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The Texas A&M University System
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*Used with permission from Cooperative Extension Service/The University of Georgia College of Agriculture/Athens
Plant Growth and Development

Germination and Seedling Development

The peanut seed consists of two cotyledons (also called seed leaves) and an embryo. The embryo comprises the plumule, hypocotyl and primary root. The plumule eventually becomes the stems and leaves of the plant, and the hypocotyl is the white, fleshy stem located between the cotyledons and the primary root. As the seed imbibes water, there is a resumption in metabolic activity, the seed begins to swell, and cell division and elongation occur. As the embryo grows, the testa (seed coat) ruptures and the seedling emerges.

The minimum and maximum temperature requirements for peanut seed germination are not well defined. Research has shown that seed will germinate under a wide range of circumstances (consider volunteer peanuts); however, under field conditions the minimum average soil temperature should be 65 degrees F at the 4-inch depth, with a favorable weather forecast. This ensures rapid, uniform emergence and reduces the risk associated with stand loss from the seedling disease complex.

The seedling uses food reserves from the cotyledons during the initial stages of growth. Under most situations, peanuts should reach the ground cracking stage 7 to 14 days after planting, depending upon soil temperature. The growth rate of the hypocotyl determines how quickly the shoot will emerge from the soil. Most current commercial varieties show little difference in emergence rates and/or seedling vigor. A final plant density of three to four plants per row foot is adequate.

Plant Development

As the plant grows, the root develops very rapidly in comparison to the shoot. By 10 days after planting, root growth can reach 12 inches. By 60 days, roots can extend 35 to 40 inches deep. Late season measurements have found peanut
roots down to 6 to 7 feet. Roots grow at a rate of about 1 inch per day as long as soil moisture is adequate.

The hypocotyl pushes the plumule upward causing "ground cracking." After emergence, the plumule is called a shoot and consists of a main stem and two cotyledonary lateral branches. At emergence the main stem has at least four immature leaves and the cotyledonary lateral branches have one or two leaves also. The seedling develops slowly showing as few as eight to 10 fully expanded leaves 3 to 4 weeks after planting.

Leaves are attached to the main stem at nodes. There is a distinct pattern by which these leaves are attached. There are five leaves for every two rotations around the main stem, with the first and fifth leaves located one above the other. Leaves attached to the cotyledonary laterals and other lateral branches are two-ranked, so there is one leaf at each node, alternately occurring on opposite sides of the stem. Peanut leaves have four leaflets per leaf, making them a tetrafoliolate. The leaflets are elliptical in shape and have a prominent midvein.

The main stem and cotyledonary laterals determine the basic branching pattern of the shoot. The main stem develops first and in runner type plants the cotyledonary laterals eventually become longer than the main stem. Additional branches arise from nodes on the main and lateral stems.

The growth habit of peanut is described as bunch, decumbent or runner. Spanish and Valencia market types are classified as "bunch," with their upright growth habit and flowering on the main stem and lateral branches. Most Virginia and runner market types are considered to have a prostrate (flat) growth habit and do not flower on the main stem. Decumbent varieties have an intermediate growth habit between a runner and bunch. Several Virginia varieties are classified as decumbent.

Peanuts are indeterminate in both vegetative and reproductive development (similar to cotton). This means that the plant is producing new leaves and stems at the same time that it is flowering, pegging and developing pods.
Consequently, developing pods compete with vegetative components for carbohydrates and nutrients. Once a heavy pod-set has been established, the appearance of flowers is greatly reduced.

Bloom

About 30 days after emergence, peanut plants begin to produce flowers. Flower numbers will continue to increase until the plant reaches peak bloom at about 60 to 70 days after emergence, and then flower development will begin to decline. High temperature, moisture stress and low humidity can have a severe impact on the flowering response, limiting the number of flowers produced and reducing flower pollination. Ultimately, this can result in reduced yield and delayed pod set. However, the peanut plant can compensate to some extent by initiating a large flush of flowers when favorable environmental conditions return.
Peanut flowers are borne in leaf axils on primary and secondary branches. Several flowers can originate from each node, however, only about 15 to 20 percent will produce a harvestable pod. The peanut flower is a perfect flower (male and female structures present in the same flower) and is self-pollinated. It has a showy yellow bloom and when it first emerges, the petals are folded together. The early morning of the following day the petals unfold and pollen is shed. Fertilization takes place in 3 to 6 hours. The fertilized ovary begins to elongate and grows downward from the node to the soil. This specialized structure, called a peg, becomes visible about 7 days after fertilization. The sharp-pointed peg enters the soil about 10 to 14 days after pollination. The developing pod is located in the tip of the peg. Once in the soil, it begins to enlarge and forms the pod and kernels. It is interesting to note that the pod will not begin growth until the peg is in the presence of darkness. Because several flowers can develop from each node, several pegs and pods can be found originating from a single node. The indeterminate fruiting habit of the peanut means the plant will have pods of varying maturity. Consequently, peanut harvest determinations are based on the presence of 70 to 80 percent mature pods.

Pod and Kernel Development
During the early stages of pod development, the tissue is soft and watery. As the pod develops, the hull and kernels
begin to differentiate. The cell layer just below the outer cell layer of the pod changes from white to yellow to orange to brown to black as it matures, providing a color indication of optimum harvest date. The inner pod tissue separates from the seed and darkens as the seed grows and presses against the hard layer of the hull. This is indicated by the dark brown to black veination on the inside of the hull.

Pods attain full size about 3 to 4 weeks after the peg enters the soil. Although the pod has reached full size, kernel development has barely begun. Mature, harvestable pods require 60 to 80 days of development. In Texas, a mature crop can be produced in 130 to 140 days in south Texas, 140 to 150 days in central Texas, and 150 to 170 days in west Texas. Temperature (both day and nighttime) interacts with variety, planting date, seasonal moisture, etc., in controlling development of the crop. However, the controlling factor in all plant development is temperature.

**Maturity and Harvest Determination**

As pods mature, the inside portions become brown to black, while immature pods retain a fresh, white appearance. The cellular layer just below the outer layer of the pod undergoes several color changes during the maturation phase. This cellular layer is called the mesocarp. It changes in color from white to yellow to orange to brown and finally black as the pod matures. This color distinction can be used to estimate crop maturity with the “hull scrape” method. Hold the pod with the beak pointing down and away from you, and with a pocket knife scrape away the outer hull in the area from the middle of the pod to the peg attachment point. This region of the pod is known as the saddle. Pods should be moist when the color determinations are made. To get an accurate representation of the field, collect three adjacent plants (about 1 foot of row) from three to five locations in the field. As with all field assessments (soil and plant tissue testing, insect and disease scouting, etc.), the results are only as good as the collection procedure, so collect an adequate sample.
Determining the optimum digging time is a crucial decision for a grower! Using the calendar to predict digging dates is a good way to lose yield, grade and money. There is no substitute for scouting fields and observing pod development, especially late in the season. The optimum time to dig a peanut crop is when it has reached its peak yield and grade. If dug too early or late, yield and crop quality will be sacrificed. Because of the indeterminate fruiting habit of the peanut, each plant will have pods of varying maturity. Consequently, the risk of losing early-set mature pods versus later-set immature pods must be considered, and a compromise must be achieved. Runner types should be dug at 70 to 80 percent maturity, Virginia types at 60 to 70 percent and Spanish and Valencia at 75 to 80 percent maturity.

Peanuts may gain from 300 to 500 pounds per acre in yield and one to two grade points during the 10- to 14-day period preceding optimum digging time. Conversely, similar yield and grade losses can occur if digging time is delayed 1 to 2 weeks. Overmature and diseased plants (pod rot complex, leaf spot, southern blight, sclerotinia blight, rust, etc.) have weakened peg attachments, resulting in significant pod loss during digging and combining.

<table>
<thead>
<tr>
<th>Digging time</th>
<th>Yield loss (lbs./A)</th>
<th>Grade (Total Sound Mature Kernels)%</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 days early</td>
<td>740</td>
<td>73.9</td>
</tr>
<tr>
<td>7 days early</td>
<td>250</td>
<td>74.2</td>
</tr>
<tr>
<td>optimum</td>
<td>——</td>
<td>75.0</td>
</tr>
<tr>
<td>7 days late</td>
<td>500</td>
<td>75.6</td>
</tr>
<tr>
<td>14 days late</td>
<td>540</td>
<td>——</td>
</tr>
</tbody>
</table>
Irrigation Management

Irrigation is the key to current and future peanut production in Texas. Since 1996, Texas irrigated acreage has steadily increased. Irrigation ensures a stable supply of high yielding, good quality, aflatoxin-free peanuts. The total seasonal water requirement for maximum peanut yields is approximately 24 to 28 inches. Water can be a scarce commodity; consequently, producers must consider system capacity as a guide in determining suitable acreage for planting. It is best to plant less acreage and irrigate adequately, than to plant larger acreages that are subject to water shortfalls. In addition, peanuts do not tolerate water quality problems as well as cotton, and this becomes evident in low rainfall seasons.

Irrigation Water Quality

Salinity has become a problem throughout many areas of Texas. As water quality becomes marginal and cropping patterns change, some areas may experience injury and reduced yields. Each crop has its own susceptibility range to marginal quality water. Peanuts are not very tolerant, so it is imperative that water quality be assessed before determining where to plant peanuts.

Water quality is determined by the total amounts of salts and types of salts present in the water. A salt is a combination of two elements or ions, one has a positive charge (sodium) and the other has a negative charge (chloride). Water may contain a variety of salts including sodium chloride, sodium sulfate, calcium chloride, calcium sulfate, magnesium chloride, etc.

Salty irrigation water can cause two major problems in crop production: salinity hazard and sodium hazard. Salts compete with plants for water. Even if a saline soil is water saturated, the roots are unable to absorb the water and plants will show signs of stress. Foliar applications of salty water commonly cause marginal leaf burn and in severe cases can lead to premature defoliation and yield and quality loss.
Sodium hazard is caused by high levels of sodium that can be toxic to plants and can damage medium and fine-textured soils. When the sodium level in a soil becomes high, the soil will lose its structure, become dense and form hard crusts on the surface. To evaluate water quality, a water sample should be analyzed for total soluble salts, sodium hazard and toxic ions.

**Total soluble salts** analysis measures salinity hazard by estimating the combined effects of all the different salts in the water. It is measured as the electrical conductivity (EC) of the water. Salty water carries an electrical current better than pure water, and EC increases as the amount of salt increases.

**Sodium hazard** is based on a calculation of the sodium adsorption ratio (SAR). This measurement is important to determine if sodium levels are high enough to damage the soil or if the concentration is great enough to reduce plant growth. Sometimes a factor called the exchangeable sodium percentage may be listed or discussed on a water test; however, this is actually a measurement of soil salinity, not water quality.

**Toxic ions** include elements like chloride, sulfate, sodium and boron. Sometimes, even though the salt level is not excessive, one or more of these elements may become toxic to plants. Many plants are particularly sensitive to boron. In general, it is best to request a water analysis that lists the concentrations of all major cations (calcium, magnesium, sodium, potassium) and anions (chloride, sulfate, nitrate, boron) so that the levels of all elements can be thoroughly evaluated.

**Water Quality, Yield Relationships**

The critical level of boron in irrigation water for cotton and grain sorghum is 3 ppm. Preliminary survey studies conducted over the past 2 years indicate that peanuts are much more susceptible to high boron concentrations. Boron levels greater than 0.75 ppm in water can cause severe yield reductions. This concentration should be viewed as the critical threshold level for irrigation systems used for peanuts.
Also, the sodium adsorption ratio (SAR) has been found to correlate with reduced peanut yields. The critical SAR value for cotton, grain sorghum and corn is 10. However, peanuts are much more sensitive to SAR values in the range of 5 to 7. Yield reductions associated with this range indicate that the critical threshold level for peanuts is much lower.

**Water Quality, Grade Relationships**

Peanut grades can be reduced with increasing chlorides and total soluble salt (EC) concentrations in irrigation water. Study results point to a critical threshold for EC of 2,100 to 2,500 umhos/cm and 400 ppm chloride. Grade reductions associated with increasing salinity may be related to reduced calcium uptake by kernels caused by antagonistic interactions with sodium, chloride, magnesium and potassium.

### Table 5. Critical Values for Salts in Irrigation Water for Peanuts

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Critical Value for Peanuts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Dissolved Salts (EC)</td>
<td>2,100 umhos/cm = 2.1 mmhos/cm = 1344 ppm</td>
</tr>
<tr>
<td>Sodium Adsorption Ratio (SAR)</td>
<td>5-to-7</td>
</tr>
<tr>
<td>Boron</td>
<td>0.75 ppm</td>
</tr>
<tr>
<td>Chloride</td>
<td>400 ppm</td>
</tr>
<tr>
<td>Sodium</td>
<td>400 ppm</td>
</tr>
</tbody>
</table>

R.G. Lemon and M.L. McFarland, Texas Agricultural Extension Service, College Station, TX

**Irrigation and Water Use**

The growing season for peanuts can be divided into three distinct phases—prebloom/bloom, pegging/pod set and kernel fill/maturity. Water use will vary with these developmental stages. In general, water use is low in the early season, but during the reproductive period water consumption is at its peak. Consumption declines as pods begin to mature. Specifically, water use can be categorized as follows:
Research conducted in Georgia demonstrated how moisture stress at various periods during the season can affect production.

During the bloom period, water stress can delay formation of flowers, or under extreme conditions flowering can be completely inhibited. In Texas, it’s not a matter of if there will be extreme heat and moisture stress, it’s just a question of when and for how long a duration. Even with irrigation, these climatic factors can be very difficult to overcome.

Peanuts are of tropical ancestry and do well at moderately warm temperatures. Temperature has a direct influence on growth and development of the crop through its effects on photosynthesis and flower set. The optimum temperature for peanut growth and development is about 86 degrees F.

<table>
<thead>
<tr>
<th>Stage of Development</th>
<th>Water Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germination and seedling establishment</td>
<td>very high</td>
</tr>
<tr>
<td>Vegetative growth</td>
<td>low to moderate</td>
</tr>
<tr>
<td>Flowering and pegging</td>
<td>very high</td>
</tr>
<tr>
<td>Pod development</td>
<td>very high</td>
</tr>
<tr>
<td>Kernel development</td>
<td>high</td>
</tr>
<tr>
<td>Maturity</td>
<td>moderate</td>
</tr>
</tbody>
</table>

### Table 6. Plant Development and Water Use

<table>
<thead>
<tr>
<th>Stage of Development</th>
<th>Water Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germination and seedling establishment</td>
<td>very high</td>
</tr>
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<td>Vegetative growth</td>
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<td>very high</td>
</tr>
<tr>
<td>Kernel development</td>
<td>high</td>
</tr>
<tr>
<td>Maturity</td>
<td>moderate</td>
</tr>
</tbody>
</table>

### Table 7. Effect of Moisture Stress on Yield

<table>
<thead>
<tr>
<th>Stress Period (days after planting)</th>
<th>Yield (lbs./A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 to 65</td>
<td>3,960</td>
</tr>
<tr>
<td>65 to 100</td>
<td>2,900</td>
</tr>
<tr>
<td>100 to 135</td>
<td>4,120</td>
</tr>
<tr>
<td>Optimum moisture</td>
<td>4,540</td>
</tr>
</tbody>
</table>

C.K. Kvien, Coastal Plain Experiment Station, Tifton, Georgia, 1987-1988.
Very high temperatures slow down the crop growth rate. Even in conditions of adequate water, temperatures above 95 degrees F can impair development of the crop. Research has shown that photosynthetic activity can be reduced by as much as 25 percent at temperatures above 100 degrees F.

Peanuts have a higher rate of flower and fruit set and better pod development at temperatures less than 90 degrees F. High temperatures, occurring both day and night, can reduce flower set. Research has shown that the optimum temperature for flowering and peg set ranges between 68 degrees F to 80 degrees F. An exposed sandy soil can get very, very hot, thus affecting flower set. High temperatures reduce the number of flowers produced, and when coupled with low humidity, flowers may not pollinate well. Under hot and dry conditions, flower structures may not develop properly, resulting in poor fertilization. Fortunately, the peanut plant can compensate by developing a large flush of flowers when the environmental conditions become more favorable. Crop canopy closure reduces temperatures and increases humidity in the canopy, creating a more favorable environment for flowering, pegging and pod development. Also, as plants become older they become less sensitive to stress.

After bloom, peg penetration into the soil requires adequate moisture. Once active pegging and pod formation have begun, it is recommended that the pegging zone be kept moist, even if adequate moisture is present in the soil profile. A moist pegging zone aids the uptake of calcium by the pods. Failure of pegs to penetrate soil and develop pods can result from low relative humidity and high soil temperatures. Therefore, it is extremely important to supply additional moisture during pegging, even if soil moisture is adequate.

**In-Season Irrigation Management**

Every producer has his own ideas about and methods for watering a crop; often what works in one field may not work well in another, or what works for one producer may not work for another. Considerable research has been done, especially in the High Plains, evaluating different methods
for conserving and delivering water to crops. Low Energy Precision Application (LEPA) systems have been developed and are widely used.

Many growers use different variations of this system. Some farmers drag socks or tubes in circular rows, others drag tubes on straight rows, still others use the bubble-mode for delivering irrigation water. Research has shown that optimum peanut yields can be attained with LEPA on circular rows using drag socks in alternate furrows, at a water application rate equal to 75 percent of the recorded cotton evapotranspiration rate.

Peanuts require about 1.5 to 2.0 inches of water per week, especially between early July and mid-August. This time period coincides with peak bloom, peg and pod set. Once full canopy development has been achieved, water use is similar to pan evaporation, indicating that water use ranges from 0.25 to 0.40 inch per day (depending upon weather conditions).

Water use by peanuts will peak in late July through August. If 0.75 inch of water is applied twice weekly, this will not supply as much water as the plants actually use. Consequently, stored water in the 2- to 3-foot depths will be used by the plants. During August, transpiration and evaporation will often range between 0.25 and 0.35 inch per day, depending on weather conditions. This amounts to 1.75 to 2.45 inches of water per week. As stated previously, two 0.75 inch applications each week total 1.5 inches, which emphasizes the need for entering the season with a full profile of water when possible.

Uniform moisture that can be maintained with two irrigation applications per week helps to ensure adequate soil moisture and high relative humidity in the canopy. The peanut plant flowers in response to elevated humidity and pod set is enhanced by elevated humidity and moist surface soils. Consequently, yield is positively affected by an extended period of high humidity during the critical 45 to 90 days after emergence. Holding humidity high during this 45-day period in the growth cycle not only increases yield, but promotes a uniform early pod set, resulting in early
maturity and harvest. Also, it creates less exposure to pod-rotting diseases. The pegging zone should be kept moist even though adequate moisture may be available deeper in the profile.

After kernels begin to fill (late August to early September) the amount of irrigation water can be slightly reduced. However, any reductions in irrigation will be based on crop maturity and rainfall. Changing from a twice-a-week to a once-a-week irrigation schedule helps stop blooming. Lower relative humidity in the canopy moves the crop into a maturation phase and reduces susceptibility to pod rot organisms. A good rule of thumb to help gauge the last 30 to 40 days of the season is to not let the crop show visible signs of stress in the morning hours. During the maturation period, the plants will be mobilizing nutrients and food reserves to the developing kernels. In addition, plant water use during maturation is moderate compared to the critical bloom, peg and pod development periods. Try to avoid large fluctuations in pod zone moisture to prevent hull splitting, which leads to increased loose shelled kernels. Loose shelled kernels correlate highly with aflatoxin problems.

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### Weed Management

Weeds in peanuts can be managed by using cultural, mechanical, physical and chemical means. A combination approach provides the most successful results. Considerations for cultural and mechanical weed control include:

- Remove spotty infestations by hand hoeing or spot spraying to prevent spreading weed seed, rhizomes, tubers or roots. This is particularly important for perennial weed species.
- Use high quality, weed-free seed. Bar-ready seed is available from shellers and has had nutsege tubers removed.
- Clean all tillage and harvesting equipment before moving to the next field, or from weedy to clean areas within a field.
Application Techniques

Field Applications

Chemigation—(Refer to B-1652, 1990 Chemigation Workbook, for in-depth chemigation procedures). Before using this technique, consult the pesticide label for restrictions and special instructions. Important note: Always use pressure-sensitive check valves in the injector system to prevent contamination of ground water.

Stationary systems (handlines and siderolls)—Calculate the acreage covered in each irrigation set by multiplying the row length by the row width (in feet) by the number of rows per set and divide this figure by 43,560. The amount of pesticide required per set equals the acreage covered in each set, multiplied by the desired rate per acre of the pesticide.

Place the amount of pesticide required per set in the injector. Before allowing the material to pass into the irrigation water, allow time for sufficient water pressure to build and activate all nozzles.

Consult the product’s label for information on timing the injection in relation to total operating time per set. For some products, it is important to inject at the beginning of the set. For other products, it is equally important to inject near the end of the set.

Moving systems (center pivots)—Determine the total area to be covered and the operating time. Place the total amount of pesticide needed for the field in the injector tank with sufficient water to fill the tank. Divide the total volume of the tank (in gallons) by the total operating time (in hours) to give the gallons per hour at which the injector meter should be set.

Example
A 500-gallon injector tank is to be used for a total of 90 hours operating time. Calculate the total gallons per hour by the following method:
Total volume of tank (500 gallons) = \[ \frac{500}{90} = 5.6 \text{ gal per hour} \]

Now that the total gallons per hour is known, consult the injector pump operation manual for proper meter setting. Once the system is operating, monitor the draw-down of the tank at hourly intervals for 3 to 4 hours to determine if the injector system is working properly.

**Band Applications**

Band applications place pesticides in a specific part of the row, thus reducing the amount of pesticide applied in direct proportion to the ratio of the band width and row width. Failure to reduce suggested broadcast rates by this ratio results in over-concentration of the pesticide in the banded area and may cause plant burn.

**Example**

The suggested broadcast rate of an insecticide is 12 ounces per acre. The insecticide label states that application of the material in a 12-inch band is effective before pegging. With a 36-inch row width, the actual amount of material applied is reduced to 4 ounces per acre.

**Formula**

Broadcast rate \((\text{oz./acre})\) x \[\frac{\text{Band width (inches)}}{\text{row width (inches)}}\] = Banded rate per acre

**Formula used with example above:**

\[
\frac{\text{Broadcast rate (12 oz./acre) x [Band width (12 inches)]}}{\text{row width (36 inches)}} = 4 \text{ oz/acre banded}
\]

**Precautions**

- Read the label on each pesticide container before use.
  Carefully follow all restrictions concerning use of plant materials as animal feed.
- Always keep pesticides in original containers.
- Dispose of empty containers according to label specifications.
Improper use of insecticides can result in poor insect control as well as crop condemnation. When using approved insecticides, do not exceed recommended maximum dosage levels, and be sure to allow the proper time between the last application and harvest. Using materials without proper label clearance, or exceeding approved tolerance limits, can result in crop condemnation.

Please follow Worker Protection Standards Regulations (WPS) per label instructions for proper treatment and re-entry restrictions.

**Points of Application**

- Restrict insecticide use to actual need, based on field inspections.
- Direct hollow cone nozzles to cover plants thoroughly for foliage-feeding insect control.
- Nozzle size, number of nozzles, ground speed and pressure influence the rate of chemical output per acre. Calibrate the sprayer accurately to ensure application of recommended amounts of insecticide.
- Periodically check the calibration during the season.
- Apply insecticide sprays when weather conditions will not cause drift to adjacent fields or crops. If showers occur and insecticides are washed off plants within 12 to 24 hours of application, the field may need to be treated again.
- Maintain accurate, detailed records of pesticide use.
References
