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Methods to Evaluate Peanut Maturity for Optimal Seed Quality and Yield[1]

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Introduction

Determining when to dig is one of the most important economic decisions a grower must make. Peanut (*Arachis hypogaea* L.) poses a unique challenge for maturity determination because it is an indeterminate crop that forms pods underground. Indeterminate crops maintain vegetative growth while in reproductive stages, continually form new reproductive structures throughout the season, and make it difficult to time harvests. Determinate crops, such as corn or wheat, typically cease vegetative growth when they enter reproductive stages and senesce as they mature. As a result, these determinate crops mature evenly throughout the field, allowing for a relatively easy and accurate determination of optimal harvest timing. The continuous setting of new peanut pods throughout the season results in a wide range of pods in various stages of development at harvest. As pods mature, the secondary layer (mesocarp) changes color from white to a dark black (Table 1). The general progression of mesocarp color is similar across peanut market types; however, the associated days between stages may vary based on the maturity range of the particular cultivar. Peanut varieties are often categorized as medium (M: 133–139 days), medium-late (ML: 140–145 days), or late-maturing (L: 146–155 days). The numbers in Table 1 relate predominantly to runner types, since certain market types (e.g., Valencia) require a shorter growing season.

Table 1. Peanut color classes and their distinctive characteristics.

Major Color	Characteristics	Days After Flower
White	Soft, watery, poorly defined kernel, between the size of a match head and a full-size pod	25–30
Yellow 1	Somewhat defined kernel; spongy texture; pod is full- size	31–37
Yellow 2	Well-defined kernel; coarser pod texture than that of yellow 1	38–44
Orange	Developing pink seed coat	45–58
Brown	Rough pod texture; dark pink seed coat	59–93
Black	Completely developed kernel; extremely rough pod texture	94–100
Adapted from Sanders et al. (1982).		

This color change can be observed by removing the outer layer (exocarp) through methods such as hand scraping or pressure washing with water. Color classes range from immature (white, yellow, and orange) to mature (brown and black) (Figure 1).

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Figure 1. View of the peanut mesocarp layer after exocarp removal by pressure washing (brown class not pictured).
Credits: Ethan Carter, UF/IFAS

Significant yield, grade, and seed quality losses can occur if the crop is dug too early or too late. Immature pods will not produce the desired yield, grade, flavor, or subsequent crop performance. Overly mature pods may fall off the vine during digging or sprout in-shell in the field. In addition, the risk for aflatoxin contamination can increase with later harvest. Digging a week early or late can decrease yield by 500 lb/acre or more and reduce grade by several points, which would impact the grower's bottom line (Wright et al. 2000). The value of one point in TSMK% (grade) varies by a few cents each year. For the 2015 crop year, one point in grade was worth $4.82/ton for runner type peanuts, and the monetary value associated with a five-point grade difference was $24.10/ton (USDA 2015).

Maturity Assessment Methods

Many growers, Extension personnel, and crop consultants struggle with accurately gauging maturity to determine an appropriate digging date. Common inaccurate methods include digging based on a neighbor's timeline as well as relying solely on days after planting (DAP). Other factors include failure to consider the different developmental rates of crops that are irrigated vs. non-irrigated, differential levels of disease and stress, or inherent differences in the rates of maturity among cultivars.

Peanut maturity is gauged by several methods, including, but not limited to, DAP, the shellout method, arginine maturity index, seed-hull maturity index, thermal time, calculation of a maturity ratio, and the maturity profile board (MPB) (Sanders et al. 1980; Rowland et al. 2006). Of these methods, the shellout, DAP, maturity ratio, and MPB techniques can be easily applied with minimal use of equipment or technology.

The shellout method is one that has been historically used by growers as a general measure of crop maturity. This method involves shelling pods to observe the interior color of the pod (Sanders et al.1980). Mature pods have darker interiors due to aged veins and cell death. Some coloration of the seed coat may also occur in the most mature pods (Miller and Burns 1971).

Recently, the MPB, based on the work of Williams and Drexler (1981), has been the most popular and widely used method. The MPB is a visual tool for pod classification that graphically interprets pod maturity. It consists of 25 categories based on mesocarp color variations within the five major color classes (listed from most immature to mature): white, yellow 1, yellow 2, orange, brown, and black (Figure 2).

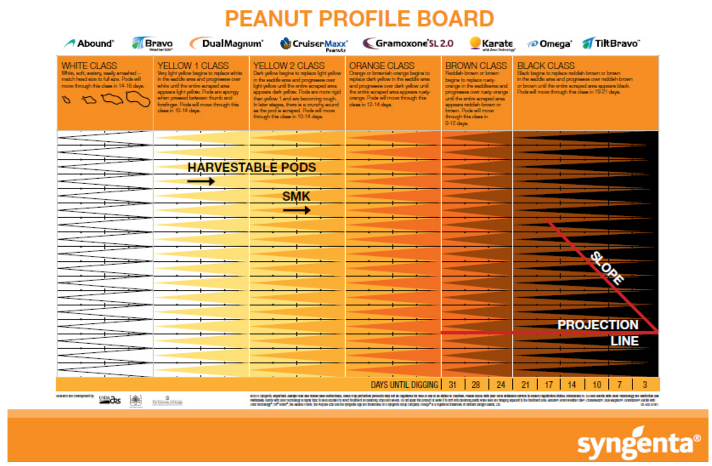

Figure 2. Maturity profile board (MPB) developed from the work of WIlliams and Drexler.
Credits: Williams and Drexler (1981)

The exocarp must first be removed in order to access the mesocarp and visually classify pods according to their mesocarp color. The exocarp can be removed by pressure washing with water, using abrasion, or hand scraping the hull (Williams and Drexler 1981; Williams 2003). Pods are placed in colored columns corresponding to the color of the saddle region (Figure 3).

Color changes across the entire pod happen gradually, but they first develop in the saddle region, which is the foundation for the MPB. At the bottom of the columns on the MPB, the estimated days until digging are projected, corresponding to the distribution of pod maturity (Figure 2). After placing peanuts on the MPB, the grower typically determines when to dig by choosing the column on the MPB farthest to the right that has at least three pods categorized as this single color class. The number below this column represents the recommended number of days before digging should commence. For example, in Figure

4, the farthest right column with three pods indicates a recommended harvest in 17 days.

Figure 3. The color of the saddle should be used for placement on the maturity profile board. The saddle is also the region that should be placed down when using the digital image model associated with PeanutFARM.
Credits: Ethan Carter, UF/IFAS

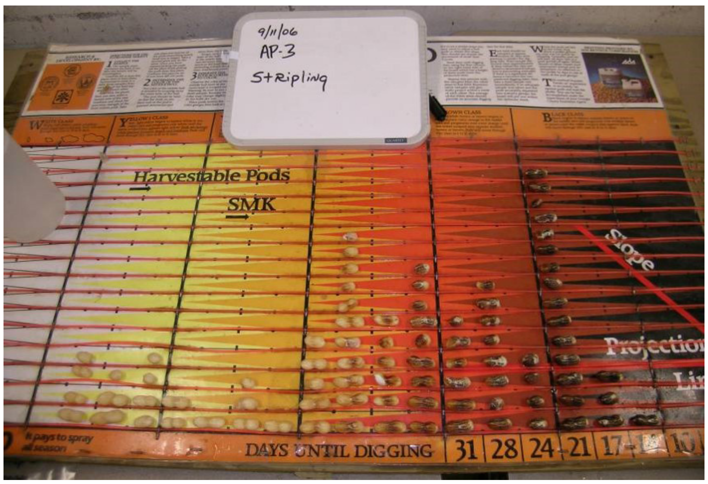

Figure 4. Peanut sample placed on the MPB according to visual color classification.
Credits: Wilson Faircloth, Syngenta

The MPB is effective in showing the distribution of pod maturity, i.e., if they are maturing uniformly or have a bimodal distribution. A bimodal distribution occurs when pods mature in two groups with few in-between. One group is typically immature, and the other is more mature. The bimodal distribution or split crop is a condition often caused by drought or other extreme weather events when the maturity of the crop slows or nearly ceases. This can be represented by a peak of pods within the more immature categories (white and yellow) and a peak within the more mature categories (brown and black) (Figure 5). In this type of situation, a grower must decide whether to harvest the more mature group or wait and harvest the second group once it reaches maturity.

Figure 5. Peanut sample placed on the MPB illustrating a split crop with a portion of the sample in the immature (yellow) and mature (brown and black) color categories.
Credits: Wilson Faircloth, Syngenta

Although the MPB is widely used in the industry, it has its weaknesses. It is time-consuming and tends to require several sample collections to accurately predict maturity before the crop is ready for harvest. Separating pods by color is highly subjective because it relies on visual color differentiation that can vary dramatically among individuals. There is also some indication that the MPB may not be applicable to new cultivars because it was designed for the mid-maturing cultivar 'Florunner', a cultivar not commercially produced in the US for several decades (Rowland et al. 2006).

Less subjective methods for gauging maturity include the calculation of a maturity ratio and thermal time. A maturity ratio can be calculated by adding the combined number of pods from the brown and black classes and dividing the sum by the total number of pods in the blasted sample (not the original number of 180–200 which included match heads). An optimal harvest is considered when a sample has a mature (brown and black) percentage of 70% or higher (Rowland et al. 2006).

It is also possible to accurately predict maturity for peanut cultivars using thermal time because temperature is a major factor that drives plant development (Ketring and Wheless 1989). Thermal time, or growing degree days (GDD), objectively tracks maturity without pod sampling. The value for adjusted GDD (aGDD) is calculated by taking into account the maximum and minimum temperatures as well as rainfall and irrigation received. The study conducted by Rowland et al. (2006) compared ten degree day models using stepwise regression models. This study resulted in the development of a new method to assess maturity through the utilization and modification of existing degree day models and found that yield and net value peaked at about

2500 aGDD (Rowland et al. 2006). This model led to the development of an automated method of calculating aGDD by accessing local weather data through the launch of the Peanut Field Agronomic Resource Manager (PeanutFARM; Figure 6).

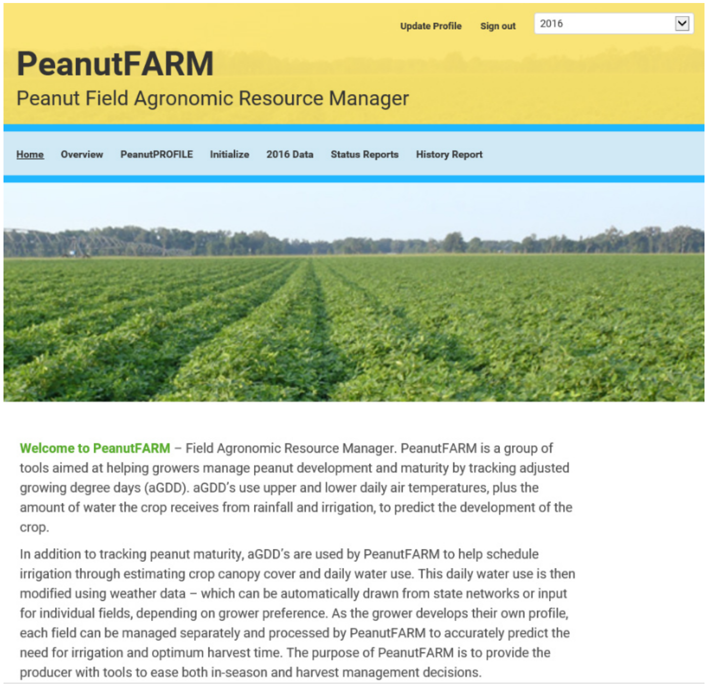

Figure 6. Screenshot of the PeanutFARM website.
Credits: Diane Rowland, UF/IFAS

This model tracks the aGDD and the DAP for each field that a grower sets up in their account.

PeanutFARM also has the capability to evaluate maturity using a digital imaging model (DIM) designed to automatically assess mesocarp color and match digging predictions to the MPB (Colvin et al. 2014). This tool requires the grower to upload digital images from a commercially available copier or scanner. This is accomplished by placing blasted pods saddle down on a scanner, covering them with a blue poster board for contrast, and scanning to obtain the best image. Scanned images are then uploaded through the website (Figure 7).

The program automatically e-mails a harvest prediction in as little as 30 minutes after the image is uploaded; if web complications arise, it sends the prediction within 24 hours. The model is more objective than visual classification because computer algorithms are responsible for classifying the sample's colors instead of a person. To reduce the number of maturity samples collected during the season, it is recommended that a combination of methods such as PeanutFARM, MPB, and maturity ratio be used to determine maturity. PeanutFARM can deliver a reminder to the grower at 2100 aGDD that the maturity level of the crop should be assessed. The grower would then collect pod samples from the field and assess them with the DIM to confirm their maturity level and the predicted digging date. There are advantages and disadvantages associated with each method (Table 2).

Figure 7. Scanned image of peanuts placed saddle side down with a blue poster board on top, ready to be uploaded to PeanutPROFILE.
Credits: Diane Rowland, UF/IFAS

Steps for Collecting and Evaluating a Maturity Sample

The following step-by-step instructions are provided for sampling and evaluating crop maturity through calculation of a maturity ratio as well as use of MPB and PeanutFARM, as these are the most common methods used by growers. They are available here in a printable PDF.

Collecting a Maturity Sample

- For each sample, collect and bag four or five plants (or enough to produce 180–200 pods) from random places throughout the field. Be sure to collect WHOLE plants, or the accuracy of your results will be compromised (Figure 8).
- If multiple peanut varieties or soil types are present in the same field, separate representative samples for each condition should be collected. If you know that certain areas of the field have not performed like the others through the season, take separate samples from those locations. AVOID collecting at end or edge rows and mixing areas of deficient plants with representative ones (Figure 9).

Figure 8. Collection of an entire peanut plant from the field as part of a maturity sample.
Credits: Andy Schreffler, UF/IFAS

Figure 9. Edge rows and row ends are not representative of the field because they receive more moisture and sunlight.
Credits: Andy Schreffler, UF/IFAS

- For each sample, starting with the first plant, remove ALL pods, from match heads (when tip of peg is swollen) to fully developed pods. Continue with subsequent plants until you have 180–200 pods. If you start a plant, you MUST pick it clean, regardless of the number of pods collected thus far (Figure 10).
- For each sample, once you have reached 180–200 pods, discard the match heads. They will not be blasted.

Figure 10. Varying pod sizes on a peanut plant. Removal of all pods is critical, from match heads to full-size pods.
Credits: Ethan Carter, UF/IFAS

Removal of Exocarp (Outer Layer)

This can be performed in several ways, but blasting with water using a pressure washer and turbo nozzle has become a primary method (Figure 11).

Figure 11. Removal of peanut exocarp using water with an electric pressure washer.
Credits: Kelly Racette, UF/IFAS

It is faster and more accurate than hand scraping the hull. An electric pressure washer between 1000 and 1500 psi is adequate. Models with higher pressure should be used with a pressure regulator or throttle to avoid damaging the pods.

- Make a wire basket from 0.25-inch mesh hardware cloth to contain the pods during blasting. The hardware cloth can be fastened together at the sides with wire or zip ties (Figure 12). It should also have a diameter small enough to fit inside a five-gallon bucket to prevent splashing.

Figure 12. Hardware cloth basket designed to hold peanuts for blasting.
Credits: Kelly Racette, UF/IFAS

- A round container should also be fashioned out of hardware cloth and attached to the body of the basket with zip ties a few inches from the bottom to hold the sample. This basket should be placed in a bucket that has holes drilled in the bottom or a drain to prevent the bucket from filling with water.
- Hold the nozzle approximately 12 inches from the pods in the basket when blasting. Stop and collect the immature pods that have their white and yellow mesocarp exposed about 30 seconds into blasting so they are not destroyed, and then finish blasting the more mature pods.

Evaluating the Sample

There are several ways to determine maturity by evaluating the blasted pods' colors, but each method has limitations. Calculation of a maturity ratio will suffice if the samples taken from a field average 70%, an optimal level of maturity for harvest, or higher. If the average of a field's maturity proportion is under 70%, the samples may need to be placed on the MPB or scanned and uploaded to the PeanutFARM website (PeanutPROFILE) to determine a prediction for harvest date.

- Calculation of the maturity ratio: Add the combined number of pods from the brown and black classes, then divide by the total number of pods from the BLASTED sample (not the number that included match heads). Only average samples collected from the same field. This will determine if the field has an optimal maturity of 70% or more.
- MPB: Place the pods using the color chart to determine the days until digging. This is most likely the best option if you have a bimodal distribution with many immature and mature pods and few in the middle. Boarding a sample will take about 15–20 minutes.
- PeanutFARM: Lay one sample at a time on a scanner (all pods saddle side down) (Figure 13), and put a BLUE poster board over them and scan. The blue poster board provides the best contrast.

  Placement should take roughly five to seven minutes. Name the file and upload it to the website. The results should be e-mailed to you within 30 minutes.

Figure 13. Pods being placed saddle side down in preparation for scanning. Scanned images are uploaded to the PeanutFARM website to determine maturity.
Credits: Kelly Racette, UF/IFAS

For more information, contact your local UF/IFAS Extension office.

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Table 2. Advantages and disadvantages of maturity methods.

Tools	Advantages	Disadvantages
Shellout (Internal Hull Color)	Simple, quick, no technology required	Destructive (digging and shelling), time-consuming (digging, picking of pods, sample preparation)
Maturity Ratio	Simple, quick	Destructive (digging and pod blasting), time-consuming (sample preparation); does not illustrate maturity distribution (bimodal)
Profile Board (MPB)	Simple, no technology required	Destructive (digging and pod blasting), time-consuming (sample preparation and boarding), developed for mid-maturing 'Florunner'
PeanutFARM Tools: Adjusted Growing Degree Days (aGDD)	Nondestructive; provides guidance for estimated dig date	Requires accurate rainfall and weather data
Digital Imaging Model (DIM)	Removes subjectivity related to color classification; provides more precise digging date	Destructive (digging and pod blasting), time-consuming (sample preparation); requires a scanner