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Managing Drought-Stressed Soybeans in the Southeast

Drought is the single most important factor limiting the yield of soybean in the southeastern United States. Almost every year high temperatures, drought stress of some duration, or both seriously restrict crop growth and development. This fact sheet provides soybean producers with information about drought stress along with suggestions for minimizing the effects of drought on crop yield and profits.

EFFECT OF DROUGHT ON SOYBEANS

Critical growth stages. There are two stages for which soil moisture is critical for optimum soybean growth and development—at planting and during the reproductive stages from bloom through pod-fill. Less important is the time from stand establishment until bloom.

At planting the soybean seed must absorb 50 percent of its weight in water to begin germination. Additional moisture is needed for emergence through the soil surface. A soil too dry to support germination and emergence can give producers cause for concern, especially if the condition lingers for several days or weeks.

Drought from late May through June often results in high soil temperatures, which are detrimental to germination, emergence, and stands. For example, it is not uncommon for the soil temperature at the 1-inch depth to be 100 °F or more in mid-June, especially in the light-textured soils of the southeastern coastal plain. If one plants the seed shallow or "dusts them in," there is a possibility that the seed will bake from the high soil temperatures and not germinate. Even if there is adequate moisture to initiate germination (seed swell), the stress for young seedlings trying to emerge through a soil layer (1 to 2 inches) of extremely high temperature (95 ° to 105 °F) can be intense enough to cause seedling death.

The reproductive stage, from onset of bloom through pod-fill, is approximately eight to ten weeks long and corresponds to a period from July 15 to October 1 for most Southeastern full-season plantings. Since a soybean crop during this stage uses approximately $^1/_4$ to $^1/_3$ of an inch of water per day, drought can deal a serious blow to high yield potential due to stress from low soil moisture and high temperatures. Flowers and young pods can abort, thereby reducing the number of seeds produced per plant.

During the first three to four weeks after bloom has begun (full bloom through pod-set), the soybean plant is very sensitive to high temperatures. Seed growth rate in the young pods can be slowed dramatically by stress from moisture shortages, high temperatures, or both. After pod-set ends, and during the last several weeks before harvest (primarily pod-fill and seed enlargement), soil moisture is extremely critical for achieving good seed weight and subsequent yields. Late stress may cause small, shriveled seed with low weights.

Photosynthesis, flowers, and pods. Soybean utilizes sunlight at top efficiency for photosynthesis when the crop has about four acres of leaves per acre of land. This is what crop physiologists refer to as a Leaf Area Index (LAI) of 4.0. From a practical standpoint, a LAI of 4.0 equates roughly to having the row middles (for 30- to 38-inch rows) lapped with plants approximately 36 inches tall. With a LAI of less than 4.0, soybeans will not capture all the available sunlight and yields will be reduced accordingly. Uncaptured sunlight may be used by weeds, which may have otherwise died or suffered suppressed growth, or it may contribute to increased soil temperature and evaporation of soil moisture. In any case, complete canopy coverage (as measured by LAI) by bloom time is very important for efficient utilization of sunlight and soil moisture.

When plants encounter drought, they typically reduce the size of their leaf pore openings (stomates), effectively reducing the loss of water vapor. This also reduces the intake of carbon dioxide and manufacture of photosynthates, and slows plant growth. When drought stress is relieved, either through rainfall or irrigation, stomates open up and normal growth is resumed. This ability to drastically reduce metabolic activity lets plants tolerate extended dry periods without dying or harming their ability to resume growth when moisture becomes available.

A soybean crop typically produces many more flowers than pods and yield is relatively unaffected by which flowers become pods. The number of pods carried to maturity will primarily be a result of the amount of photosynthate available during pod-set. If more pods are present than the supply of photosynthate can support, the plant will abort (or shed) some pods. If fewer pods are available than the photosynthate will support, the plant will probably continue flowering for as much as two to three weeks longer than normal and will set additional pods.

Pods per plant is a reflection of the number of plants per acre and growing conditions during pod-set. The better the growing conditions, the more photosynthate is produced and the more pods set. After pods reach one-half to three-fourths their final size, response to available photosynthate is expressed in seed size and seed weight. The number of seeds per pod is primarily a genetic characteristic of the variety. The seed size depends on the number of seeds per acre of crop and the environmental conditions during the final three to four weeks of the growing season.

Photoperiod sensitivity. The soybean plant's growth and life span, including length of vegetative growth, time of flowering, and harvest maturity, are largely determined by photoperiod (length of days and nights) and temperature. Most varieties have a critical threshold night length requirement for flower initiation. In the South, varieties grow vegetatively during periods of shorter nights, and then begin flowering when nights exceed the critical threshold length. Soybean varieties across the U.S. are grouped according to their photoperiod (or night length) requirement for flowering. Those varieties with the lowest designation (Maturity Groups 000 to IV) have a shorter night length requirement and are adapted to the northern U.S., while varieties adapted to southern latitudes (predominately Maturity Groups V through VIII) have a longer night length requirement for flower initiation.

The amount of vegetative growth after flowering depends on both the environment and the growth habit, described as being indeterminate, semi-determinate, or determinate. Indeterminates (Groups 000 to IV) are grown primarily in the Midwest and have overlapping vegetative and reproductive growth periods. Flowering begins early on the mid to lower nodes and progresses up the main stem. Most flowers (and pods) are in clusters along the main stem nodes. Semi-determinate varieties result from a cross of determinate and indeterminate germ plasm and are usually much shorter in stature than their adapted counterparts in the same maturity group. Semi-determinates grow vegetatively for only a short time after flowering.

Determinate varieties (Groups V to VIII), adapted to the southern U.S., have rather distinctive vegetative and reproductive periods. After flowering, most growth, including the number of nodes on the main stem ceases. Lateral branches off the main stem, however, continue to grow. Flowers which first appear on the main stem also soon show up on the lateral branches.

Root growth. Soybeans have branched taproot systems. After germination, the radicle or taproot begins to extend downward within the next 12 to 24 hours. Then, the hypocotyl (the small stem section between the cotyledonary node and the taproot) begins to elongate, pulling the cotyledons with it. Under optimum conditions for moisture and temperature, emergence usually occurs four to six days after planting.

Once emergence takes place, lateral roots begin branching off the taproot and growing through the soil. Roots grow best when there are adequate amounts of soil moisture, nutrients, and oxygen. Drought and various factors such as compaction or low soil pH can cause root growth to be restricted to the top 3 to 4 inches.

SOYBEAN GROWTH STAGES

Stage	Description	Avg. # of Days After Beg. Bloom (R1)	Avg. # of Days to Harvest
VE Emergence	Cotyledons above the soil surface.		
VC Cotyledon	Unifoliolate leaves unrolled sufficiently so the leaf edges are not touching.		
V1 First node	Fully developed leaves at unifoliolate nodes.		
V2 Second node	Fully developed trifoliolate leaf at node above the unifoliolate nodes.		
V3 Third node	Three nodes on the main stem with fully developed leaves beginning with the unifoliolate nodes.		
V(n) nth node	"n" number of nodes on the main stem with fully developed leaves beginning with the unifoliolate nodes.		
R1 Beginning Bloom	One open flower at any node on the main stem.		83 to 88
R2 Full Bloom	Open flower at one of two uppermost nodes on main stem with fully developed leaf.	3	80 to 85
R3 Beginning Pod	Pod 3/16" long at one of the four uppermost nodes on the main stem with fully developed leaf.	13	67 to 72
R4 Full Pod	Pod 3/4" long at one of the four uppermost nodes on the main stem with fully developed leaf.	22	61 to 66
R5 Beginning Seed	Seed beginning to develop in a pod in one of four uppermost nodes on main stem.	31	52 to 57
R6 Full Seed	Pod containing a green seed that fills pod cavity at one of four uppermost nodes on main stem.	46	37 to 42
R7 Beginning Maturity	One normal pod on the main stem that has reached a mature color.	64	19 to 24
R8 Full Maturity	95% of the pods have reached a mature color.	73	10 to 15
Harvest	Harvest maturity with seed moisture at 13% (+/-).	83 to 88	

DROUGHT AND CROP MANAGEMENT STRATEGIES

Soil fertility. On many farms in the Southeast, soybeans are often relegated to fields containing soils marginal in productive capacity. The best soils are given to higher-value (gross income per acre) crops such as tobacco, cotton, peanuts, or corn. Producers should refer to their county's soil survey from the USDA-NRCS (formerly the USDA-SCS) and choose fields with soils capable of producing high soybean yields under ideal conditions (over 40 bushels per acre). Even under drought conditions, the better soils will come closer to sustaining profitable yields than the less productive soils (as listed in the survey).

If the soil pH is low, usually 5.5 or lower, nodulation and early crop root growth is hindered due to toxic levels of available aluminum. If magnesium (Mg) levels are low, dolomitic lime should be used to correct the low pH, while either dolomitic or calcitic limestone can be used if magnesium levels are medium or high. An adequate soil pH (usually 6.0 to 6.5) allows for optimum root growth, which enhances efficiency of nutrient uptake and nitrogen-fixing bacteria in the nodules and reduces stress from nematodes, soilborne diseases, or the moisture-limiting effects of drought.

Tillage. Many of the light-textured soils of the Southeastern coastal plains hold less than 2 inches of available water in the top 18 to 24 inches. Excessive tillage on many of these sandy soils causes soil compaction, which hinders soybean root growth. In the summer, unnecessary tillage trips for seedbed preparation can also increase evaporative losses of soil moisture. Therefore, tillage trips should be reduced if possible, especially if soil moisture is limited during a drought.

Deep tillage, such as with a chisel plow or subsoiler, is necessary for breaking the compacted zones or hardpans. Producers should use soil probes or shovels to determine if hardpans exist and how deep to till to break them. When deep tillage is done properly, roots can reach the B horizon, or clay, where there is likely enough moisture available to the crop to avert most effects of drought. Also, accessing leached nutrients, such as nitrogen, potassium, sulfur, manganese, and boron present in the top 1 to 2 inches of the clay can alleviate other detrimental effects of drought.

Variety selection. Most years in the Southeast, many areas will annually receive a drought of some duration during the soybean-growing season. Usually, it occurs during the reproductive stage, such as pod-fill, when yields can be threatened. By planting varieties of three to four different maturity groups (for example, Maturity Groups V through VIII), producers can reduce the risks of drought damage considerably. Even between two adjacent groups there is sometimes 10 to 15 days' difference in maturity, which means that a 2-week drought in late August won't damage varieties equally.

Another strategy is drought avoidance. If long-term rainfall data in your geographic area suggests that you get more rain in July and early to mid August than in late August to October, then you may want to consider using the early planted, early maturing soybean production system. By planting varieties that mature much earlier than do traditional varieties, you may avoid late-season droughts. This strategy is being used by producers in Texas, Arkansas, Kentucky, and other states.

Planting. Producers should plant early and long to efficiently utilize soil moisture. For full-season plantings, it is strongly suggested that producers start planting around May 1, especially if good soil moisture conditions are present. For drought tolerance during vegetative stages after emergence, a good stand is a must. Usually, weather in early May results in cooler and more moist soils than in late May and into June. As long as fields have adequate moisture, producers should plant until the late evening or longer, if labor and safety permit. For achieving good stands in the droughty, sandy coastal plain soils, it is extremely important to plant when there is good moisture at the $^{1}/_{2}$- to 1-inch depth.

Conservation tillage. Conservation tillage, in which at least 30 percent of the soil surface is covered with crop residue after planting, can help the crop withstand drought once a good stand is assured. A residue cover can help reduce soil-moisture evaporation and possibly hinder some weed seed germination. Also, long-term conservation tillage systems have been shown to enhance soil tilth. Good soil tilth means larger soil aggregates (groupings of soil particles), which improve rainfall infiltration and water and nutrient movement.

Consider narrow rows. Soybean grown in narrow rows, especially drilled, can generally tolerate drought better than when grown in wide rows. A canopy from drilled rows occurs sooner and therefore provides earlier competition with weeds and a barrier to evaporative soil-moisture losses.

Plant for an optimum population. Soybean plant populations per acre do not substantially influence yield. This is because determinate soybeans have the capacity to branch, if there is room. The higher the population, the fewer the branches. In the Southeast, 60 bushels per acre can be produced with as few as 50,000 plants per acre (approximately 3 plants per row foot in 30-inch rows) to as many as 150,000 plants per acre (9 plants per row foot in 30-inch rows). Planting for a dense population, however, can cause some soybean plants to be barren of pods and essentially act like weeds during drought, competing with other crop plants for sunlight, water, and nutrients. The recommended final plant population for different row spacings is:

Row Width (inches)	Plants Per Row Foot
7 to 15	2 to 4
16 to 29	4 to 7
30 to 40	7 to 9

Pests.

Weeds: Competition with the soybean crop for light, moisture, and nutrients makes weeds a serious yield-limiting factor, especially during a drought. Adequate soil moisture is critical for maximum cost-effectiveness for all types of soybean herbicides. For preemergence herbicides, moisture is necessary for soil activation, while most postemergence herbicides work best against weeds that are not drought-stressed.

Producers who apply postemergence herbicides to a crop stressed by moisture deficits or high temperatures can experience less effective weed control and more crop injury, especially with some of the broadleaf materials. And, if a drought-stressed crop is injured, the rate of recovery is slower than for a crop growing under optimum environmental conditions. For these reasons, producers should closely follow all label directions for application, especially for timing considerations for postemergence materials.

Cultivation can be relatively inexpensive and avoids the problem of crop injury from postemergence herbicides. However, cultivation increases soil moisture loss through evaporation and exposes more weed seed to an environment conducive to germination. If the soybean crop is drought-stressed and soil temperatures are extremely high, cultivation should be done early or late in the day and not done very deep or too close to the crop row.

Insects: Insects eating soybean crop foliage can reduce crop tolerance to drought by reducing its photosynthetic potential (lower LAI). Entomologists have determined that a 30 percent foliage loss can occur before bloom before economic yield damage occurs. After a bloom, the threshold drops to 15 percent since the plant has less ability to recover vegetatively because most resources have already been channeled to the seed.

Pod feeders can increase the effects of drought, but the time of damage appears to have more influence on how much yields are affected. If damage occurs before pod-set is terminated, the effect on yields is not as severe as when damage (such as from corn earworm) occurs late in the season. At first bloom, producers should start regularly (every five to seven days) scouting the crop for insects, and use their state's insect-management recommendations to determine if an insecticide is needed or not.

Although usually less common than foliage or pod-feeding insects, stem- and root-feeding insects (for example, lesser cornstalk borer) can be more prevalent in sandy soils during drought. The larval form attacks young seedlings near the ground and burrows up the stem, essentially strangling the plant. Even though stands can be reduced under heavy infestations, it is rare that the use of a preplant or postemergence insecticide can be economically justified. In most cases, scattered plants may be killed by the insect, but adjacent plants, though slightly damaged, can recover and produce a normal yield for the field.

Nematodes and diseases: A soybean variety infested with a nematode or attacked by a disease is not going to be very tolerant of drought. Parasitic nematodes attack soybean roots, feeding externally or internally, and restrict the plant's ability to receive supplies of water and nutrients to sustain optimum growth. Diseases may infect roots, stems, and leaves, and, like nematodes, make the crop more susceptible to damage from drought.

If there is reason to expect a disease or a nematode problem (through field history records or soil assays for nematodes), resistant varieties should be sought for the particular field in question. Information about soybean varieties that possess resistance is available from the Cooperative Extension Service in each state.

Rotation. Crop rotation is a basic management practice for achieving cost-effective pest control and better yields. Most nematode, weed, and disease problems can be reduced through rotating with a grass crop such as corn, while research has also shown an increase in crop yield potential with such a rotation. Improvement in the physical, biotic, and fertility characteristics of the soil are likely the main reasons for better yields. Enhanced drought tolerance is, no doubt, an additional benefit of good crop-rotation systems.

AFTER THE DROUGHT, THEN WHAT?

A drought can affect the soybean crop in many ways, depending on when it occurs and how long it lasts. If early in the season, it can be detrimental to vegetative growth, but if later in July or August, the effect is primarily on reproductive development. The following are some suggestions about harvesting and using a drought-stressed soybean crop.

Forage. If there is good vegetative growth and the drought has greatly reduced pod-set, and if livestock feed is needed, the crop may be harvested for forage—for silage, for green-chop, or for hay.

Hay yields of one to two tons per acre are possible from a drought-damaged crop, if the crop is cured properly. For highest protein and forage yield, soybeans should be harvested at mid-to-late pod-fill and before the leaves turn yellow. For hay, some conditioning would be helpful since the drought-stressed crop may have stems with higher fiber content than normal.

CAUTION: Use of some pesticides precludes the use of treated crop as forage for livestock; also, there is a waiting period for certain pesticides before treated crop can be fed. Refer to each pesticide's label for details.

Grain. A drought-stressed crop may reach harvest maturity two to three weeks earlier than normal. Also, the seed will likely be smaller and plant height shorter than normal. Harvesting as close to the ground as possible will be important to minimize harvest losses. A flexible, floating cutter bar with the reel placed as close to the cutter bar as feasible will also help.

Economic Considerations. To determine whether the crop should be harvested, the producer should ask, "What are my variables and labor costs for harvesting the crop, what is my estimated crop yield, and what is the market price for this crop?"
After harvesting a small part of a field to obtain an estimate of the crop yield, the producer can calculate whether it will pay to harvest it or leave it in the field. For example, if the estimated yield is 5 bushels per acre and the market price is $6 per bushel, the crop is worth $30 per acre (5 bu/A x $6/bu = $30/A). If the costs to harvest are $20 per acre, then it would pay the producer to harvest that crop ($30/A Sales - $20/A Expenses = $10/A Gain).

FUTURE DROUGHT STRATEGIES

Research is being conducted to develop drought-tolerant varieties. Scientists are developing soybean lines which have a more extensive root system to explore additional soil water resources. A few investigators have also been looking at soybean lines which have increased water-use efficiency.
These drought-tolerant varieties will not solve all of our problems when facing dry conditions, but they will give us a few more bushels per acre when there is a drought.

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