 3 MPH and 10 MPH. Do not apply if wind speeds are greater than 15 MPH.
5) Do not spray Enlist™ herbicides during a temperature inversion.
6) Must maintain a 30' foot downwind buffer from any area except a) roads, paved, or gravel surfaces; b) planted agricultural fields except those listed as susceptible; c) agricultural fields that have been prepared for planting; and d) areas covered by the footprint of a building, shade house, greenhouse, silo, feed crib, or other man-made structures with walls and/or a roof.
7) Do not spray if wind is blowing towards susceptible crops including tomatoes (EPA crop group 8), cucurbits (EPA crop group 9), grapes, and non-tolerant cotton.
8) Use a minimum of 10 GPA (15 GPA is preferred).
9) Apply either 4.75 pts/A of Enlist Duo® or 2 pts/A of Enlist One®.
10) Follow Corteva™ labeled/recommended sprayer cleanout procedures (including triple-rinsing).
11) The certified applicator applying this product on soybeans must attend UGA's Using Pesticides Wisely (UPW) training.

For more complete information about application requirements, tank-mixes, nozzle types, etc. for the Enlist™ Weed Control System, please refer to the following web-site:

https://www.enlist.com/en.html

*****It is illegal to apply older formulations of 2,4-D amine or ester (i.e. Weedar 64 or Weedone, etc.) to 2,4-D-tolerant soybeans.*** It is also very important to note that Enlist™ soybean variety performance data for the Southeast is very limited at this time.

Xtend™ Soybean Production Systems (Dicamba-Tolerant Soybeans)

Soybean varieties that are tolerant to both glyphosate and dicamba have been developed. Collectively, the trait and herbicides will be marketed as the Roundup Ready® Xtend® Crop System. Currently, 3 low-volatile formulations of dicamba are labeled for use in this system including Xtendimax ™ with Vapor Grip™ (Monsanto) and Engenia™ (BASF) and FeXapan™ with Vapor

Grip™ (DuPont). ***It is illegal to apply non-labeled formulations of dicamba (i.e. Banvel, Clarity, Rifle, Sterling Blue, etc.) on dicamba-tolerant soybeans!!!!***

Xtendimax™ with VaporGrip™, Engenia™, and Fexapan™ with VaporGrip™ are ***restricted use pesticides*** and their labels have numerous requirements for application including but not limited to the following:

1) Can only be used on Roundup Ready 2 Xtend® soybean varieties.
2) Can only be ***purchased*** and ***applied*** by certified pesticide applicators.
3) Can be applied preemergence and/or postemergence (R1) but no later than 45 days after soybean planting. Only 2 POST applications can be made in soybeans (7 days apart)
4) Can only be tank-mixed with products that have been tested and found not to adversely affect off-site movement potential. Check the following web-sites for a current list of approved tank-mixes:
    a. Xtendimax: www.xtendimaxapplicationrequirements.com
    b. Engenia: www.engeniatankmix.com
    c. Fexapan: https://www.corteva.us/products-and-solutions/crop-protection/fexapan.html
5) Cannot be tank-mixed with AMS or UAN.
6) Can only be applied using specific nozzles. Refer to above web-sites for current list of approved nozzles.
7) Must be applied in minimum of 15 GPA.
8) Application speeds cannot exceed 15 MPH.
9) Maximum boom height of 24".
10) Cannot be applied when wind speeds are < 3 MPH or > 10 MPH.
11) Can only be applied between 1 hour after sunrise to 2 hours before sunset.
12) Must maintain a 110' to 220' downwind buffer for all applications (depending upon rate). Additionally a 57' omni-directional buffer around other sides of a field is required in counties where endangered dicot species exist. More information about endangered species in Georgia counties can be obtained at the following web-sites:
    a. **Bulletins Live! Two**: https://www.epa.gov/endangered-species/bulletins-live-two-view-bulletins
13) Cannot be applied when wind is blowing toward sensitive crops/residential areas including but not limited to non-dicamba tolerant cotton/soybean, tomatoes and other fruiting vegetables (EPA Crop Group 8), cucurbits (EPA Crop Group 9), and grapes.
14) Specific application records must be generated with ***72 hours*** of application and kept for a minimum of ***2 years***. Refer to product labels.
15) All growers/applicators who intend to apply Xtendimax™ with VaporGrip™, Engenia™, and Fexapan™ with VaporGrip™ in soybeans in 2020 must have attended UGA's "*Using Pesticides Wisely*" training program.

Soybean variety performance data for Georgia can be obtained from the UGA Variety Testing Program (https://swvt.uga.edu/summer-crops/soybeans.html)

Sicklepod Control

Historically, sicklepod has been one of the most troublesome weed problems in Georgia soybeans. Although it is considered to be less competitive than many other weeds, sicklepod populations can quickly reach levels that can cause significant yield loss. Fortunately, several control strategies for this weed are available.

In conventional soybeans, the best method to control sicklepod is to use a systems approach that includes a preplant incorporated or preemergence application of Tricor (metribuzin), Canopy/Cloak (metribuzin + chlorimuron), or Boundary (metribuzin + *S*-metolachlor) followed by a postemergence application of Classic. Caution is advised when using metribuzin products because several restrictions on soil type, organic matter, pH, and variety exist. Refer to the specific herbicide label for these restrictions. Python (flumetsulam) can be substituted for metribuzin products in those situations where metribuzin use would be prohibited or not preferred.

Sicklepod is susceptible to glyphosate and glufosinate (Liberty) thus can be managed using either the RR or LL production systems. However, 2 applications of glyphosate or glufosinate may be required to provide season-long control.

Tropical Spiderwort (Benghal Dayflower) Control in Soybean

Tropical spiderwort, also known as hairy wandering jew or Bengal dayflower, has become an increasing problem in many soybean production fields. Planting in narrower rows and increasing soybean plant populations will help improve the control of tropical spiderwort through competition and shading. Tropical spiderwort control can also be improved using tillage (i.e. moldboard plow).

The most effective herbicide control strategies for tropical spiderwort include using a combination of both preemergence (PRE) and postemergence (POST) herbicides. One of the best soil-applied herbicides for the control of tropical spiderwort is Dual Magnum *(S*-metolachlor). Generic formulations of metolachlor are available (Me-Too-Lachlor, Stalwart, and Parallel PCS) but these formulations have not provided the same length of residual control of tropical spiderwort as Dual Magnum in UGA trials. Warrant (micro-encapsulated acetochlor) and Zidua (pyroxasulfone) will also provide very effective residual control of tropical spiderwort. POST herbicides that have fair to good activity on tropical spiderwort include Basagran, Classic, FirstRate, and Pursuit.

Gramoxone/Firestorm/Parazone or Aim can be used post-directed or in a hooded sprayer. When using Gramoxone/Firestorm/Parazone post-directed, the soybeans must be at least 8" in height and the herbicide should not be sprayed higher than 3" on the soybean plant.

In RR soybean systems, glyphosate can provide fair to good control of tropical spiderwort if it is applied to plants that are 3" tall or less and under ideal growing conditions. However, more effective control can be obtained by applying either Sequence or Extreme/Tackle. Sequence is a pre-mix of glyphosate + Dual Magnum. Extreme/Tackle is a pre-mix of glyphosate + Pursuit. Other herbicides which can be tank-mixed with glyphosate to improve control of tropical spiderwort include Classic or FirstRate.

Rotational Crop Concerns

Advances in herbicide chemistry have led to the development of some exceptional families including the sulfonlyureas (Classic, Pinnacle), imidazolinones (Pursuit, Scepter), sulfonanilides (Python, FirstRate), and others. Many herbicides in these families are used in soybeans. However, some of these herbicides have the potential to injure rotational crops if the appropriate replanting interval is not observed. Because of the diversity of crops that are grown in Georgia, producers must consider the potential effects that herbicides could have on a rotational crop the next year. This information is readily available on nearly all herbicide labels.

Herbicide-Resistant (HR) Weeds

HR-weed species can become a serious problem in fields when a single herbicide or herbicides with similar modes of action are used repeatedly. This phenomenon has been documented in Georgia with Palmer amaranth (pigweed) and other weed species (Table 3). Populations of Palmer amaranth have been found in the state that are resistant to atrazine, glyphosate, and/or ALS-inhibiting herbicides. Check with your local county extension agent for updated information about the distribution of HR-weeds in your area.

Table 5. Confirmed Herbicide-Resistant Weeds in Georgia

Weed	Year	Herbicide(s)	Site of Action
goosegrass	1992	Treflan	Microtubule inhibitor
prickly sida	1993	Scepter	ALS inhibitor
Italian ryegrass	1995	Hoelon, Poast	ACCase inhibitor
Palmer amaranth	2000	Cadre, Pursuit	ALS inhibitor
Palmer amaranth	2005	glyphosate	EPSP synthase inhibitor
Palmer amaranth	2008	Staple + glyphosate	ALS + EPSP
large crabgrass	2008	Poast	ACCase inhibitor
Palmer amaranth	2008	atrazine	PS II inhibitor
Italian ryegrass	2009	Hoelon + Osprey	ACCase + ALS
Palmer amaranth	2010	Atrazine + glyphosate + Staple + Cadre	PS II + EPSP + ALS
spotted spurge	2014	Manor, Blade	ALS

PPO-resistance is on the rise in other areas of the country (4 species in US). PPO-resistance has recently been officially confirmed in at least 1 population of Palmer amaranth in Georgia. Popular PPO herbicides include Aim (carfentrazone), Cobra (lactofen), Reflex (fomesafen), Spartan (sulfentrazone), Ultra Blazer (acifluorfen) and Valor (flumioxazin). Avoid repeated applications of PPO herbicides in the same year and hand-remove any weed escapes before seed production!

Auxin-resistance has already occurred in **41** weed species worldwide including **10** species in the U.S. Thus, it will be extremely important to wisely steward the new Xtend™ (dicamba) and Enlist™ (2,4-D choline) soybean weed control systems.

Finally, HR-weeds can only be successfully managed by using a diversified system that utilizes a combination of strategies including crop rotation, row patterns, mechanical cultivation, herbicides with different modes of action, timely POST herbicide applications, and hand-weeding.

Herbicide Recommendations

A general summary of potential herbicide programs for the various soybean weed control systems is provided in Table 4. For a more complete listing of herbicides and their use patterns in soybeans, please refer to the latest edition *Georgia Pest Control Handbook – Commercial Edition (UGA Special Bulletin #28)*. This publication is available from your local county extension office or can be viewed/downloaded from the following web-site:

https://extension.uga.edu/programs-services/integrated-pest-management/publications/ handbooks.html

Table 6. Potential Herbicide Programs for Georgia Soybeans.

Soybean Variety/System	Program	Preemergence[1]	Postemergence (~20-30 DAP)
Roundup Ready® (glyphosate)	1	***One*** of the following: Authority MTZ; Canopy/Cloak; TriCor/Metribuzin; Trivence	glyphosate + Reflex; or glyphosate + (Prefix or Warrant Ultra); or Flexstar GT
	2	Boundary	glyphosate + Reflex; or Flexstar GT
	3	***One*** of the following: Prowl; Anthem Maxx; Dual Magnum; Warrant; Zidua	glyphosate + Reflex; or Flexstar GT
	4	***One*** of the following: Authority XL; Envive; Fierce; Surveil; Trivence; Valor	glyphosate + (Dual Magnum or Warrant or Zidua or Anthem Maxx); or Sequence
LibertyLink® (glufosinate)	1	***One*** of the following: Prowl; Anthem Maxx; Dual Magnum; Tricor/Metribuzin; Warrant; Zidua;	Liberty + Reflex
	2	***One*** of the following: Authority XL; Envive; Fierce; Surveil; Tricor/Metribuzin; Valor	Liberty + (Dual Magnum or Warrant)
Xtend® (dicamba)[2]	1	***One*** of the following: Authority MTZ; Boundary; Canopy/Cloak; Envive; Fierce; Surveil; Tricor/Metribuzin; Trivence; Valor	1) labeled glyphosate + [Xtendimax (VG) or Fexapan (VG)] + (Dual Magnum or Warrant) or 2) labeled glyphosate + Engenia + (Dual Magnum or Warrant or Zidua or Outlook) or 3) labeled glyphosate + Tavium
Enlist E3™ (2,4-D choline)	1	***One*** of the following: Authority MTZ; Boundary; Canopy/Cloak; Envive; Fierce; Surveil; Tricor/Metribuzin; Trivence; Valor	Enlist One + Liberty + (Dual Magnum or Warrant)

Conventional	1	Prowl + ***One*** of the following: Authority MTZ; Canopy/Cloak; TriCor/Metribuzin; Trivence	Reflex; or Prefix; or Warrant Ultra *(tank-mix with Classic or FirstRate if annual MG is a problem)*
	2	Boundary	Reflex *(tank-mix with Classic or FirstRate if annual MG is a problem)*
	3	***One*** of the following: Prowl; Anthem Maxx; Dual Magnum; Warrant; Zidua	Reflex *(tank-mix with Classic or FirstRate if annual MG is a problem)*

[1]Before using any metribuzin product in soybeans, check variety tolerance, soil pH, organic matter, and soil texture. [2]Xtend® soybeans are NOT tolerant of glufosinate (Liberty). Updated: January 15, 2020 (replaces all previous versions).

Soybean Insect Control

(*Phillip Roberts*)

A number of insect pests are capable of severely damaging soybeans. However, it is important to realize that soybeans can withstand considerable insect damage at certain times without economic yield losses. In Georgia, it is possible to produce a crop of soybeans without having to use any insecticides. In some years, however, several insecticide applications may be necessary to protect the crop. Because of this situation, soybeans are ideally suited to an insect pest management program. This program consists of two phases:

1) Understanding risk of pest outbreaks and planning to prevent damage.
2) Periodic monitoring or scouting and the use of thresholds.

Risk of Early-Season Insect Problems

Before Planting

Check for soil insects such as wireworms, white grubs, and white fringed beetle larvae in each field. Inspect soil closely when preparing land for planting (especially when turning land) for the presence of these insects. In reduced tillage systems cover crops or winter annual weeds should be controlled at least three weeks prior to planting. In conventional tillage fields, let fields remain fallow for as long as possible before planting. These practices reduce the risk of cutworms, lesser cornstalk borer, and other seedling pests which may have been established on weeds or the previous crop from infesting soybean seedlings.

At-Planting

Anticipate seedling-insect problems in the following situations and plan at-planting and/or an early post emergence insecticide application and intensified scouting accordingly.

1) When late-planting for any reason, lesser cornstalk borer populations may increase as the season progresses.
2) When planting on light soils following periods of drought, lesser cornstalk borer damage is more likely under these conditions.
3) When planting behind burned wheat stubble, lesser cornstalk borer infestations are more likely to develop.
4) When planting in double-crop or minimum-till situations where previous-crop residue remains on the soil surface, cutworms or other soil insects may have built up in the preceding crop.

Scouting: Check Crop Regularly to Prevent Insect Damage

Soybeans should be scouted at least once a week, twice a week under certain conditions, from seedling emergence until the leaves begin to turn yellow and fall from the plants. Management decisions should be made independently for each field based on the pest(s) situation. Accurate monitoring of fields will allow growers to make timely applications of the correct insecticide(s) and rate to prevent damage from reaching economic levels.

Several species of predatory and parasitic beneficial insects are present in Georgia soybeans. These natural controls or beneficial insects are our most economical pest management tools and conservation of beneficial populations should be considered especially during early season. Big-eyed bugs, minute pirate bugs, fire ants, and Cotesia wasps are four important beneficial insects. The presence of these natural controls may delay the need to treat for some insect pests. The use of natural controls should be maximized in attempts to reduce production costs.

Action or economic thresholds have been established for major soybean insect pests and are defined as the pest density at which action must be taken to prevent economic damage. The decision to apply an insecticide should be based on scouting and the use of thresholds. Thresholds for major soybean insects found in the Soybean Insect Control tables below should serve as a guide for decision making. An unnecessary application can be more costly than just the cost of the insecticide due to the destruction of beneficial insects. In the absence of beneficial insects, the risk of economic infestations for many insect pests increases. Application of insecticides on an as-needed basis allows beneficial insects to be preserved and reduces the likelihood of secondary pest outbreaks.

Seedling Pests

Soybean fields should be scouted for seedling pests until the plants are about 12 inches tall; the stems become woody and severe damage from seedling pests becomes less likely at this time. Look for insects on the plant (threecornered alfalfa hopper) or in the soil around the base of the plants (lesser cornstalk borer, cutworms, sugarcane beetle). Evaluate stand loss (percentage of dead or dying plants) and try to determine if future stand loss is probable (insects easily found and actively damaging plants).

Foliage Feeders

Throughout the season, determine what insects are feeding on the foliage and how much defoliation they are causing. On small beans, it is possible to brush the insects off the plants into the row middle where they can be counted. On larger beans, it is better to use a shake cloth or sweep net. Place the shake cloth on the ground in the row middle ahead of you under undisturbed plants, because some insects fly or fall off plants quickly when disturbed. Quickly shake or beat the plants from 3 feet of row on each side of the cloth so that insects are dislodged onto the cloth where they can be identified and counted. With a sweep net, take a 25 sweep sample across a single row to capture insects into the net. After passing the net through the foliage take a step forward, then pass the net back across the foliage. Then identify and count the insects present in the net. At each sample point, estimate the percent of the foliage loss so that an average defoliation value can be calculated for the field.

Pod Feeders

After full bloom (when pods are being set), look closely for stink bugs and any pod feeding caterpillars (corn earworm and fall armyworm) that are dislodged on the shake cloth or in the 25-sweep sample.

When to Treat

Important: Reserve materials which are highly disruptive to beneficial insects for late season use. Conservation of beneficial insects and spiders, especially during early and mid-season, suppress some pest species.

Soil Insects (wireworms, white grubs, whitefringed beetle larvae): Treat fields with a history of infestation or if insects are found during land preparation at an average of one per square yard.

Seedling Pests: Use preventive methods if damage is expected due to planting situation and/or treat if stand is being threatened. From seedling emergence until plants are 12-inches tall treat for:

Lesser cornstalk borer: treat when 10% of seedlings are infested with larvae.

Cutworms: treat when 10% of stand is lost and larvae are still present.

Sugarcane beetle: treat when 10% of plants (regardless of size) are damaged or dead and beetles are still present.

Threecornered alfalfa hopper: treat when 10% of plants are infested with nymphs and/or adults.

It is uncommon for the above pests (with the exception of sugarcane beetle) to damage soybeans larger than 12-inches.

Foliage Feeders

Foliage feeders should be controlled based on defoliation and plant growth stage;

Prior to bloom: treat when the defoliation level reaches 30%.

After bloom: treat when the defoliation level reaches 15%.

Fields should be scouted twice per week when insect pest populations and percent defoliation are within 50 percent of the treatment threshold, and the decision to treat is being delayed in order to derive maximum benefits from natural control factors.

Foliage feeders commonly encountered include velvetbean caterpillar, soybean looper, green cloverworm, grasshoppers, fall and beet armyworms, and occasionally blister beetles, Japanese beetle and others. The green cloverworm rarely requires control measures on soybeans in Georgia. It is very common on soybeans throughout the season but generally does not occur in sufficient numbers to cause economic defoliation losses. Green cloverworms infest soybeans early at low levels and serve as a host for numerous insect parasites and predators, spiders, and diseases. These beneficial insects in turn are of great value in suppressing subsequent infestations of insect pests.

Pod Feeders

Stink bugs are the most common pod feeding insect pest of soybean in Georgia. Occasionally, corn earworm and fall armyworm may also feed on developing pods.

Pod feeders should be controlled based on number of pod feeding insects present and plant growth stage:

Stink Bugs: Bloom to mid pod fill: 0.33 stink bugs per row foot or 3/25 sweeps

Mid pod fill to maturity: 1 stink bug per row foot or 9/25 sweeps

** Soybean grown for seed production, 1 stink bug per 6 row feet with justify control.*

Kudzu Bugs

Kudzu bugs can be scouted using a 15-inch diameter sweep net. Although kudzu bug populations have been low in recent years (due to the naturally occurring fungus Beauvaria bassiana (kudzu bug cadavers covered with white fungal growth) and the egg parasitoid Paratelenomus saccharalis), infestations in soybeans can be extremely high. Kudzu bug infestations tend to be higher in early planted soybeans. Current recommendations include interrupting the development of each generation of kudzu bug by applying an insecticide to target the immature stage of the insect. Insecticide should be applied when sweep–net sampling catches one immature insect per sweep. Samples should be taken from all areas of the field, including edges and the middle, taking care not to bias sampling along border rows where populations build initially. As an alternative to sweep-net sampling, visual inspections of insect density lower in the canopy will suffice. If immature kudzu bugs are easily and repeatedly found on leaf petioles and/or main stems, treatment is likely warranted.

Trap Cropping

Trap cropping has been proven to be a cost effective means of managing insects in soybeans. Soybean producers have found that managing stink bugs using trap crops can often reduce insecticide applications and preserve yields. Soybean field borders (trap) are planted using a soybean variety at least 2 maturity groups earlier than the rest of the field. Early maturity group soybeans planted around late MG VII or MG VIII soybeans have been proven to be most effective in trapping stink bugs from the whole field. Treating only the trap area for stink bug controls the pest without disrupting beneficial insect populations in the rest of the field. Although a trap crop is used, be sure to scout the remainder of the field and treat on an as needed basis. Field evaluations indicate that trap cropping can be extremely effective in controlling stink bugs without flaring soybean looper or velvetbean caterpillar populations. Two or more insecticide treatments of the trap may be necessary.

Preventive Insect Control and Damage

Historical insect data indicate that the probability for treating late season foliage feeding caterpillars in soybeans is extremely high in the Coastal Plain Region of Georgia. Populations of 50 velvetbean caterpillar and soybean looper migrate into Georgia during August and September. For this reason, growers often apply protective treatments using the insect growth regulator Dimilin in combination with boron at the R2-R3 stage.

A two ounce application of Dimilin at the R2-R3 stage controls velvetbean caterpillar (VBC) and green cloverworm (GCW) with minimal disrupt ion of beneficial insect populations. In most cases, fields treated with Dimilin at the R2-R3 stage do not require an addit io nal insect icide treatment for VBC or GCW for the remainder of the growing season. Dimilin will not control soybean looper and soybean loopers will sometimes require treatment and should be scouted closely. Control of VBC and GCW will lower the risk of having to treat soybean loopers based on defoliation since two of the three most common foliage feeding caterpillars have been removed from the system.

Risk of Common Soybean Insect Pests by Production System

Soybeans are planted from April until early August in Georgia. Risk associated with commonly encountered insect pests varies in each of these production systems. The risk of kudzu bug infestations is higher on early planted soybeans compared with late planted soybeans. The risk of stink bugs and foliage feeding caterpillars is higher on later planted soybeans. Ultra-late planted soybeans should be scouted frequently upon emergence for foliage feeders, especially beet armyworm.

Production System	Planting Date	Insect Pest RISK		
		Kudzu Bug	Stink Bugs	Foliage Feeders
Early Season	April	High	Moderate	Low
Full Season	May	Moderate	Moderate	Moderate
Double Crop	June	Low	High	High
Ultra-Late	July/Aug	Low	High	High

Sweep Net and Drop Sheet Thresholds for Soybean Insects

Insect Pest	Sweep Net (Avg/25 sweeps)	Drop Sheet (Avg/foot of row)
Kudzu Bug	25 immatures	
Stink Bug	3 bloom to mid pod fill 9 mid-pod fill to maturity	0.33 1
	**Soybean grown for seed production, 1 stink bug per 6 row feet will justify control*	
Velvetbean Caterpillar	38	8
Green Cloverworm	38	8
Corn Earworm	5	2
Soybean Looper	19	8
Threecornered Alfalfa Hopper	50	6
Mites: Treat for mites if infestations become general over the field and leaf discoloration is becoming evident.		

Soybean Irrigation

(*Wes Porter*)

Irrigation requires a relatively high investment in equipment, fuel, maintenance and labor, but offers a significant potential for stabilizing and increasing crop yield and proportionally net farm income. Frequency and timing of water application have a major impact on yields and operating costs. To schedule irrigation for the most efficient use of water and to optimize production, it is necessary to frequently determine soil moisture conditions throughout the root zone of the crop being grown. A number of methods for monitoring soil moisture have been developed and employed with varying degrees of success. In comparison to investment in irrigation equipment, scheduling methods are relatively inexpensive. When properly utilized and coupled with grower experience, a scheduling method can improve the grower's chances of successful and profitable production. Irrigation is expensive and requires proper management to be economically feasible. This can usually be accomplished when soybean market prices are good and irrigation for soybeans can be targeted for soybean "critical periods" in July, August and September.

Soybeans are one of the last row crops in Georgia that are typically considered for irrigation. Typically corn, cotton, and peanut are our most popularly irrigated row crops, however, we do see soybeans rotate into irrigation. Dryland soybean yields in Georgia range from about 5 to 50 bushels per acre. Extended drought during the "critical fruiting period" is the major reason for yield variation. Timely irrigations have the ability to stabilize soybean yields at 45 to 50 bushels per acre **OR MORE** and improve average yields by at least 20 bushels per acre. Thus, with higher commodity prices and more soybeans being rotated into irrigation production it is critical that producers have the necessary information to properly irrigate them throughout the season.

When soybean market prices were below seven dollars per bushel, irrigating soybean was a difficult task when considering profitability. Recently, soybean market prices have remained extremely high and there is no doubt that irrigation, if applied properly, has an economic benefit.

The utilization of any irrigation scheduling method is typically better than no plan or method at all. A good plan pays dividends in terms of yield, water-use efficiency (WUE) and net returns. In soybean, improper irrigation timing causes yield loss while irrigating too much wastes energy, water, and money. It is important to note that studies have shown that a lack of irrigation and rainfall during peak consumptive periods can deplete deep soil moisture, which is very difficult to replace via irrigation only. Thus, caution is advised during high water requiring periods.

The most simple and practical way of scheduling soybean irrigation is to use a moisture balance or checkbook method. This method helps a grower keep up with an estimated amount of available water in the field as the crop grows. The objective is to maintain a record of incoming and outgoing water so that an adequate balanced amount is maintained for crop growth. Growers require certain basic information to use a checkbook method. This information typically includes the soil type of the field and/or soil infiltration rate and water holding capacity, expected daily water use of soybean, and a rain gauge or access to nearby rainfall information. An example of a checkbook method calculation is presented in Figure XX. The UGA Soybean Checkbook was developed from a historical average of evapotranspiration between the years of 2001-2016. The crop coefficient has been refined from the development of an irrigation scheduling application by using soil moisture sensors, soil moisture information, and soybean yields. A checkbook method is very conservative and most often errors on the side of over irrigating rather than under irrigating. However, caution is advised when utilizing a checkbook method alone as it was developed from a historical average, and may not adequately address water requirements during extreme (either wet or dry) years. This means that in years that are drier than average the checkbook method would tend to under-irrigate and during years that are wetter than average it would tend to over-irrigate.

Irrigation recommendations for soybean in the past have been based on properly utilizing irrigation to produce a moderate yield of 45 to 50 bushels while maintaining profitability at much lower market prices. To meet those criteria, the following recommendations were created and have been used for many years.

The following water balance method is suggested for 45 to 50 bushel soybean yields:

Growth Stage	Trigger	Amount
Stand Establishment	Irrigate prior to planting	1 - 1.5”
Prior to 1st Bloom (VE – R1)	Wilting by late afternoon	1 – 1.5”
1st Bloom – Beginning Pod Elongation (R1 – R4)	Wilting by mid-day	1.0 – 1.5”
Beginning Seed – Full Seed (R5 – R6)	Keep from wilting	1.0 – 1.5”
Full Seed – Maturity (R6 – R7)	Wilting by late afternoon	1.0”

This scheduling method has the ability to consistently increase yield. However, current soybean market prices and higher yield potential of modern varieties create a situation where producers may be able to more adequately manage irrigation to further increase yield. Thus, it is advised that a producer new to irrigating soybean start at a minimum with the UGA Checkbook method as a guide.

It should be noted that one issue with these traditional recommendations is that scheduling has been based on wilting of the soybean crop. It’s very likely that once the soybean plant wilts, yield potential will be lost and the degree of loss is related to crop stage during which that stress occurs. Specifically, when wilting occurs during reproductive growth the chance for lost yield potential is greater than if it were to occur during vegetative growth. Therefore, one way to potentially modify this system would be to irrigate to prevent wilting from first Bloom (R1) until full seed (R6) instead of just between R5 and R6.

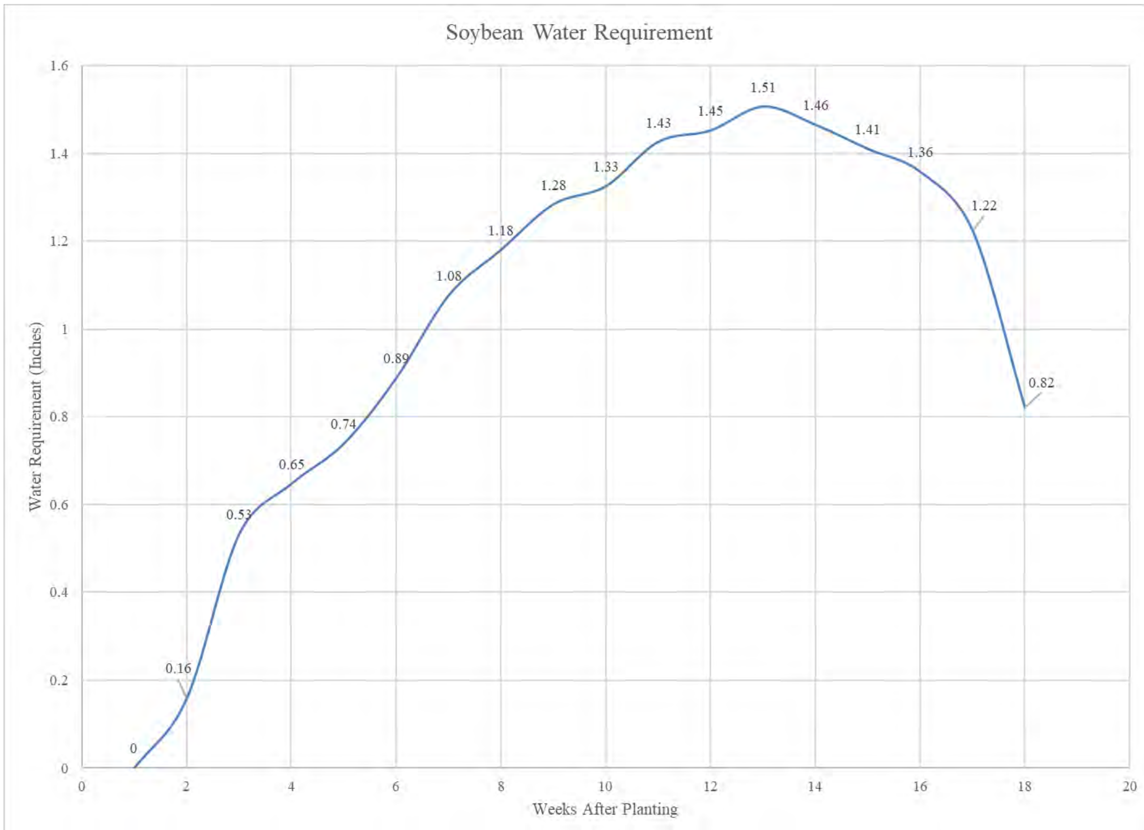


Figure 1. The weekly water requirement for soybeans.

Weeks After Planting	Average Weekly Water Requirement (Inches)	Average Daily Water Requirement (Inches)
1	0.16	0.02
2	0.53	0.08
3	0.65	0.09
4	0.74	0.11
5	0.89	0.13
6	1.08	0.15
7	1.18	0.17
8	1.28	0.18
9	1.33	0.19
10	1.43	0.20
11	1.45	0.21
12	1.51	0.22
13	1.46	0.21
14	1.41	0.20
15	1.36	0.19
16	1.22	0.17
17	0.82	0.12

Temperatures during early reproductive growth also likely play a large role in Georgia soybean yield potential. High temperatures during early reproductive growth (R1 through R3) can significantly reduce flower and pod retention, often negatively impacting yield. There are two ways in which proper irrigation could help alleviate these effects. First, proper irrigation prior to bloom can help to ensure canopy closure, so that shading may potentially create a cooler microclimate during reproductive growth. Secondly, by ensuring adequate soil moisture during initiation of reproductive growth with proper irrigation, the crop may be able to withstand more heat and maintain adequate retention of pods and blooms.

Irrigation Scheduling Methods

To schedule irrigation for most efficient use of water and maximum production, it is essential to frequently determine the soil moisture conditions throughout the root zone of the crop being grown. A number of methods for doing this have been developed and used with varying degrees of success. In comparison to investment in irrigation equipment, these instruments are relatively inexpensive. Talk to your local UGA County Extension Agent for more information about particular sensors technology and potential costs.

Keeping a Record of Rainfall/Irrigation

Regardless of what method is used to irrigate, you can obtain the full benefit of irrigation by keeping an accurate record of irrigation and rainfall events. Maintaining good records allows a producer to more properly predict irrigation events because they will know exactly how much water has been applied to the crop during which stages. This method can be used in combination with any of the irrigation scheduling methods whether it is simply using the Checkbook or as advanced as using soil moisture sensors.

Water Balance Methods

The most common method used that does not require frequent field activity is the water balance method. The principle of the water balance method is to obtain a balance of incoming and outgoing soil water so that adequate soil water is maintained for the plant. Inputs include incoming water in any form, whether rainfall or irrigation. It is suggested that irrigation and rainfall efficiency be accounted for to provide more accurate estimations of soil moisture. Outputs include evapotranspiration, runoff, and deep percolation. Water removal is more commonly referred to as evapotranspiration (ET). Evapotranspiration is usually expressed in inches per day. It consists of water removal by the plant and water loss directly by the soil. Two variations of the water balance method are used. One uses crop water use curves, the other uses pan evaporation data. To use either variation you must know your soil type and the available water holding capacity of the soil. This information can be obtained from your local Natural Resource Conservation Service, County Agent or online through the NRCS Web Soil Survey. It should be noted that the Checkbook is a simplified version of this method. The Checkbook does not account for soil type if it is used standalone, but it can be used in combination with a water balance method as is being described here. Next you should determine the soil zone you are trying to manage. This zone will vary according to the effective rooting depth of the soybeans. Usually 24 inches or less (2 feet) is the most that can be managed with irrigation. Determine the total water you have available to manage in this zone. It is desirable to try to maintain water content above 50% of the available water holding capacity. As water is removed daily (by either crop use or evaporation) these amounts are subtracted from the water available. When the moisture available approaches a zero balance, it is time to irrigate. The amount to add depends on the soil type, but will usually be the same as the 50 percent value calculated earlier plus an added amount to account for application efficiencies less than 100%. (Typical application efficiencies for sprinkler irrigation equipment vary from 75 percent to 90 percent.)

Soil Water Balance Irrigation Example

Step 1. The soil type of the field is a Tifton loamy sand. In Table 3, the average available water holding capacity is 1.0 inches/ft. Assuming a rooting depth of 2 feet, the total available water is 2.0 inches (2 ft x 1.0 inches/ft).

Step 2. If the soybean crop is determined to be during the 10^{th} week after planting. From Table 2, the daily water use by the crop is 0.2 inches/day.

Step 3. Determine replacement water amount by setting the lower allowable limit of available water in the profile. For this example, we will use a typical value of 50% allowable depletion (i.e. only 50% of the water in the root zone will be allowed to be depleted). Therefore, 1.0 inches of water will be required to replace the water used (2.0 inches x 0.50).

Step 4. Determine the amount of irrigation to apply by dividing the amount to be replaced by an irrigation efficiency from Table 4. (There are always losses between water pumped and water actually reaching the crop, such as evaporation, drift, etc.). In this example, we will assume a fairly new center pivot with optimal efficiency, at 88%. Thus, amount to apply = 1.0 inches / 0.88 = 1.14 inches.

Step 5. Determine the frequency of irrigation by dividing the amount of water replaced by water use per day. For example, frequency = 1.0 / 0.2 = 5 days.

Step 6. In this example, it would be necessary to apply 1.14 inches every 5 days to maintain 50% available water in the Tifton loamy sand soil profile for cotton during the 10^{th} week after planting. Any rainfall received would be subtracted from the amount to apply.

It is important to note that typically an irrigation application amount greater than 0.75 inches results in runoff in most soil types in Georgia. This is due to the infiltration rate of our Georgia soils. It is also important to consider this when monitoring rainfall events. This means that you will lose any additional water over 0.75 inches, thus it is recommended that you not exceed this amount in any one single application. High intensity rainfall events often become runoff too, and it is recommended that a producer carefully manage for rainfall. It is more beneficial for the crop if the required 1.14 inches were split into two applications of 0.57 inches every 2.5 days. If you have a pivot so large that it cannot make a round through the field in the calculated split time it is recommended that you apply the minimum amount required for the pivot to travel around the field as quickly as possible, and repeat this step as often as needed to reach required irrigation amounts. In most cases more frequent irrigation applications with lower rates are recommended. However, the rates still need to be high enough so that they can reach and infiltrate into the soil.

Irrigation intervals for most of the season will be 3 to 4 days for coarse textured sand, 4 to 6 days for more productive loamy sand and sandy loam, and 5 to 8 days for fine textured sandy loam or clay soils. A 4 to 6 day interval will fit a majority of the situations.

Table 3. Examples of Available Water Holding Capacities and Infiltration Rates of Soils in the Coastal Plain of Georgia.

Soil Series	Description	Infiltration Rate (Inches/Hr) for Bare Soil*	Available Water Holding Capacity (inches/Ft)
Faceville	Sandy Loam, 6-12" Moderate intake, but rapid in first zone	1.0	1.3
Greenville			1.4
Marlboro			1.2-1.5
Cahaba	Loamy Sand, 6-12" Loamy subsoil, rapid in first zone, moderate in second	1.2	1.0-1.5
Orangeburg			1.0-1.3
Red Bay			1.2-1.4
Americus	Loamy Sand, 40-60" Rapid permeability	2.0	1.0
Lakeland			0.8
Troup			0.9-1.2
Norfolk	Loamy sand, 12-18" Rapid permeability	1.3	1.0-1.5
Ochlocknee			1.4-1.8
Dothan	Loamy sand and sandy loam, 6-12" Moderate intake	1.0	1.0-1.3
Tifton			0.8-1.0
Fuquay	Loamy sand, 24-26" Rapid permeability in first zone, moderate in second	1.5	0.6-0.8
Lucy			1.0
Stilson			0.9
Wagram			0.6-0.8

* Increase soil infiltration rate in field where conservation tillage methods are used.

Table 4. Examples of Application Efficiency Values for Various Irrigation Systems.

Irrigation System Type	Application Efficiency (%)	
	Attainable	Expected
Center Pivot w/ Impact Sprinklers	85	75-85
Center Pivot w/ Spray-type Sprinklers	95	75-95
Lateral Move w/ Spray-type Sprinklers	95	75-95
Subsurface Drip	95	70-95
Micro-Spray	95	70-95
Trickle	95	75-95
Subsurface Drip	95	70-95
Moving Big Gun	75	60-75

Advanced Irrigation Scheduling

The soil water balance or Checkbook method of scheduling described above is a relatively straight-forward means of determining WHEN and an estimated amount of HOW MUCH to irrigate. This method helps a grower keep up with an estimated amount of available water in the field as the crop grows. However, this is a pretty basic method and as was earlier stated in this chapter is not applicable to all years. Thus, more advanced producers should consider utilizing more advanced irrigation scheduling methods such as soil water balance models or soil moisture sensors. More advanced methods include software such as the SmartIrrigation Soybean App (www.smartirrigationapps.org). The benefit of an interactive App is that it utilizes real time weather data to make daily decisions on irrigation requirements based a few parameters input by the producer. Soil moisture sensors provide near real-time readings of either soil moisture content or soil water tension in the root zone and can identify when water is needed to replenish the root zone. Soil moisture sensors coupled with a sound irrigation strategy will typically provide the highest yield level when compared to other methods because they are providing current readings and current crop water status, while other methods may just be estimates. Research results have shown that the checkbook method, even though most conservative, is not necessarily the most economically feasible method. Especially during years with higher levels of rainfall the checkbook method tends over-irrigate to reduce yields if not properly managed.

As stated earlier, growers with high yield goals should consider implementing a robust irrigation management plan. However, the grower must evaluate if the implementation of this plan is feasible for their operation. Based on the level of interest the grower should decide if they want to implement a simple plan that they can manage themselves or if they want to go more advanced and either hire a full time employee for irrigation management or hire a consultant to provide recommended irrigation amounts. This decision will be related to farm size, crop produced, and grower investment. Irrigation scheduling does take time, and growers are cautioned against implementing a plan without being properly prepared.

Harvesting, Drying, and Storage

Producing a high-quality soybean crop is one thing. Harvesting those soybeans with minimum losses and then drying and storing them in a way that maintains quality until the soybeans are marketed is another. A reduction in harvest losses of three bushels per acre when harvesting three acres per hour can result in a savings of $54 per harvesting hour based on $6 per bushel. Proper drying and storage will maintain quality soybeans and assure minimum losses.

Harvesting

Harvesting Losses

The grain-combine harvester has been used for soybeans since the mid-twenties but little progress was made in reducing harvesting losses until about 1970. Until then, the average combine using a rigid grain platform header resulted in as much as 10 percent losses during the harvesting operation. The introduction of attachments such as the floating cutter bar and pick-up reel reduced harvesting losses to 7 or 8 percent. Combine headers that have a built-in, flexible cutterbar have been designed and developed specifically for use in soybeans can reduce harvest losses to about 4 percent of yield.

The types of harvesting losses should be identified and measured so that proper combine adjustments can be made to increase soybean harvesting efficiency.

Preharvest losses are those that occur from natural causes before harvest. These losses result from soybeans that have fallen to the ground by the time harvest begins. If soybeans that are ready for harvest are subjected to several alternating periods of wet and dry weather, preharvest losses could be as high as 25 percent.

Gathering or header losses are soybeans that are not gathered into the combine. These losses are caused by the action of the cutter bar, reel and auger and account for more than 85 percent of the total soybean losses at harvest. There are four kinds of gathering losses. **Shatter losses** are shelled soybeans and detached soybean pods that are shattered from stalks by the header. **Stubble losses** are soybeans in pods remaining on the stubble because of operating the cutterbar too high, etc. **Stalk losses** are soybeans remaining in pods attached to stalks that were cut but not delivered into the combine. **Lodged losses** are soybeans remaining in pods attached to stalks that were not cut or that were cut at heights greater than that of the stubble.

Soybeans are easy to thresh, separate and clean. Soybeans can be rubbed out of the pod readily and their size and shape are ideal for cleaning. Even so, small errors in the adjustment of the combine can result in disastrous losses during the threshing, separating, and cleaning operations. **Threshing or cylinder losses** occur when shelled soybeans are carried out the back of the machine with the stalks. Separating losses are usually insignificant unless the combine is overloaded. **Cleaning or shoe losses** occur when shelled soybeans are carried over the chaffer or top sieve and out the back of the combine.

Measuring Losses

Harvesting losses can be measured by enclosing a ten square foot area with a rectangular frame and counting the soybeans remaining in that area after harvest. A count of 40 beans within the frame represents approximately one bushel per acre. Make the frame from heavy cord or cloth line so it can be coiled and carried on the combine. The length of the frame should be equal to the cutting width of the combine header (see table on page 58). Make four pins 3 to 4 inches long from No. 9 wire and tie them to the frame to mark the corners. The pins should be pushed into the ground to hold the frame tight.

Frame Width Based on Combine Header Width

Header Width (feet)	Frame Width (inches)
16	7.5
18	6.75
20	6
22	5.5
24	5

The procedure for determining field losses can be done by operating the combine in the normal way, move into the crop until well away from the edge of the field. Then, the combine should be stopped, the platform drive disengaged, the platform raised and the combine backed up 15 to 20 feet. In measuring total losses the frame should be placed across the harvested rows behind the combine and the loose soybeans, soybeans in pods on or off the stalks, and soybeans on the stubble inside the frame should be counted. This figure divided by 40 represents an estimate of the losses in bushels per acre, and it includes both preharvest and harvest losses. If the loss is near 3 percent of the yield, continue harvesting.

To measure preharvest losses, the frame should be placed across the rows of standing soybeans in front of the combine and loose soybeans and soybeans in pods on the ground should be counted and divided by 40. To determine the total harvesting losses, the preharvest losses should be subtracted from the total losses found behind the combine.

The shaded areas indicate frame placement for measuring total soybean loss, preharvested loss, and gathering loss..

Reducing Losses

Preharvest losses can be minimized by planting shatter-resistant varieties and early harvest. Soybeans should be harvested shortly after their moisture content first reaches 14-16 percent.

Header designs play an important role in reducing harvesting losses. The row-crop header has proven to be more efficient than platform type headers. Of the platform type headers, the flexible floating cutterbar header is the most efficient but slightly less efficient than the row-crop header.

The flexible floating cutterbar header has several features that enable it to reduce soybean losses: its long dividing points help prevent problems that occur in lodged soybeans; its extended platform and low profile reduce shatter and stalk losses; and its large-diameter auger rapidly moves plant material to the center and helps reduce stalk losses.

To take full advantage of the time available for harvesting, make all necessary repairs and major adjustments well before the harvest season. The combine should be thoroughly repaired, lubricated and adjusted as instructed in the operator's manual. Reduction in gathering losses can be accomplished only if the header is adjusted to cut close to the ground to avoid leaving soybeans on the stubble and shattering them from the stalks. To further reduce shatter losses, set the header to handle the soybeans as gently as possible. Rough handling by the header's cross auger and by the slat conveyors in the feeder housing can thresh a substantial percentage of the soybeans before they reach the combine cylinder. These soybeans can be lost if the slope of the header's deck is improperly adjusted, the deck is not tight, or if the plant material is not fed uniformly into the combine cylinder.

Almost all gathering losses are caused by the action of the knife and reel. The knife must be kept sharp, and broken or badly worn sections replaced. Plates should be adjusted to minimize knife vibration. The guards should be aligned and the knife clips adjusted so the knife can move freely and cut efficiently.

Proper reel adjustments are particularly necessary to keep losses low. If the reel turns too fast, it will shatter soybeans excessively. If the reel turns too slowly, it may drop stalks or allow them to be recut. A pick-up reel can help reduce harvesting losses. The speed of the pick-up reel should be 50 percent greater than ground speed. A 42-inch reel should rotate at about 12 revolutions per minute (rpm) for each 1 mph of forward speed.

The reel axle should be eight to 12 inches ahead of the sickle on most headers. With a pick-up reel and floating cutter bar, the reel axle should be about eight inches ahead of the sickle. Several manufacturers are now providing headers with a built-in, flexible cutter bar. When harvesting short plant material, the reel axle should be moved nearer the cutter bar.

To prevent excessive threshing and separating losses and to still keep the soybeans clean, the threshing and separating mechanisms must be kept properly adjusted. The single most important item to check is the separator speed. In each combine a particular shaft serves as a starting point for checking the operation speed. In some machines this starting point is the cylinder beater cross-shaft; in others it is the primary counter shaft. Most combines are designed to operate at the proper speed when the speed control lever of the engine is in the maximum position. Adjustment is needed if the separator is not running at the proper speed with the control level in this position.

To determine the procedure for adjusting engine speed, the operator's manual should be used or adjustments should be made by a local dealer. A small deviation from the correct engine speed can affect the operation of the cleaning and separating units making it impossible to get soybeans clean and keep losses to a minimum.

Before taking the combine to the field, the cylinder speed, the cylinder-concave clearance, the sieve settings, and the speed and opening of the cleaning fan should be adjusted. If the operator's manual is followed closely in making these adjustments, only minor adjustments should have to be made in the field.

The cylinder and fan speed must be adjusted to fit threshing conditions. When the moisture content of the soybeans is above 13 percent, they are usually tough; so the cylinder speed may have to be increased to 600 rpm. As soybeans dry, lower the cylinder speed to reduce breakage; 450 to 550 rpm should be high enough for soybeans that are below 13 percent in moisture content.

Drying and Storing Soybean

Drying soybeans has two principal advantages. Drying permits harvesting the grain as soon as it is ripe and mature to avoid field losses and it places the grain in a condition for safe storage reducing storage losses from heat damage and molds. Drying is the universal method of conditioning wet grain to preserve its quality and nutritive value for feed and food and its germination for seed.

Soybeans should be harvested promptly when they are mature to reduce field losses and lessen chances of damage from bad weather. However, at this stage soybeans contain too much moisture for safe storage. With adequate **drying methods**, soybeans can be harvested at a moisture content as high as 20 percent.

However, when drying from 20 percent to a safe moisture content, a large amount of water must be removed increasing the cost of the drying operation. High moisture grain loses this moisture rapidly in the field; thus, for maximum returns soybeans should be harvested when they have reached approximately 14 to 16 percent moisture content. The percent weight reduction when drying grain and soybeans can be easily estimated (see following).

Percent Reductions in Weight of Soybeans from Drying

Original Moisture	**Final Moisture Content (%)**					
Content (%)	**10**	**11**	**12**	**13**	**14**	**15**
	Weight Reduction (%)					
16	6.7	5.6	4.5	3.4	2.3	1.2
17	7.8	6.7	5.7	4.6	3.5	2.3
18	8.9	7.9	6.9	5.8	4.7	3.6
19	10.1	9.0	8.0	6.9	5.8	4.7
20	11.0	10.1	9.0	8.1	7.0	5.8

For example, soybeans with an original moisture content of 16 percent dried to a final moisture content of 11 percent lose approximately 5.6 percent from the original weight. On 1,000 pounds of soybeans (original weight), the loss would be 56 pounds and the final dried weight, 944 pounds.

The recommended maximum moisture content for one year of safe storage of soybeans in Georgia is 11 percent in north Georgia and 10 percent below the fall line. Note that this is the maximum moisture content to be found anywhere in the storage bin and is not the average for all the beans in the bin.

The two principal factors involved in the safe storage of soybeans are moisture content and temperature. The amount of moisture in soybeans determines whether or not mold damage will occur. The higher the moisture and temperature, the faster mold growth and more rapid the spoilage of soybeans will occur. Insect damage is also less in dry, stored soybeans.

Low temperatures offset the effects of high moisture, particularly as it affects the development of molds and insects. Cooling is one of the greatest benefits gained from moving and turning soybeans in elevators. This can be accomplished more effectively by aeration which cools soybeans so that damp soybeans can be held in storage for weeks or even months.

In all practical soybean drying systems, air is used as a medium for removing moisture as it is evaporated. Evaporation of the moisture requires heat energy that is normally supplied by the air forced through the soybeans. When dry air is forced up through a deep layer of wet soybeans, drying starts at the bottom where the air first enters. As the flow of air continues, more of the soybeans begin to dry, so that a layer known as the "drying zone" is formed. The drying zone continues to move upward through the wet soybeans until it is passed through the surface layer.

Relative humidity of the drying air determines the moisture to which grain will dry. At a given temperature and relative humidity, there is a corresponding moisture content below which the grain will dry no more. This property of grains is referred to as the "equilibrium moisture content" (see table below).

Equilibrium Moisture Content						
	Relative Humidity (%)					
Air Temp (ºF)	20	35	55	70	80	90
	Moisture Content (%)					
40	6.3	8.5	11.0	13.5	15.5	19.5
60	5.8	8.0	10.0	12.0	14.0	17.5
80	4.5	7.0	9.0	11.0	13.0	15.8
100	4.0	6.0	8.2	10.3	12.2	14.5

The safe maximum temperature of the heated air for drying any grain is determined by the final use of the grain. For soybeans to be milled for oil and those to be used for food, the temperatures in heated-air batch driers should be limited to 130°F. Soybeans to be used for seed should not be exposed to air over 110°F.

For in-storage drying, temperatures of the drying air over 100°F are seldom encountered. However, the initial moisture content and the time of exposure of the wet grain to this higher temperature above the drying zone become important factors. The greater the moisture content of the soybeans, the greater the air flow required per bushel to dry it to a safe moisture content before mold attach can set in.

Stored soybeans should be aerated to keep them at a cool, uniform temperature. If stored in bins equipped for drying, all the soybeans can be cooled to a uniform temperature in about 10 to 15 hours. The soybeans should be cooled immediately after drying is completed and the cooling repeated every two months during the winter and once in the spring on a cool, dry day. After each cooling, all openings to the plenum under the floor should be closed and a tight cover put over the fan inlet to prevent any outside air circulating through the grain. The air can be forced up through the grain as in drying, provided condensation does not occur on the bin roof. It is not always necessary to pull the air through the grain as in aerating grain with smaller fans, in which case pulling is essential. The purpose of aeration is to keep the grain at a uniform cool temperature which prevents "top sweating" in the top layer of grain in the center of the bin.

Mechanical injury to soybean seed should be avoided as it is an important cause of decline in germination and vigor. Injury to soybean seed results primarily from impacts of the seed with hard surfaces or other seed. The extent and severity of mechanical damage are related to the moisture content of the seed, the velocity of the seed at the moment of impact, and the degree of hardness of the impacted surface. A single 10-foot drop of seed with less than 12 percent moisture against a metal surface can reduce germination by as much as 10 to 15 percent. Seeds with 14 percent or more moisture are relatively unaffected by impacts resulting from drops as high as 20 feet.

Soybeans for use other than seed are also affected by dropping into a bin if moisture content is too low. A certain amount of splitting will occur each time they are dropped. Soybeans should be handled as little and as gently as possible.

Safety

Good safety habits are a must for anyone who operates a modern combine or who is involved in soybean storage and hauling.

Always keep the combine clean because field trash around the exhaust system can cause fires. Before a combine is lubricated or adjusted or cleaned, all drives should be disengaged and the engine stopped.

Grain drying and handling can be dangerous. Transport augers can hit power lines, unguarded augers can catch hands or feet, and fans and shafts can catch unsuspecting victims. A deadly hazard exists for anyone in a grain bin as deaths occur every year from suffocation and injuries caused by unloading augers. Power to the unloading auger should be disconnected before entering bins. A knotted safety rope hanging near the center of the bin offers greater protection, and a second person who can offer assistance should be standing by. Air pockets sometimes form when grain bridges over unloading augers due to spoiled grain and moisture. This crusted surface should not be walked over because the pocket can collapse. Wear an effective dust mask when exposed to grain dust.

2020 SOYBEAN OUTLOOK & COST ANALYSIS

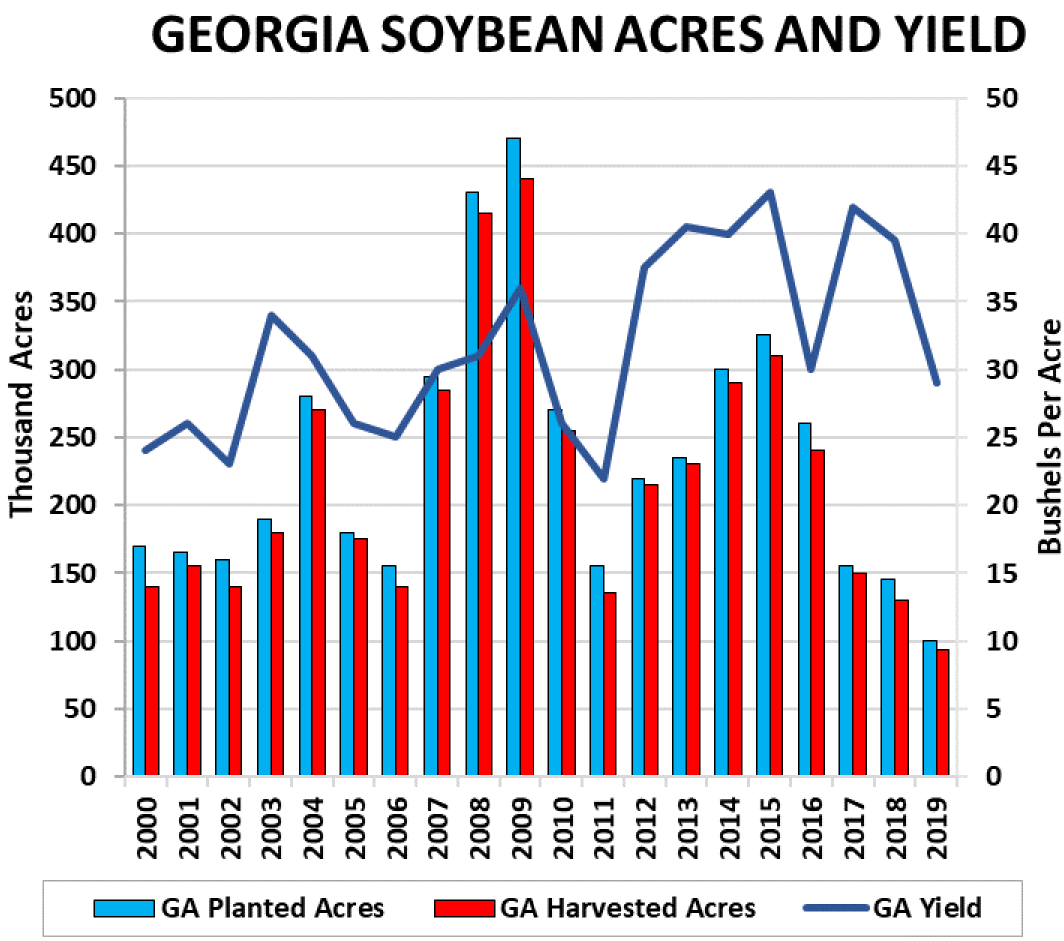
(***Adam Rabinowitz & Amanda Smith***)

Soybean Supply and Demand Highlights

- **Acreage** - U.S. soybean plantings decreased by 14.7% to 76.1 million acres in 2019. Harvested acres were down 14.4% from 2018 to 75 million. Georgia soybean growers planted nearly 31% fewer acres in 2019 for a total of 100,000 acres and a harvested 93,000 acres.
- **Soybean Production Lower** - U.S. soybean production in 2019 was the lowest since 2013. The U.S. average yield dropped to 47.4 bushels per acre. Total production equaled 3.6 billion bushels, down 19.6% from 2018. Georgia production decreased 47.5% to 2.7 million bushels, the lowest level of production since 1963. The Georgia average yield for 2019 was 29 bushels per acre, down 26.6%.
- **Soybean Use Increasing** - Total soybean use for the 2019/20 marketing year is projected at 4 billion bushels, up 2.2% from the previous year. However, this is still off from the recent high of 4.3 billion bushels in the 2017/18 marketing year.
- **Exports Rebounding –** Trade issues have continued to depress the soybean market, although exports are projected to increase. China remains the number one destination for U.S. soybeans, even with tariffs and trade disputes. Mexico and Egypt have also seen increased exports. With respect to global production, Brazil has surpassed the U.S. to become the largest producer of soybeans while continuing to be the number one exporting country.
- **Stocks on the Decline** – With production declining, ending stocks are projected to decrease to an estimated 425 million bushels. This is down 3% from the pre-trade dispute period two years ago. While this has helped prices rebound some since the trade dispute with China began, U.S. prices are still projected to only top out around $8.75 per bushel due to high levels of global supply.
- **2020 Crop -** The 2020 U.S. crop will increase in acreage given that much of the decline was due to weather and trade related issues. U.S. soybean futures for 2020 harvest are close to $9.15 per bushel providing an opportunity for the price of soybeans in Georgia to fluctuate around $8.65.

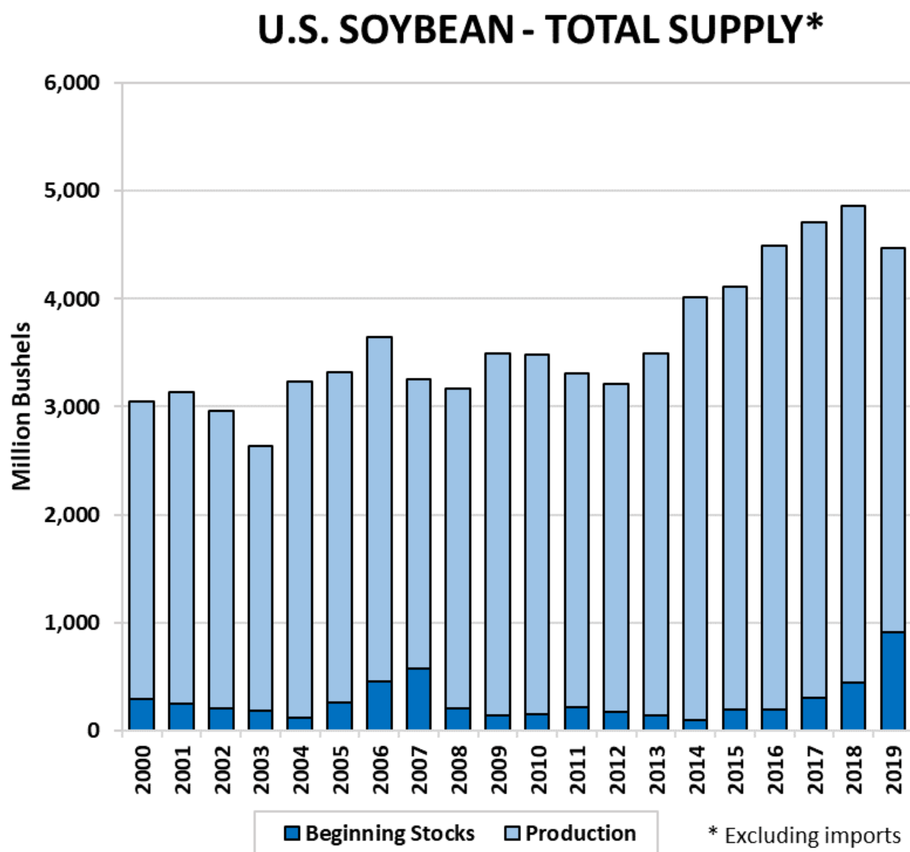
2019 Crop Review and 2020 Outlook

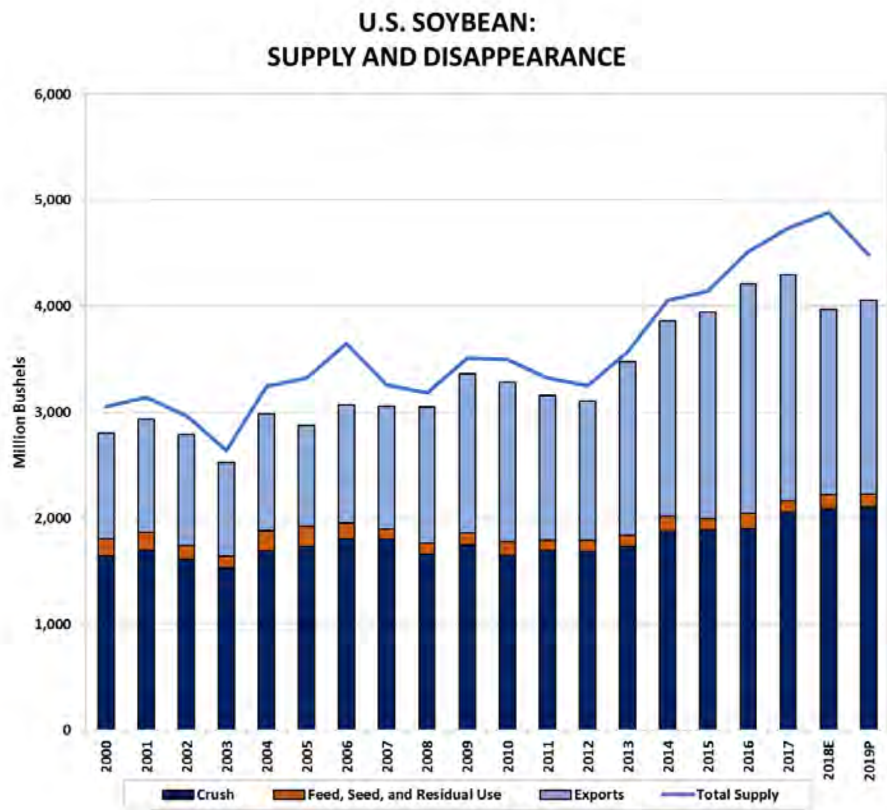
Georgia growers planted 100,000 acres of corn in 2019 with harvested acres estimated at 93,000. The state average yield was 29 bushels per acre, 26.6% below the previous year. Soybean production in Georgia was 2.7 million bushels, down 47.5% from 2018 and down 80% since the recent high in 2015. As one can see from the graph below, GA soybean yields have fluctuated between 30 and 40 bushels per acre since 2012. Planted acres have also been the lowest since 1959.



Total U.S. soybean production was down in 2019 to 3.6 billion bushels, due to a combination of weather issues throughout the nation and significant ending stocks from trade disruption. U.S. yields were down to 47.4 bushels per acre, a drop from the recent high of 51.9 bushels in 2016. The decrease in acres, however, was the biggest influence to the drop in overall production with acreage dropping to 76.1 million acres, the lowest level since 2011. Ending stocks of soybeans are projected down at the end of the 2019/20 marketing year, but due to record levels of ending stocks the year prior they are still more than double where they were during the 2008-2015 period.

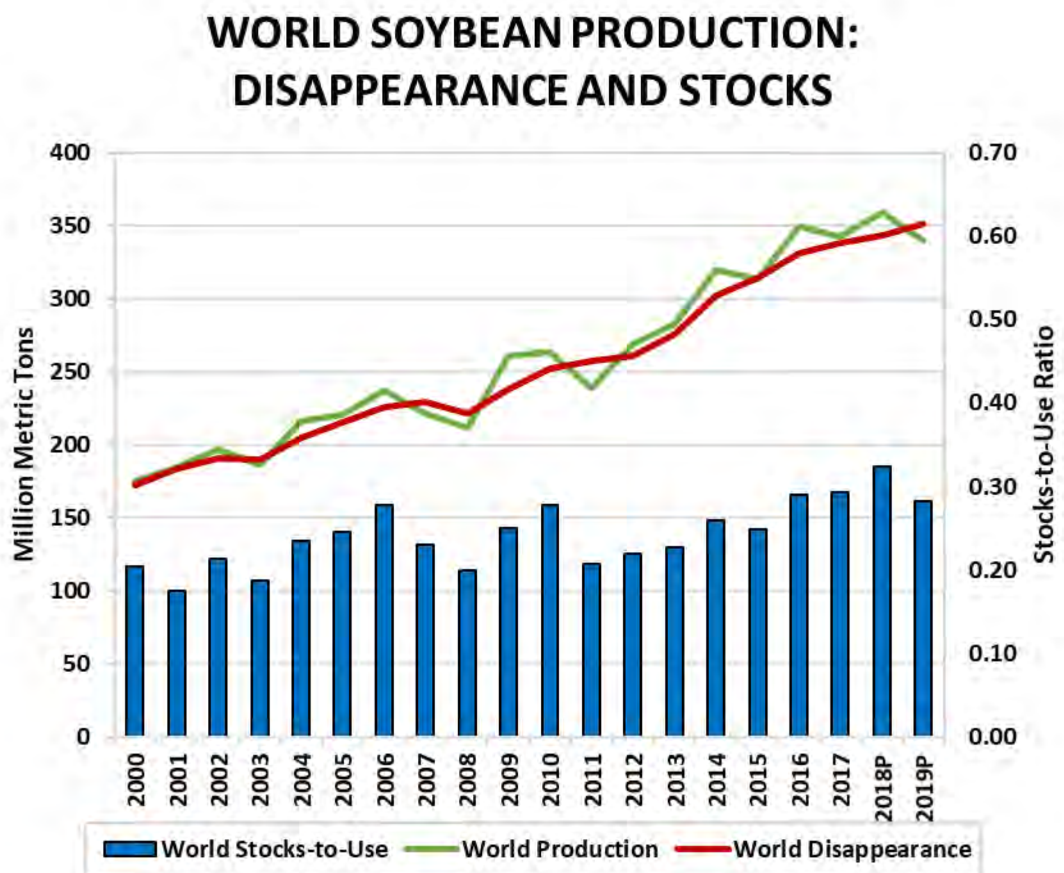
Total use of U.S. soybeans dropped in 2018/19 for the first time in 5 years on a decrease in exports. With a slight rebound in exports in 2019, total use of soybeans is expected to increase in 2019/20 to 4 billion bushels. About half of the soybeans are used for crush, with over 2.1 billion bushels of demand. This has increased every year since 2012. Exports make up roughly the other half of U.S. disappearance, with feed and seed relatively consistent over time.


U.S. SOYBEAN - TOTAL SUPPLY*
Million Bushels
6,000
5,000
4,000
3,000
2,000
1,000
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Beginning Stocks
Production
* Excluding imports



Exports have been rebounding slowly since the trade disputes with China started in 2018. China has granted some tariff relief to U.S. soybeans and it is expected that with the recent agreement to buy more agricultural products that additional tariff exemptions will occur in 2020. However, Brazil has increased their global dominance of soybeans with record levels of production and exports. China also faces issues with a smaller hog herd due to the African swine fever. As the hog herd starts to recover there may be opportunities to further increase soybean exports to China, but that is expected to be a slow process.

Overall, world production was less than demand for the first time since 2011. Thus the stocks-to-use ratio, a combined measure of supply relative to demand, had been on a steady increase for the last decade. While a decrease is projected for 2019, there are still very substantial world supplies of soybeans that will keep prices in check. With Brazil expanding production the overall trend of increasing world stocks is expected to continue.



2020 Price Outlook in Georgia

Once the U.S. soybean acreage is known early in the year, the market will be driven by weather and yield estimates. Georgia figures to continue to be a fringe player in the soybean market, largely following national price trends with a negative local basis. The most probable outlook right now is for soybean prices to fluctuate around $8.65 per bushel based on current futures market prices.

Budgeted Production Costs

Variable costs for 2020 are projected to be slightly higher for dryland soybeans up 1.8% but flat for irrigated soybeans.

Seed, Fertilizer and Chemicals - Seed cost is up $2 per bag from last year. Fertilizer prices are mixed with phosphate down $0.04/lb but potash up $0.03/lb and boron flat. Costs for weed control are expected to fall while insect control costs and disease control costs increase slight.

Cost of Borrowed Funds – The interest rate charged in the soybean budgets is at 6.0%, reflecting a conservative estimate but also the risk of inflation and relatively low prices for row crops. This is a decrease from the prior year budget that assumed a 6.3% interest rate. The prime lending rate decreased during 2019 from 5.5% in December 2018 to 4.75% in October 2019. The decrease in the prime rate is an indication that some farmers may see decreases in their own lending rate, but a farmer in good financial standing can probably get an even lower rate than reflected in the budgets.

Fuel and Energy Costs – Energy prices are projected to be stable in 2020. The 2020 budgeted price is $2.50 per gallon which is the same as the 2019 budgets. The irrigated corn budget charges an average of $8.65 per acre-inch of water reflecting a 70/30 ratio of electric to diesel power sources. This is a decrease in cost from the 2019 budget that assumed a 60/30 electric to diesel ratio.

Labor and Repairs – Operator labor rates increased to $13.50 per hour with a $0.25 per hour increase from 2019. Machinery repairs are expected to increase in 2020.

As always, enterprise budgets are designed to give the user a guide based on our expectations of cost changes for the upcoming growing season. The producers actual cost of production is the most important consideration and input costs can vary based on different practices, geographic considerations, and a producer's individual needs.

Sources

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Irrigated Soybeans
South Georgia, 2020

Estimated Costs and Returns

Expected Yield: **60** bushel Your Yield __________

Variable Costs	Unit	Amount	$/Unit	Cost/Acre	$/bushel	Your Farm
RR Seed	bag	1	$ 55.00	$ 55.00	$ 0.92	________
Inoculant	acre	1	$ 6.50	$ 6.50	$ 0.11	________
Lime	ton	0.33	$ 45.00	$ 14.85	$ 0.25	________
Fertilizer						
Phosphate	pounds	40	$ 0.40	$ 16.00	$ 0.27	________
Potash	pounds	80	$ 0.35	$ 28.00	$ 0.47	________
Boron	pounds	0.5	$ 6.00	$ 3.00	$ 0.05	________
Weed Control	acre	1	$ 25.58	$ 25.58	$ 0.43	________
Insect Control	acre	1	$ 4.55	$ 4.55	$ 0.08	________
Disease Control *	acre	1	$ 24.00	$ 24.00	$ 0.40	________
Preharvest Machinery						
Fuel	gallon	4.4	$ 2.50	$ 10.92	$ 0.18	________
Repairs and Maintenance	acre	1	$ 11.17	$ 11.17	$ 0.19	________
Harvest Machinery						
Fuel	gallon	2.4	$ 2.50	$ 5.95	$ 0.10	________
Repairs and Maintenance	acre	1	$ 7.63	$ 7.63	$ 0.13	________
Labor	hours	0.9	$ 13.50	$ 12.52	$ 0.21	________
Irrigation**	applications	5	$ 8.65	$ 43.25	$ 0.72	________
Crop Insurance	acre	1	$ 9.00	$ 9.00	$ 0.15	________
Land Rent	acre	1	$ -	$ -	$ -	________
Interest on Operating Capital	percent	$ 138.96	6.0%	$ 8.34	$ 0.14	
Total Variable Costs:				**$ 286.25**	**$ 4.77**	

Fixed Costs	Unit	Amount	$/Unit	Cost/Acre	$/bushel	Your Farm
Machinery Depreciation, Taxes, Insurance and Housing						
Preharvest Machinery	acre	1	$ 31.76	$ 31.76	$ 0.53	________
Harvest Machinery	acre	1	$ 37.47	$ 37.47	$ 0.62	________
Irrigation	acre	1	$ 130.00	$ 130.00	$ 2.17	________
General Overhead	% of VC	$ 286.25	5%	$ 14.31	$ 0.24	________
Management	% of VC	$ 286.25	5%	$ 14.31	$ 0.24	________
Owned Land Cost, Taxes, Cash Payment, etc.	acre	1	$ -	$ -	$ -	________
Other __________________	acre	1	$ -	$ -	$ -	
Total Fixed Costs				**$ 227.86**	**$ 3.80**	
Total Costs Excluding Land				**$ 514.11**	**$ 8.57**	
Your Profit Goal				**$** __________	**/bushel**	
Price Needed for Profit				**$**	**/bushel**	

* In the case of Asian Soybean Rust or other disease, add $15-$30 for additional fungicide sprays.

** Average of diesel and electric irrigation application costs. Electric is estimated at $7/appl and diesel is estimated at $12.50/appl when diesel costs $2.50/gal.

Developed by Amanda Smith and Adam Rabinowitz

Sensitivity Analysis of Irrigated Soybeans

Net Returns Above Variable Costs Per Acre

Varying Prices and Yields (bushel)

	-25%	-10%	Expected	+10%	+25%
Price \ bushel/Acre	45	54	60	66	75
$9.00	**$118.75**	**$199.75**	**$253.75**	**$307.75**	**$388.75**
$10.00	**$163.75**	**$253.75**	**$313.75**	**$373.75**	**$463.75**
$11.00	**$208.75**	**$307.75**	**$373.75**	**$439.75**	**$538.75**
$12.00	**$253.75**	**$361.75**	**$433.75**	**$505.75**	**$613.75**
$13.00	**$298.75**	**$415.75**	**$493.75**	**$571.75**	**$688.75**

Estimated Labor and Machinery Costs per Acre

Preharvest Operations

Operation	Acres/Hour	Number of Times Over	Labor Use**** (hrs/ac)	Fuel Use (gal/ac)	Repairs ($/ac)	Fixed Costs ($/ac)
Heavy Disk 27' with Tractor (180-199 hp) MFWD 190	13.2	2	0.19	1.48	$ 4.23	$ 12.29
Disk Harrow 32' with Tractor (180-199 hp) MFWD 190	16.3	1	0.08	0.60	$ 1.84	$ 5.35
Bed-Disk (Hipper) 6R-36 with Tractor (180-199 hp) MFWD 190	9.6	1	0.13	1.02	$ 1.80	$ 5.55
Plant - Rigid 6R-36 with Tractor (120-139 hp) 2WD 130	9.5	1	0.13	0.70	$ 2.01	$ 5.60
Spray (Broadcast) 60' with Tractor (120-139 hp) 2WD 130	35.5	3	0.11	0.57	$ 1.28	$ 2.97
Total Preharvest Values			0.63	4.37	$ 11.17	$ 31.76

Harvest Operations

Operation	Acres/Hour	Number of Times Over	Labor Use**** (hrs/ac)	Fuel Use (gal/ac)	Repairs ($/ac)	Fixed Costs ($/ac)
Header -Soybean 18' Flex with Combine (200-249 hp) 240 hp	7.0	1	0.18	1.75	$ 6.24	$ 33.71
Grain Cart Corn 500 bu with Tractor (120-139 hp) 2WD 130	10.6	1	0.12	0.63	$ 1.39	$ 3.76
Total Harvest Values			0.29	2.38	$ 7.63	$ 37.47

**** Includes unallocated labor factor of 0.25. Unallocated labor factor is percentage allowance for additional labor required to move equipment and hook/unhook implements, etc.

Developed by Amanda Smith and Adam Rabinowitz

Irrigated Soybeans, Strip Tillage
South Georgia, 2020

Estimated Costs and Returns

Expected Yield: **60** bushel Your Yield ____________

Variable Costs	Unit	Amount	$/Unit	Cost/Acre	$/bushel	Your Farm
Cover Crop Seed	bushel	1.5	$ 17.00	$ 25.50	$ 0.43	________
RR Seed	bag	1	$ 55.00	$ 55.00	$ 0.92	________
Inoculant	acre	1	$ 6.50	$ 6.50	$ 0.11	________
Lime	ton	0.33	$ 45.00	$ 14.85	$ 0.25	________
Fertilizer						
Phosphate	pounds	40	$ 0.40	$ 16.00	$ 0.27	________
Potash	pounds	80	$ 0.35	$ 28.00	$ 0.47	________
Boron	pounds	0.5	$ 6.00	$ 3.00	$ 0.05	________
Weed Control	acre	1	$ 36.34	$ 36.34	$ 0.61	________
Insect Control	acre	1	$ 4.55	$ 4.55	$ 0.08	________
Disease Control *	acre	1	$ 24.00	$ 24.00	$ 0.40	________
Preharvest Machinery **						
Fuel	gallon	3.1	$ 2.50	$ 7.65	$ 0.13	________
Repairs and Maintenance	acre	1	$ 7.82	$ 7.82	$ 0.13	________
Harvest Machinery						
Fuel	gallon	2.4	$ 2.50	$ 5.95	$ 0.10	________
Repairs and Maintenance	acre	1	$ 7.63	$ 7.63	$ 0.13	________
Labor	hours	0.7	$ 13.50	$ 10.09	$ 0.17	________
Irrigation***	applications	4	$ 8.65	$ 34.60	$ 0.58	________
Crop Insurance	acre	1	$ 9.00	$ 9.00	$ 0.15	________
Land Rent	acre	1	$ -	$ -	$ -	________
Interest on Operating Capital	percent	$ 135.49	6.0%	$ 8.13	$ 0.14	
Total Variable Costs:				**$ 304.60**	**$ 5.08**	
Fixed Costs						
Machinery Depreciation, Taxes, Insurance and Housing						
Preharvest Machinery ***	acre	1	$ 21.96	$ 21.96	$ 0.37	________
Harvest Machinery	acre	1	$ 37.47	$ 37.47	$ 0.62	________
Irrigation	acre	1	$ 130.00	$ 130.00	$ 2.17	________
General Overhead	% of VC	$ 304.60	5%	$ 15.23	$ 0.25	________
Management	% of VC	$ 304.60	5%	$ 15.23	$ 0.25	________
Owned Land Cost, Taxes, Cash Payment, etc.	acre	1	$ -	$ -	$ -	________
Other ________________	acre	1	$ -	$ -	$ -	
Total Fixed Costs				**$ 219.90**	**$ 3.66**	
Total Costs Excluding Land				**$ 524.50**	**$ 8.74**	
Your Profit Goal				**$** ____________	**/bushel**	
Price Needed for Profit				**$**	**/bushel**	

* In the case of Asian Soybean Rust or other disease, add $15-$30 for additional fungicide sprays.

** Rip, strip and plant in one pass. Performing rip, strip and plant as separate operations increases preharvest fuel use by 0.6 gal ($1.35/ac), labor costs by $0.85/ac, and repairs by $0.90/ac. Fixed costs would increase by $2.50/ac.

*** Average of diesel and electric irrigation application costs. Electric is estimated at $7/appl and diesel is estimated at $12.50/appl when diesel costs $2.50/gal.

Developed by Amanda Smith and Adam Rabinowitz

Sensitivity Analysis of Irrigated Soybeans, Strip Tillage

Net Returns Above Variable Costs Per Acre

Varying Prices and Yields (bushel)

	-25%	-10%	Expected	+10%	+25%
Price \ bushel/Acre	45	54	60	66	75
$9.00	**$100.40**	**$181.40**	**$235.40**	**$289.40**	**$370.40**
$10.00	**$145.40**	**$235.40**	**$295.40**	**$355.40**	**$445.40**
$11.00	**$190.40**	**$289.40**	**$355.40**	**$421.40**	**$520.40**
$12.00	**$235.40**	**$343.40**	**$415.40**	**$487.40**	**$595.40**
$13.00	**$280.40**	**$397.40**	**$475.40**	**$553.40**	**$670.40**

Estimated Labor and Machinery Costs per Acre

Preharvest Operations

Operation	Acres/Hour	Number of Times Over	Labor Use***** (hrs/ac)	Fuel Use (gal/ac)	Repairs ($/ac)	Fixed Costs ($/ac)
Spin Spreader 5 ton with Tractor (120-139 hp) 2WD 130	23.8	1	0.05	0.28	$ 0.64	$ 1.81
Disk Harrow 32' with Tractor (180-199 hp) MFWD 190	16.3	1	0.08	0.60	$ 1.84	$ 5.35
Spray (Broadcast) 60' with Tractor (120-139 hp) 2WD 130	35.5	1	0.04	0.19	$ 0.43	$ 0.99
ST Plant Rigid 6R-36 with Tractor (180-199 hp) MFWD 190	6.9	1	0.18	1.42	$ 3.63	$ 10.84
Spray (Broadcast) 60' with Tractor (120-139 hp) 2WD 130	35.5	3	0.11	0.57	$ 1.28	$ 2.97
Total Preharvest Values			0.45	3.06	$ 7.82	$ 21.96

Harvest Operations

Operation	Acres/Hour	Number of Times Over	Labor Use***** (hrs/ac)	Fuel Use (gal/ac)	Repairs ($/ac)	Fixed Costs ($/ac)
Header -Soybean 18' Flex with Combine (200-249 hp) 240 hp	7.0	1	0.18	1.75	$ 6.24	$ 33.71
Grain Cart Corn 500 bu with Tractor (120-139 hp) 2WD 130	10.6	1	0.12	0.63	$ 1.39	$ 3.76
Total Harvest Values			0.29	2.38	$ 7.63	$ 37.47

***** Includes unallocated labor factor of 0.25. Unallocated labor factor is percentage allowance for additional labor required to move equipment and hook/unhook implements, etc.

Developed by Amanda Smith and Adam Rabinowitz

Non-Irrigated Soybeans
South Georgia, 2020

Estimated Costs and Returns

Expected Yield: **30** bushel Your Yield ________

Variable Costs	**Unit**	**Amount**	**$/Unit**	**Cost/Acre**	**$/bushel**	**Your Farm**
RR Seed	bag	1	$ 55.00	$ 55.00	$ 1.83	________
Inoculant	acre	1	$ 6.50	$ 6.50	$ 0.22	________
Lime	ton	0.33	$ 45.00	$ 14.85	$ 0.50	________
Fertilizer						
Phosphate	pounds	40	$ 0.40	$ 16.00	$ 0.53	________
Potash	pounds	80	$ 0.35	$ 28.00	$ 0.93	________
Boron	pounds	0.5	$ 6.00	$ 3.00	$ 0.10	________
Weed Control	acre	1	$ 20.88	$ 20.88	$ 0.70	________
Insect Control	acre	1	$ 4.55	$ 4.55	$ 0.15	________
Disease Control *	acre	1	$ -	$ -	$ -	________
Preharvest Machinery						
Fuel	gallon	4.4	$ 2.50	$ 10.92	$ 0.36	________
Repairs and Maintenance	acre	1	$ 11.17	$ 11.17	$ 0.37	________
Harvest Machinery						
Fuel	gallon	2.4	$ 2.50	$ 5.95	$ 0.20	________
Repairs and Maintenance	acre	1	$ 7.63	$ 7.63	$ 0.25	________
Labor	hours	0.9	$ 13.50	$ 12.52	$ 0.42	________
Crop Insurance	acre	1	$ 15.00	$ 15.00	$ 0.50	________
Land Rent	acre	1	$ -	$ -	$ -	________
Interest on Operating Capital	percent	$ 105.98	6.0%	$ 6.36	$ 0.21	
Total Variable Costs:				**$ 218.33**	**$ 7.28**	

Fixed Costs						
Machinery Depreciation, Taxes, Insurance and Housing						
Preharvest Machinery	acre	1	$ 31.76	$ 31.76	$ 1.06	________
Harvest Machinery	acre	1	$ 37.47	$ 37.47	$ 1.25	________
General Overhead	% of VC	$ 218.33	5%	$ 10.92	$ 0.36	________
Management	% of VC	$ 218.33	5%	$ 10.92	$ 0.36	________
Owned Land Cost, Taxes, Cash Payment, etc.	acre	1	$ -	$ -	$ -	________
Other ________________	acre	1	$ -	$ -	$ -	
Total Fixed Costs				**$ 91.06**	**$ 3.04**	

Total Costs Excluding Land		**$ 309.39**	**$ 10.31**
Your Profit Goal	**$**	________	**/bushel**
Price Needed for Profit	**$**		**/bushel**

* In the case of Asian Soybean Rust or other disease, add $15-$30 for additional fungicide sprays.

Developed by Amanda Smith and Adam Rabinowitz

Sensitivity Analysis of Non-Irrigated Soybeans

Net Returns Above Variable Costs Per Acre

Varying Prices and Yields (bushel)

	-25%	-10%	Expected	+10%	+25%
Price \ bushel/Acre	23	27	30	33	38
$9.00	**-$15.83**	**$24.67**	**$51.67**	**$78.67**	**$119.17**
$10.00	**$6.67**	**$51.67**	**$81.67**	**$111.67**	**$156.67**
$11.00	**$29.17**	**$78.67**	**$111.67**	**$144.67**	**$194.17**
$12.00	**$51.67**	**$105.67**	**$141.67**	**$177.67**	**$231.67**
$13.00	**$74.17**	**$132.67**	**$171.67**	**$210.67**	**$269.17**

Estimated Labor and Machinery Costs per Acre

Preharvest Operations

Operation	Acres/Hour	Number of Times Over	Labor Use*** (hrs/ac)	Fuel Use (gal/ac)	Repairs ($/ac)	Fixed Costs ($/ac)
Heavy Disk 27' with Tractor (180-199 hp) MFWD 190	13.2	2	0.19	1.48	$ 4.23	$ 12.29
Disk Harrow 32' with Tractor (180-199 hp) MFWD 190	16.3	1	0.08	0.60	$ 1.84	$ 5.35
Bed-Disk (Hipper) 6R-36 with Tractor (180-199 hp) MFWD 190	9.6	1	0.13	1.02	$ 1.80	$ 5.55
Plant - Rigid 6R-36 with Tractor (120-139 hp) 2WD 130	9.5	1	0.13	0.70	$ 2.01	$ 5.60
Spray (Broadcast) 60' with Tractor (120-139 hp) 2WD 130	35.5	3	0.11	0.57	$ 1.28	$ 2.97
Total Preharvest Values			0.63	4.37	$ 11.17	$ 31.76

Harvest Operations

Operation	Acres/Hour	Number of Times Over	Labor Use*** (hrs/ac)	Fuel Use (gal/ac)	Repairs ($/ac)	Fixed Costs ($/ac)
Header -Soybean 18' Flex with Combine (200-249 hp) 240 hp	7.0	1	0.18	1.75	$ 6.24	$ 33.71
Grain Cart Corn 500 bu with Tractor (120-139 hp) 2WD 130	10.6	1	0.12	0.63	$ 1.39	$ 3.76
Total Harvest Values			0.29	2.38	$ 7.63	$ 37.47

*** Includes unallocated labor factor of 0.25. Unallocated labor factor is percentage allowance for additional labor required to move equipment and hook/unhook implements, etc.

Developed by Amanda Smith and Adam Rabinowitz

Non-Irrigated Soybeans, Strip Tillage
South Georgia, 2020

Estimated Costs and Returns

Expected Yield: **30** bushel Your Yield ___________

Variable Costs	Unit	Amount	$/Unit	Cost/Acre	$/bushel	Your Farm
Cover Crop Seed	bushel	1.5	$ 17.00	$ 25.50	$ 0.85	________
RR Seed	bag	1	$ 55.00	$ 55.00	$ 1.83	________
Inoculant	acre	1	$ 6.50	$ 6.50	$ 0.22	________
Lime	ton	0.33	$ 45.00	$ 14.85	$ 0.50	________
Fertilizer						
Phosphate	pounds	40	$ 0.40	$ 16.00	$ 0.53	________
Potash	pounds	80	$ 0.35	$ 28.00	$ 0.93	________
Boron	pounds	0.5	$ 6.00	$ 3.00	$ 0.10	________
Weed Control	acre	1	$ 31.64	$ 31.64	$ 1.05	________
Insect Control	acre	1	$ 4.55	$ 4.55	$ 0.15	________
Disease Control *	acre	1	$ -	$ -	$ -	________
Preharvest Machinery **						
Fuel	gallon	3.1	$ 2.50	$ 7.65	$ 0.25	________
Repairs and Maintenance	acre	1	$ 7.82	$ 7.82	$ 0.26	________
Harvest Machinery						
Fuel	gallon	2.4	$ 2.50	$ 5.95	$ 0.20	________
Repairs and Maintenance	acre	1	$ 7.63	$ 7.63	$ 0.25	________
Labor	hours	0.7	$ 13.50	$ 10.09	$ 0.34	________
Crop Insurance	acre	1	$ 15.00	$ 15.00	$ 0.50	________
Land Rent	acre	1	$ -	$ -	$ -	________
Interest on Operating Capital	percent	$ 106.84	6.0%	$ 6.41	$ 0.21	
Total Variable Costs:				**$ 245.58**	**$ 8.19**	

Fixed Costs	Unit	Amount	$/Unit	Cost/Acre	$/bushel	Your Farm
Machinery Depreciation, Taxes, Insurance and Housing						
Preharvest Machinery ***	acre	1	$ 21.96	$ 21.96	$ 0.73	________
Harvest Machinery	acre	1	$ 37.47	$ 37.47	$ 1.25	________
General Overhead	% of VC	$ 245.58	5%	$ 12.28	$ 0.41	________
Management	% of VC	$ 245.58	5%	$ 12.28	$ 0.41	________
Owned Land Cost, Taxes, Cash Payment, etc.	acre	1	$ -	$ -	$ -	________
Other __________________	acre	1	$ -	$ -	$ -	
Total Fixed Costs				**$ 83.99**	**$ 2.80**	
Total Costs Excluding Land				**$ 329.58**	**$ 10.99**	
Your Profit Goal				**$ ________**	**/bushel**	
Price Needed for Profit				**$**	**/bushel**	

* In the case of Asian Soybean Rust or other disease, add $15-$30 for additional fungicide sprays.

** Rip, strip and plant in one pass. Performing rip, strip and plant as separate operations increases preharvest fuel use by 0.6 gal ($1.35/ac), labor costs by $0.85/ac, and repairs by $0.90/ac. Fixed costs would increase by $2.50/ac.

Developed by Amanda Smith and Adam Rabinowitz

Sensitivity Analysis of Non-Irrigated Soybeans, Strip Tillage

Net Returns Above Variable Costs Per Acre

Varying Prices and Yields (bushel)

	-25%	-10%	Expected	+10%	+25%
Price \ bushel/Acre	23	27	30	33	38
$9.00	**-$43.08**	**-$2.58**	**$24.42**	**$51.42**	**$91.92**
$10.00	**-$20.58**	**$24.42**	**$54.42**	**$84.42**	**$129.42**
$11.00	**$1.92**	**$51.42**	**$84.42**	**$117.42**	**$166.92**
$12.00	**$24.42**	**$78.42**	**$114.42**	**$150.42**	**$204.42**
$13.00	**$46.92**	**$105.42**	**$144.42**	**$183.42**	**$241.92**

Estimated Labor and Machinery Costs per Acre

Preharvest Operations

Operation	Acres/Hour	Number of Times Over	Labor Use**** (hrs/ac)	Fuel Use (gal/ac)	Repairs ($/ac)	Fixed Costs ($/ac)
Spin Spreader 5 ton with Tractor (120-139 hp) 2WD 130	23.8	1	0.05	0.28	$ 0.64	$ 1.81
Disk Harrow 32' with Tractor (180-199 hp) MFWD 190	16.3	1	0.08	0.60	$ 1.84	$ 5.35
Spray (Broadcast) 60' with Tractor (120-139 hp) 2WD 130	35.5	1	0.04	0.19	$ 0.43	$ 0.99
ST Plant Rigid 6R-36 with Tractor (180-199 hp) MFWD 190	6.9	1	0.18	1.42	$ 3.63	$ 10.84
Spray (Broadcast) 60' with Tractor (120-139 hp) 2WD 130	35.5	3	0.11	0.57	$ 1.28	$ 2.97
Total Preharvest Values			0.45	3.06	$ 7.82	$ 21.96

Harvest Operations

Operation	Acres/Hour	Number of Times Over	Labor Use**** (hrs/ac)	Fuel Use (gal/ac)	Repairs ($/ac)	Fixed Costs ($/ac)
Header -Soybean 18' Flex with Combine (200-249 hp) 240 hp	7.0	1	0.18	1.75	$ 6.24	$ 33.71
Grain Cart Corn 500 bu with Tractor (120-139 hp) 2WD 130	10.6	1	0.12	0.63	$ 1.39	$ 3.76
Total Harvest Values			0.29	2.38	$ 7.63	$ 37.47

**** Includes unallocated labor factor of 0.25. Unallocated labor factor is percentage allowance for additional labor required to move equipment and hook/unhook implements, etc.

Developed by Amanda Smith and Adam Rabinowitz

Steps to High Yield, High Quality Soybean in Georgia

1) Rotate land so that soybean and other legumes are planted (on the same site) no more than once every two years. **If field has nematodes, plant an appropriate nematode resistant variety.** Avoid deep sands or eroded clay soils.
2) Soil test. Lime and fertilize for soybeans according to test results. **Apply an inoculant specific for soybeans** if soybeans have not been grown on this land in the last three years. Make sure soybean inoculant is fresh. Check expiration date.
3) For Coastal Plain soils, use deep tillage (12-14 inches) to get deep soybean rooting. For conservation tillage, use strip tillage and/or traffic control to reduce soil compaction.
4) Use good cultural practices.
    a. Plant between **April 10 and June 10.**
    b. Plant tall growing and/or late maturing varieties if planting after June 10.
    c. Plant in rows 10-36 inches wide.
    d. **Plant about 145,000 seed per acre (~ 10 seed/foot for 36" spacing).**
    e. Plant seed 1-1.25 inches deep in moist soil.
    f. Plant when soil temperature is between 70-90º F at 2 inch depth.
5) **Plant recommended varieties for your location and planting situation.** Plant varieties of different maturities to spread drought risk. Contact your local county extension agent or refer to the UGA Soybean Webpage for the most current list of recommended varieties.
6) Irrigate (if possible) to eliminate stress from deficits in soil moisture. Refer to the Irrigation Section of this guide for more details.
    a. If irrigating, apply water
        i. During vegetative growth, if leaf wilt occurs by mid-day.
        ii. During reproductive growth (R2-R5) to eliminate soil moisture stress and prevent wilting.
7) Control Weeds.
    a. In reduced tillage production systems, do everything possible to obtain a weed-free seedbed at planting.
    b. Use preemergence herbicides at planting.
    c. Apply postemergence herbicides when weeds are 2-4 inches tall.
    d. Be on the lookout for glyphosate and ALS-resistant Palmer amaranth.
    e. Refer to the weed control section of this guide for more specific weed control information.
8) Control insects.
    a. Scout fields weekly to monitor insect populations.
    b. If in the Georgia Coastal Plain, apply preventative velvetbean caterpillar control treatment (Dimilin + Boron) **at or after full flower (R2).**
    c. Treat for stinkbugs, and other pod/foliage feeding insects as needed.
    d. Refer to the insect control section of this guide for more specific insect control information.
9) Control Asian Soybean rust and other foliage diseases.
    a. Scout fields bi-weekly prior to first-bloom and weekly at first-bloom and beyond to monitor for leaf diseases (Asian soybean rust, frogeye leaf spot, etc.).
    b. Pre-bloom, apply foliar fungicide if Asian soybean rust is detected in your fields or very close by.

c. Post-bloom, apply foliar fungicide if Asian soybean rust is detected in you region or local area. Specific choice of a fungicide will be determined in part by confirmed proximity of disease to a specific field.
d. Refer to the disease control section of this guide for more specific disease control information.

10) Harvest soon after maturity to reduce seed shatter and maintain good seed quality.
    a. Adjust combine to match crop and field situation.
    b. Begin harvest soon after soybean seed have dried to 13% moisture or less.