Soybean Production in the Rio Grande Valley

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Introduction

During the past several years, interest in growing soybeans in the Rio Grande Valley has increased. In 2010, approximately 12,900 acres were planted in the Rio Grande Valley with most of those acres in Cameron and Willacy counties. Soybeans have proven to be a viable crop for the Rio Grande Valley. One of the main reasons for planting soybeans is the low input cost associated with them when compared to corn, grain sorghum, and cotton. When compared to cotton, spending less time managing the crop during the season is another advantage of soybean production.

Uses of Soybeans

Soybeans are used in livestock feed, food for human consumption, and many nonfood (industrial) products. Soybeans are high in protein (38%) and are a major ingredient in livestock feed. More than half of the soybeans processed for livestock feed are fed to poultry and about one quarter is fed to swine. The remainder is used in beef and dairy cattle feed and pet food. For human consumption, soybeans are used for cooking oil, soy milk, soy flour, soy protein, and tofu. Biodiesel can be produced from soybean oil, which burns cleaner than petroleum-based diesel oil. Other industrial products that soybeans are used in include cleaning solvents, lubricants, soy-based foams for use in coolers, refrigerators, and automotive interiors.

Growth and Development

Seed

A viable soybean is a living organism that carries on metabolic processes (even in storage). The shape of soybean seeds may vary but is generally oval. The soybean seed consists of a seed coat, which encloses the embryo. The embryo consists of two cotyledons, which upon germination produce a plumule with two simple or unifoliate leaves and a hypocotyl. The hypocotyl will be green or purple depending upon whether the variety produces white or purple flowers. The embryo will also have a radicle, which is the root. Located on the surface of the seed coat will be a hilum or seed scar and is readily identified by being either black, imperfect black, buff, or clear. A very small hole called the micropyle will be located near the hilum. The hilum, which is formed during seed development, accounts for nearly all of the gaseous exchange between the seed and its environment. Water is absorbed through the entire seed coat surface.

Germination

The germination process begins with a viable soybean seed having access to moisture and proper temperature (>50 °F). Moisture and proper temperature enable the plant to complete a normal life cycle. At the initiation of germination, water is absorbed by the seed, which in turn, doubles in size. A soybean seed must absorb 50% of its weight in water to germinate, compared to only 30% for corn. Within two days the root or radicle becomes visible and the first branch of the developing root occurs when the radicle is about 1 inch long. The hypocotyl (green or purple in color) is the structure that enables the seedling to break through the soil surface, exposing the cotyledon to sunlight. This process usually will take 3–7 days. Seed emergence can be as long as 10–17 days when it is planted in temperatures less than 55 °F. The cotyledons are the structures that provide immediate food reserves for the developing seedlings. The next structure to appear, between 5 and 10 days, is the unifoliate leaves (one leaf per petiole). These two leaves are located opposite each other on the main stem at the unifoliate node. During this entire time period, root development is rapid, with root nodules appearing within 7–14 days after emergence. Nodules are responsible for fixing nitrogen for the plant. The root system consists of a branched taproot. Bud development occurs at the axil or the junction of the main stem and the leaf. Flowering buds (auxiliary buds) develop normally at the fourth node.

Vegetative Development

During vegetative development, root development increases faster than shoot height when environmental conditions are good. However, the dry weight of the above ground parts does exceed the root dry weight.

As vegetative development continues during the season, there will be an increase in the number of nodes along the main stem with each one having trifoliate leaves. Each node or trifoliate leaf will be alternately arranged along the main stem. As each new trifoliate unfurls up the main stem, this event is used to determine the plant's current vegetative stage.

Table 1. Vegetative Stages

Stage No.	Stage	Description
VE	Emergence	Cotyledons above the soil surface
VC	Cotyledon	Unifoliate leaves unrolled sufficiently so the leaf edges are not touching
V1	First Node	Fully developed leaves at unifoliate nodes
V2	Second Node	Fully developed trifoliate leaf at node above the unifoliate nodes
V3	Third Node	Three nodes on the main stem with fully developed leaves beginning with the unifoliate nodes
V_n	n^{th} - node	n number of nodes on the main stem with fully developed leaves beginning with the unifoliate nodes

Plants in a field will not all be at the same stage at the same time. When staging a field of soybeans, each specific V stage is defined only when 50% or more of the plants in the field are in or beyond that stage.

Growth Habit

Determinate and indeterminate growth habits are used to describe the development of soybean varieties. The determinate growth type is defined as completing over 80% of vegetative growth prior to bloom and is further characterized by a terminal raceme and normally blooms over 2–3 weeks. A mature determinate soybean plant often has between 15 and 20 nodes. Determinate varieties are generally associated with maturity groups 5–10; however, there are exceptions. Indeterminate varieties continue vegetative development while they bloom and set pods, and they have an obvious terminal raceme and may bloom for up to six weeks. Mature indeterminate soybean plants often will have 22–24 nodes. Indeterminate varieties are typically associated with maturity groups 0–4; however, there are exceptions. Also, many varieties have been developed that exhibit characteristics of both indeterminate and determinate and are referred to as semi-determinate varieties.

Reproductive Development

There are several factors that affect the length of each stage of development (vegetative and reproductive). These factors include temperature, maturity group, and day length (number of hours of darkness).

Reproductive stages of development are based on flowering, pod development, seed development, and seed maturation. When a flower appears on a soybean plant, this signals the beginning of the reproductive (R) growth phase. Reproductive stages beginning at flower are described in Table 2. There are several factors that affect the length of each stage of development (vegetative and reproductive). These factors include temperature, maturity group, and day length (number of hours of darkness). Flowering is induced in soybeans by day length. Soybeans are referred to as short-day plants because short days (long nights or dark periods) initiate flowering. Severe moisture or temperature stress can impact or influence the photoperiod effect on blooming, making it very difficult to predict date of blooming. Blooms under these

Soybean flowering

abiotic stresses normally do not result in significant pod set. Stages R1 and R2 occur almost simultaneously in determinate varieties because flowering begins at the upper nodes of the main stem. Stages R1 and R2 are approximately three days apart for indeterminate varieties. Flowering will begin in the lower portion of the main stem and progress up the plant. Pod length is measured for R3 and R4 from the base of the calyx to the tip of the pod. Once pods have reached ¾-inch long or R4, the pod cavity in which each seed will develop is outlined by a white membrane. At R6 the seed has enlarged enough to cover the entire membrane.

Table 2. Reproductive Stages

Stage No.	Stage	Description
R1	Beginning Bloom	One open flower at any node on the main stem
R2	Full Bloom	Open flower at one of the two uppermost nodes on the main stem with a fully developed leaf
R3	Beginning Pod	Pod 3/16 inch long at one of the four uppermost nodes on the main stem with a fully developed leaf
R4	Full Pod	Pod 3/4 inch long at one of the four uppermost nodes on the main stem with a fully developed leaf
R5	Beginning Seed	Seed 1/8 inch long in a pod at one of the four uppermost nodes on the main stem with a fully developed leaf
R6	Full Seed	Pod containing a green seed that fills the pod 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 that has reached its mature pod color
R8	Full Maturity	95% of the pods have reached their mature pod color; 5–10 days of drying weather are required after R8 before the soybeans have less than 15% moisture

Plants in a field will not all be at the same stage at the same time. When staging a field of soybeans, each specific R stage is defined only when 50 % or more of the plants in the field are in or beyond that stage.

At the end of the season when the plant is mature, the ideal situation is simultaneous leaf and pod yellowing. However, in some situations leaves may remain green after the pods have reached maturity. Leaves and stems remaining green after the seed and pod mature can interfere with harvest.

Green soybeans and soybeans ready for harvest

Mature pods for most varieties are brown or tan in color; however, a few lines have black pods.

Factors that Influence Days Between Growth Stages

Factors that can influence soybean development include temperature, water, day length, variety, and other factors. Consequently, there can be considerable variation in the number of days between stages.

Temperature is the major factor affecting vegetative development. For example, the number of days for seedling emergence to occur can range from about 5 to 15 days. The effect of temperature becomes less important after the V5 stage. A new node is produced on the main stem about every three days after V5.

Temperature, day length, and variety can impact the beginning of flowering and subsequent reproductive development. High temperatures and short days will speed the beginning of reproductive development.

Listed in Table 3 are the time intervals (average number of days and range in number of days) in days between stages that scientists have reported. The information in the following table is only averages and should only be used as estimates of what may occur in any particular growing season.

Table 3. Number of Days Between Stages of Development

Stages	Average Number of Days	Range in Number of Days
Vegetative Stages		
Plant to VE	10	5–15
VE to VC	5	3–10
VC to V1	5	3–10
V1 to V2	5	3–10
V2 to V3	5	3–8
V3 to V4	5	3–8
V4 to V5	5	3–8
V5 to V6	3	2–5
V6 and later	3	2–5
Reproductive Stages		
R1 to R2	0*, 3	0–7
R2 to R3	10	5–15
R3 to R4	9	5–15
R4 to R5	9	4–26
R5 to R6	15	11–20
R6 to R7	18	9–30
R7 to R8	9	7–18

**Stages R1–R2 generally occur simultaneously in determinate varieties. For indeterminate varieties the time interval between R1 and R2 is about three days.*

Photo credit: Ruben Saldaña

Soybean plants in the Rio Grande Valley

Variety Selection

Selecting a variety to plant is one of the most critical management decisions that a producer will make throughout the year. Obviously, finding a variety that will yield the most is important but there are other factors to consider when selecting varieties to plant.

Lodging resistance is important when selecting a variety. Lodging reduces yields and increases harvest losses. There are varieties that stand better than others. Shatter resistance is another factor to be considered when selecting a variety. This is especially important when selecting a variety for droughty soils, where shattering can be more of a problem.

Other factors to consider include the variety's sensitivity to iron chlorosis and chlorides. Iron chlorosis is a problem in high pH and calcareous soils. Often in fields, chlorides in irrigation water can increase chloride levels greatly. If a field has a history of iron chlorosis or being high in chlorides, then it would be wise to find a variety that is less sensitive to iron chlorosis or to high chloride levels.

In the Rio Grande Valley, soybean yields have been acceptable as long as supplemental water (irrigation) is provided. A few of the varieties that are currently being planted in the Rio Grande Valley are Vernal, Hornbeck 7200, Hornbeck C5941, and Hornbeck R5425.

- Vernal has a determinate growth type and is considered to be less sensitive to the photoperiod. This conventional soybean was developed by the Agricultural Research Service, U.S. Department of Agriculture, in cooperation with the Mississippi Agricultural and Forestry Experiment Station. Vernal was released in 1992 and it can be planted beginning in the middle of February.
- Hornbeck R7200 has a relative maturity group of 7.2, which contains the Roundup Ready® trait. It is an indeterminate growth type that is planted in the middle of March.
- Hornbeck C5941 is a conventional soybean that has a relative maturity group of 5.9. R7200 is an indeterminate growth type that is planted at the beginning of March.
- Hornbeck R5425 contains the Roundup Ready® trait and has a relative maturity group of 5.4. R5425 is an indeterminate growth type and is recommended to be planted no earlier than the middle of March.

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Soybean plants in the Rio Grande Valley

Also in the Rio Grande Valley, once a spring crop, such as grain sorghum, has been harvested it is not uncommon to plant a fall crop of soybeans. These soybeans are usually planted during June, July, and August.

Planting Practices

The optimum soil temperature for soybean germination is around 95 °F; however, a soybean seed will germinate between 37 °F and 109 °F. For spring plantings, a soil temperature of at least 50 °F is recommended for a uniform stand establishment. Obtaining quality seed for planting is important in establishing an optimum stand of vigorously growing seedlings. Seed with a standard germination test of 80% or better generally results in adequate stands. In the Rio Grande Valley, soil temperatures are usually between 55–75 °F for the recommended spring planting dates.

Proper placement of seed and good seed-to-soil contact is critical in obtaining a good stand. The optimum planting depth in most soils is 1–1.5 inches. However, certain planting conditions may dictate otherwise. For example, a shallower planting depth would be desirable when a significant rainfall event is predicted after planting. This would allow the seed to emerge more readily through crusted soil.

Conversely, a deeper depth of planting is desirable when moisture availability is at a deeper depth. Most people agree that a seed should never be planted deeper than 2 inches in most soils. Adequate soil moisture is important to complete the germination process. If enough moisture is not present, the seed could only swell and stop before the germination process is complete. A soybean seed must absorb 50% moisture by weight to germinate.

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At planting, soybean seed will need to be inoculated if the field has not been planted in soybeans in recent years or if previously grown soybean plants did not have adequate nodulation. Additional information related to this topic is presented in the fertility section (p. 13). The cultural practice of planting on beds will help reduce harvest losses. Planting on a high-shaped bed allows the combine header to cut lower on the plant, thereby reducing potential harvest losses.

Most producers prefer a plant population of 100,000–120,000 plants per acre on conventional row spacings of 38–40 inches. Studies in Texas have shown that there is little yield difference in plant populations of 65,000 and 130,000 per acre. The reason for this is that soybeans have the ability to compensate for variation in plant populations. At low populations, soybean plants usually are bushy and set pods on long lateral branches near the ground. As populations increase, pods are set closer to the plant's main stem and higher up from the soil line. However, if plant populations are too high lodging can become a problem. Also, varietal differences have an impact on the amount of lodging that may occur. Often, under droughty conditions many plants are weeds or barren soybean plants, reducing the amount of available soil moisture for the productive plants.

Soybeans planted in a row spacing of 30 inches or less will often show a yield increase over soybeans that are planted on 38–40 inches, but this yield increase is not always consistent over years and/or environments. Reduced or narrow row spacings affect the growth habit of the soybean plant similar to reduced plant populations on wide row spacings. Pod height may be lower and lateral branch length may increase when row width is greatly reduced. Harvest loss may be reduced on narrow or broadcast soybeans by increasing the plant population 25–50% over that used on conventional row spacings.

Rows of soybean plants

Fertility

The best way to determine fertilizer needs is with a reliable soil test. Investing in a good soil testing program is one of the most cost-effective ways to increase profits in soybean production. A good soil test can either save money by eliminating unnecessary fertilizer or make money by increasing yields when fertilizer is recommended. More information on soil sampling can be obtained at your local Texas AgriLife Extension Service county office. Nutrients most critical to soybeans are phosphorus, potassium, and molybdenum. Iron deficiencies can be a problem on high pH and calcareous soils. Liming is important if soil pH becomes acidic.

A good soil test can either save money by eliminating unnecessary fertilizer or make money by increasing yields when fertilizer is recommended.

Phosphorus is critical in the early stages of soybean growth. It stimulates root growth, is essential in the storage and transfer of energy, and is an important component of several biochemicals that control plant growth and development. Phosphorus deficiencies are not easily observed. Usually no striking visual symptoms indicate phosphorus deficiency in soybeans. The most common characteristic of phosphorus-deficient soybean plants is reduced growth and yields. Phosphorus rates should be based on soil test results. The Texas AgriLife Extension Service recommends phosphate as shown in Table 4.

Table 4. Recommended amounts of P_2O_5 (Mehlich III ICP only) at different soil test levels for soybeans

Soil Test Level	Soil Test P (ppm)	P_2O_5 (lbs/A)
Extremely Low	0-4.99	80
Very Low	5-9.99	70-60
Low	10-19.99	55-45
Moderate	20-49.99	40-5
High	50-99.99	0
Very High	100 or >	0

While 5–40 pounds of P_2O_5 per acre is recommended on moderate testing soils, this is primarily a maintenance application. Soybeans usually respond to phosphorus only when the soil test P level is low or very low.

Phosphorus availability in the soil is largely controlled by soil pH. When the soil pH is highly acidic, phosphorus becomes tied up in very insoluble compounds with iron and/or aluminum. When the soil pH is alkaline (pH> 7.0), phosphorus becomes tied up in insoluble compounds with calcium. Phosphorus is most available to soybeans when the soil pH is between 6.0 and 7.0.

Banded applications of phosphorus are sometimes preferable to broadcast applications, especially if the soil pH is either strongly acidic or alkaline, and soil test phosphorus levels are very low. This is because there is less soil:fertilizer contact in a band, and thus less chance of soil being able to tie up the phosphorus.

Potassium is essential in the growth and development of soybeans. Potassium is indirectly related to many plant cell functions. Some 60 enzymes require the presence of potassium. Plants with adequate amounts of potassium are better able to fight diseases than potassium-deficient plants. Many of our clay soils along the Texas Gulf Coast have sufficient potassium, so potassium fertilization may not be necessary. If soil test potassium levels are 180 ppm or greater, K_2O applications are not recommended. Potassium does not chemically tie up in the soil as phosphorus does.

Potassium deficiency symptoms are fairly easy to diagnose when they are severe enough to be seen visually. Potassium deficiency symptoms usually occur on the lower leaves. The deficiency symptom will usually occur during bloom or pod fill. The margins (edges) of the leaves are necrotic (dead and brown).

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Nitrogen requirements of soybeans can be obtained from the atmosphere. They accomplish this with the aid of the bacteria *Rhizobium japonicum*. These bacteria use soybean roots as a livable environment to complete their life cycles. They form nodules on soybean roots to secure a better environment and to protect themselves from predators. They capture nitrogen from the atmosphere and fix it in a usable form. When cut with a knife, productive nodules are pink inside while non-fixing nodules will appear greenish to gray or white. The *Rhizobium japonicum* bacteria will use available soil nitrogen before fixing their own from the soil atmosphere. Many tests have been conducted to determine if nitrogen

Photo credit: Ruben Saldaña

Soybean plants in the Rio Grande Valley

fertilization pays in soybean production. The only time a benefit in yield might be seen is if there was not a supply of *Rhizobium japonicum* bacteria in the soil and the seed were not properly inoculated with the bacteria, or environmental conditions during the early nodulation were so severe the bacteria could not survive. Examples include very cold weather or extremely wet or dry weather.

Molybdenum is a nutrient needed by soybeans in small quantities. Molybdenum is required for the synthesis and activity of the enzyme nitrate reductase. This enzyme system reduces nitrates to ammonium in the plant. Molybdenum is vital for the process of symbiotic nitrogen fixation by *Rhizobia* bacteria in legume root nodules. Symptoms of this deficiency resemble those of nitrogen deficiency and are probably caused indirectly by reduced nitrogen use rather than directly by lack of molybdenum. Leaves are pale green or yellow, necrotic, and twisted. Usually there is enough molybdenum in Rio Grande Valley soils for optimum growth, but molybdenum becomes less available to plants as the soil becomes more acidic. When soil pH is higher than 6.2, additional molybdenum is not needed as a seed treatment or fertilizer.

Iron is a catalyst to chlorophyll formation and acts as an oxygen carrier. It also helps form certain respiratory enzyme systems. Iron deficiency symptoms show up as a pale green leaf color (chlorosis) with a sharp distinction between green veins and yellow interveinal tissues.

Iron chlorosis can be problem on high pH and calcareous soils, which reduce the availability of soluble iron in the soil. In some cases, iron chelate sprays should be used to prevent chlorosis expression.

Various environmental, climatic, and cultural factors can affect formation of acid soils. Lime applications will need to be made when soil pH drops below 5.5. The most important benefit of liming acid soils is a reduction of the potentially toxic elements hydrogen, aluminum, and manganese. These elements can become toxic to plant root growth and as pH drops below 5.5, nutrients are not as readily available to the plant.

Irrigation

Total seasonal water needs for a 40–50 bushel per acre soybean crop can be as high as 20–25 inches, depending on planting date and maturity. For each inch of water, this usually equates to about two bushels of soybeans being produced. Average water use is about 0.18 inches per day for soybeans. Peak water use is about 0.20–0.25 inches per day during the reproductive stages when full canopy is obtained. The effect of irrigation on soybean yields can vary from year to year because of weather conditions, soil type, and management practices. Including wet, dry, and "normal" years, the best estimate based on limited research and observations shows expected yield increases of 5–20 bushels per acre with irrigation.

Usually irrigation of soybeans is not needed prior to bloom if the soil moisture profile is completely full prior to planting. If the soil profile is not carrying a full amount of moisture before planting, a preplant irrigation may be required. Adequate soil moisture must exist from beginning bloom until the beans are fully touching in the pods.

Including wet, dry, and "normal" years, the best estimate based on limited research and observations shows expected yield increases of 5–20 bushels per acre with irrigation.

After the soybeans have reached the flowering period, irrigation should begin when the available soil moisture drops to about 50%. Experienced producers can estimate the 50% available moisture level by squeezing the soil in their hand. A sandy loam will not form a ball; loams and silt loams forms a ball that crumbles easily; clay loams form a ball which is pliable but shows cracks.

Another method to determine irrigation is the use of Watermark® sensors, which measure soil moisture tension. This method involves placing the sensors in the field at two to three different depths to measure moisture throughout the soil profile. The number of sensors placed in the field will depend on the size of the field and the number of different soil types. Soil moisture tension readings will need to be taken from each of the sensors 1–2 times a week by using a handheld meter. More information is available from the Texas AgriLife Extension Service publication B-6194, *Irrigation Monitoring with Soil Water Sensors*.

Once the decision has been made to irrigate, the goal should be to apply enough water to penetrate at least 2 feet in sandy soils and 1 foot in finer textured soils.

Growers frequently ask when to make the last irrigation for the season. A general rule of thumb is if 50% or more of the pods have seeds that are touching within the pod and if there is good soil moisture at this point, then irrigation can be terminated for the season. However, if soil moisture is not adequate, then an additional irrigation may be required to finish up the crop.

Photo credit: Enrique Perez

Soybean plants in the Rio Grande Valley

Weeds

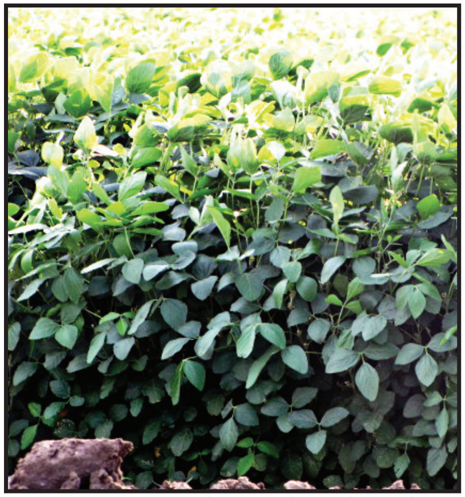
Soybeans, like most crops, are sensitive to weed competition. Weeds compete for water, sunlight, nutrients, and space. The major objective of a weed control program should be to control weeds that emerge at or about the same time as the soybeans. In general, the first four weeks after planting is the most critical time period to keep soybeans weed-free. At harvest, weeds create problems by causing foreign matter dockage, reducing yield and harvest efficiency, and increasing moisture levels in the grain.

The first step in weed management is to identify the weed correctly in the seedling stage. Proper weed identification is needed to apply the proper herbicide when an application is warranted. Also, any management practice that promotes a rapid soybean stand establishment, recommended seeding rates, and rapid canopy closure will increase the ability of soybeans to compete with weeds. Field scouting is important during the season to determine what weeds are present, their density levels, and where they are located. This information is necessary to decide if a treatment is needed and which postemergence herbicide should be used. If you apply the wrong herbicide, adequate weed control will not be achieved.

Soybean growers have a choice of many different herbicides and herbicide combinations. The selection of herbicide is based on what weed species are present and the method of application. The methods of herbicide application include: burndown, preplant, preemergence, or postemergence.

Burndown encompasses the chemical removal of existing weeds prior to planting. Instead of mechanical removal of weeds, a herbicide or combination of herbicides is used. This method is used frequently in no-till and minimum tillage operations. Preplant is used when the herbicide is applied prior to planting the crop. The application of herbicide can be either incorporated into the soil or surface applied. Incorporation of a herbicide is less dependent on rainfall for activation. Preemergence involves herbicides being applied before weeds emerge from the soil and usually before the emergence of the soybean crop.

The main disadvantage of preemergence weed control is its dependency on rainfall within a relatively short time after application. Herbicides vary in their solubility but at least .5–1 inch of rain is needed within a week or two to move most herbicides into the soil. Therefore, good soil moisture conditions are needed for proper activation of preplant incorporated herbicides.



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Soybean plants in the Rio Grande Valley

To select the proper herbicide, growers must know the weed history of the field since no weeds are visible. Postemergence is easier in determining which herbicide to use since the weeds are visible for identification. However, application timing is the critical factor. Weeds can become too large for the selected herbicide to be effective. Applications to weeds stressed by insufficient moisture may result in unsatisfactory control. Also, cultivation of weeds 7 days prior to or within 7 days after application may reduce percent control.

The use of herbicides is not the only tool available to control weeds. Cultural practices along with herbicide applications are the key to weed management. Cultural practices that should be considered include proper crop rotation, good seedbed preparation, good stands, and timely cultivation.

The number of resistant weeds is continuing to increase throughout the United States and Texas. Relying on one herbicide or one mode of action is a recipe for resistant weeds to develop. Management practices to avoid weed resistance should always be considered in a weed control program.

- Practice crop rotation when possible.
- Use preemergence and postemergence herbicides with different modes of action.
- Avoid sequential applications of the same herbicide or herbicides that have the same mode of action.
- Control weeds on fallow land.
- If you suspect resistance after herbicide application, attempt to eradicate escapes with alternative herbicides or cultural methods. Do not let them go to seed.

Insects

There are many insects that feed on soybeans and have an impact on yield and/or quality. The frequency and severity of insect damage varies considerably between production areas, within and between fields, and from season to season.

The cornerstone of managing insect pests is integrated pest management (IPM). IPM is the use of multiple control tactics to effectively keep pests from reaching population levels that will cause economic crop injury. These tactics include cultural control, biological control, host plant resistance, and chemical control.

Cultural control of insects includes practices such as crop rotation, planting dates, tillage practices, row patterns, etc., which help control an insect pest. However, such agronomic practices must not affect maximum economic yield.

Biological control is the conservation and use of natural enemies of insect pests to keep them from reaching damaging levels. The goal is to allow natural enemies to control pests without any disruption from pesticides. When insecticides are applied only when needed, the full economic advantage of natural enemies is realized.

Integrated pest management (IPM) is the use of multiple control tactics to effectively keep pests from reaching population levels which will cause economic crop injury. These tactics include cultural control, biological control, host plant resistance, and chemical control.

Chemical control or an insecticide application should be the last option to prevent insect damage after cultural and biological controls have failed. Correct insect identification is important to ensure the effective use of a labeled insecticide. Insecticide applications are made when insect pest levels reach economic thresholds and action must be taken to avoid an economic loss.

The only way to determine if the economic threshold has been reached is by scouting the field. Never base a decision to treat all fields based on what is found in one field. Differences in planting date, growing conditions, stage of maturity, and other factors often influence pest population levels. All fields should be scouted individually.

Insect populations can change rapidly in soybean fields. Therefore, growers should scout fields at least once and preferably twice a week to observe the species present, the pest density, and the amount of damage. Plant damage estimates are useful in making management decisions. Beginning at the onset of bloom (R1–R2) through physiological cutout (R7) is a very critical time for insect scouting. Random sampling should be conducted at four or more locations in a field. Sampling should be taken from each side of the field to adequately detect early insect infestations entering the field. Grasshoppers, stinkbugs, and other insects often feed on wild hosts adjacent to nearby soybean fields.

There are two tools used to sample soybean insect pests: (1) the drop cloth or shake sheet and (2) the sweepnet.

There are three different types of insect pests in soybeans: (1) foliage feeders, (2) pod feeders, and (3) stem, root, and seedling feeders.

Insects considered to be economic pests on the above ground portion of the plant include corn earworm, stinkbugs (green, southern green, and brown), green cloverworm, Mexican bean beetle, soybean looper, cabbage looper, velvetbean caterpillar, bean leaf beetle, beet armyworm, fall armyworm, grasshoppers, three-cornered alfalfa hopper, cutworms, garden webworm, saltmarsh caterpillar, and blister beetles.

For more information on soybean insects, labeled insecticides, and economic thresholds can be found on Texas AgriLife Extension Service publication B-1501, *Managing Soybean Insects*.

Diseases

By itself, a plant pathogen cannot cause disease. It must occur in combination with a susceptible host plant under environmental conditions that favor infection and subsequent pathogen growth. Furthermore, a plant growing under optimal conditions can withstand the effects of a pathogen. Good root development and regeneration greatly reduce severity of fungal root rot. An abundance of leaves diminishes the impact of foliar pathogens on yield. Healthy plants often grow to compensate for neighboring plants killed by diseases.

Diseases of soybeans are managed through the use of resistant varieties, fungicides, and crop rotation. Crop rotation is most useful for managing foliar diseases caused by fungi, but won't eliminate root-infecting fungi from soil. Fungicides can be applied to seed to manage seedling diseases, but may not work well with extended cool, wet soil that favors damping-off and seedling diseases.

Although soybeans are susceptible to a multitude of diseases, only a handful of those diseases are ever seen in the production of soybeans in the Gulf Coast and Lower Rio Grande Valley of Texas. Only three diseases may affect yield and for this to occur rainy weather is needed during the course of the season. These three diseases are Asian soybean rust, purple seed stain, and frogeye leaf spot. If conditions are humid and rainy during the growing season, one application of a foliar fungicide after flowering may be necessary to control these diseases, particularly if the field is used for seed production. For the most economical application, a fungicide should be applied to prevent disease, rather than treat it, using the timing and rate on the label. Fungicides should not be used for other purposes (e.g. yield enhancement), as indiscriminant use can result in pathogens becoming resistant to it.

The proper diagnosis of the disease is the first, necessary step to managing it.

Disease: Asian soybean rust (also known as rust)
Cause: a fungus, *Phakopsora pachyrhizi*
Symptoms: The undersides of leaves have raised, brownish, circular to irregularly-shaped areas. Under some magnification, these raised areas have openings in the center and resemble volcanoes. On the upper surface of the leaf, there may be yellow areas with circular brown spots just above affected areas on the undersides. A large amount of rust on leaves results in defoliation. The disease is favored by rainy weather, but since the fungus does

not survive from season to season in Texas, spores must be blown in from elsewhere to start the disease. Similar symptoms may be caused by drought and nutrient deficiencies related to drought, but a rust diagnosis can be confirmed by microscopic examination or a strip test kit (www.envirologix.com).
Control: Rust can be controlled by a fungicide application, which should only be made between R1 and R5. If a small amount of rust is already detectable on plants, then a triazole or triazole/strobilurin mixture should be used. If there is no rust in the field, a strobilurin fungicide can be used. Currently, the decision to apply a fungicide can be assisted by a tracking and forecast network (www.sbrusa.org). Texas-specific rust control information can be found at soybeanrust.tamu.edu or sickcrops.tamu.edu.

Disease: Purple seed stain
Cause: a fungus, *Cercospora kikuchii*
Symptoms: The upper sides of leaves have a purple coloration. Seeds have pink to purple discoloration. The infection originates from spores from infected seed or residue from a previous soybean crop. Disease development is favored by high temperatures and humidity.
Control: In areas where it is consistently a problem, a fungicide application can be made from R2–R5, especially if the crop is used for seed. Strobilurin fungicides tend to give better control than triazole fungicides. Crop rotation and changing varieties is also recommended.

Disease: Frogeye leaf spot
Cause: a fungus, *Cercospora sojina*
Symptoms: Leaves have circular spots with light brown centers and a darker brown edge. The infection originates from spores from infected seed or residue from a previous soybean crop.
Control: Some varieties may be resistant. Residues from previous soybean crops should be deep plowed and 2-year rotations used. In areas where it is consistently a problem, a fungicide application can be made from R2–R5, especially if the crop is used for seed. Strobilurin fungicides tend to give better control than triazole fungicides.

Other Diseases

Other noticeable foliar diseases that are a low risk for causing yield loss include downy mildew, aerial web blight, target spot, anthracnose, and mosaic. Soilbourne diseases that generally don't cause yield loss include seed decay, seedling disease, cotton root rot, charcoal rot, and southern blight.

Harvest Aids

Harvest aids in soybeans are used in fields when weeds are present at the end of season. At this time, weeds are not competing with the crop but they do pose problems at harvest. Weeds that are still growing in the field can cause excessive green material to interfere with an efficient harvest. Green weed seed and plant parts contribute to a higher seed moisture and foreign matter, which impacts the price that producers receive for soybeans.

Gramoxone Inteon (paraquat dichloride), Aim (carfentrazone-ethyl), and sodium chlorate are three desiccants or harvest aids that are labeled for soybeans. The primary objective of these products is to desiccate weeds. Several formulations of these three harvest aids are sold as harvest aids. Labels should be consulted for rates of application since active ingredients vary between formulations.

Timing of applications is important because yields can be affected if harvest aids are applied too early, causing pod-fill to be cut short. If applied too late, growers will have to wait for the weeds to dry down and watch their yield be reduced by pod shatter losses. For best results, harvest aids should be made at physiological maturity. Physiological maturity signals that the transport of photosynthate into the seed has stopped. At this time, seed moisture will be about 30–35%. When this occurs, the seed has reached its maximum dry weight. All that remains is for the excessive seed moisture to be removed. For indeterminate varieties, 65% of the seed pods should be a mature brown or gray color. On determinate soybean varieties, 50% of the leaves will have dropped and the rest will be yellow.

Desiccants will not accelerate harvest or kill soybean plants that are still green or immature. However, they are a valuable tool in early maturing soybean systems where indeterminates are grown and where grass and weeds come through the canopy prior to harvest.

Harvest

Weather conditions such as moisture fluctuations, changing fields, and crop conditions, which include weedy or droughty areas require that combine adjustments be made during most days to maintain combine efficiency. A skilled operator can return a significant increase in profit per hour of harvest. Also, harvesting is the single most costly operation of soybean production.

If dryer facilities are not available, harvest at a moisture content of 13%. When the moisture content is 10% or below, shatter losses become excessive. If drying facilities are available, harvest beans at moisture contents up to 20%.

Minimizing Field Losses

The following adjustments to the combine at harvest will help keep yield losses to a minimum, reduce damaged or split beans, and assist in a cleaner harvest.

- A sharp, well adjusted cutterbar is vital to speeding harvest and minimizing gathering loss. Four items need to be checked; ensure that
  - all sickle sections are sharp,
  - all sickle hold downs are gapped properly,
  - all guards are in alignment,
  - the sickle is in correct guard register.
- Operate the cutter bar as close to the ground as possible.
- Use a ground speed of 2.8–3.5 miles per hour.
- Run the reel tip speed 10–25% faster than ground speed.
- Reel axle should be 6–12 inches ahead of cutter bar. For short, low yielding beans, the reel axle may need to be moved directly over the cutter bar. Reel bats should leave beans just as they are cut. Reel height should be just low enough to control the beans.
- Set fan speed to remove chaff and straw, but not to blow beans into the tailings or out of the rear of the combine.
- To reduce over-threshing, start by narrowing the thresher to concave or rotor grate spacing to the position recommended in the operator's manual and then reduce it further if some unthreshed pods are leaving the rear of the combine. Cylinder speed must be adjusted for threshing conditions. When beans are above 13% moisture, they are usually tough and cylinder speed may have to be increased to 700–750 rpm. Reduce to 500–550 rpm for dry soybeans (8.5–13% moisture).

Soybeans ready for harvesting

Estimating Field Losses

Companies that sell combines consider the maximum combine capacity to be the feed rate (weight) at 3% field loss. However, experienced producers can keep field losses between .5 and 2 bushels per acre. The desired field loss should be .5 bushels per acre under normal or good growing conditions and 1.5 bushels per acre under extremely droughty, low-podded soybeans or muddy fields. However, when harvest is delayed, excessive shattering or severely lodged soybeans can cause field losses up to 2 bushels per acre.

When checking for field losses, an average of 4–5 beans per square foot equals about one bushel per acre loss. To obtain a good sample, soybeans in 10 square feet should be counted. Take several random samples and average them to find the average and divide the average by 50. For example, if an average of 75 beans is found within the 10 square feet, the field loss is 1.5 bushels per acre (75/50 = 1.5).

A combine harvesting soybeans

Table 5. Estimated costs and returns per Acre
Soybeans-GMO Seed-12 Row Conventional Till-Dryland
Upper Coastal Bend, 30 bushel Yield Goal, 2011, District 11

ITEM	UNIT	PRICE	QUANTITY	AMOUNT	YOUR FARM
		dollars		dollars	
INCOME					
Soybeans	bu	10.50	30.0000	315.00	________

TOTAL INCOME				315.00	________
DIRECT EXPENSES					
CUSTOM					
Scout - Soybeans	acre	5.00	1.0000	5.00	________
Custom Haul Grain	cwt	0.30	18.0000	5.40	________
HERBICIDE					
Glyphosate (gal)	gal	13.00	0.5625	7.31	________
2,4-D Amine	pt	1.50	1.0000	1.50	________
Surfactant	pt	1.21	0.0417	0.05	________
Soybean-PreEm-Herb	pt	9.46	1.0000	9.46	________
Roundup	pt	2.09	0.5000	1.05	________
Soy Desiccant/Defol	pt	4.23	1.0000	4.23	________
INSECTICIDE					
Beans-Stinkbug Cntrl	lb	5.25	1.5000	7.88	________
SEED/PLANTS					
Soybean Seed/RR	bag	48.00	1.0000	48.00	________
OTHER					
Inoculants	bag	5.00	1.0000	5.00	________
Crop Ins - Soybeans	acre	6.25	1.0000	6.25	________
OPERATOR LABOR					
Tractors	hour	13.75	0.2709	3.73	________
Self-Propelled	hour	13.75	0.1755	2.44	________
HAND LABOR					
Implements	hour	7.50	0.1000	0.76	________
Self-Propelled	hour	7.50	0.1200	0.90	________
DIESEL FUEL					
Tractors	gal	2.45	2.7899	6.84	________
Self-Propelled	gal	2.45	1.3600	3.35	________
REPAIR & MAINTENANCE					
Implements	Acre	1.59	1.0000	1.59	________
Tractors	Acre	1.50	1.0000	1.50	________
Self-Propelled	Acre	5.98	1.0000	5.98	________
INTEREST ON OP. CAP.	Acre	4.42	1.0000	4.42	________

TOTAL DIRECT EXPENSES				132.67	________
RETURNS ABOVE DIRECT EXPENSES				182.33	________
FIXED EXPENSES					
Implements	Acre	5.85	1.0000	5.85	________
Tractors	Acre	6.91	1.0000	6.91	________
Self-Propelled	Acre	14.07	1.0000	14.07	________

TOTAL FIXED EXPENSES				26.83	________

TOTAL SPECIFIED EXPENSES				159.50	________
RETURNS ABOVE TOTAL SPECIFIED EXPENSES				155.50	________
RESIDUAL ITEMS					
Management Charge	%	315.00	0.0500	15.75	________
Land Charge	acre	40.00	1.0000	40.00	________
G&A Overhead	acre	10.50	1.0000	10.50	________

RESIDUAL RETURNS				89.25	________

Websites of Interest

agrilifeextension.tamu.edu
sickcrops.tamu.edu
soybeanrust.tamu.edu
twri.tamu.edu

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