CHAPTER 1

GOOD AGRICULTURAL PRACTICES

FOR

PEANUT GROWING AND HARVESTING

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These Good Management Practices are not standards nor are they mandatory but represent consensus thinking on best practices in each area.

Changes this revision: Moved section on Aflatoxin control from Chapter 7 to Appendix in this chapter.

A. INTRODUCTION

The production of high quality, flavorful, and wholesome peanuts begins at the farm. The quality of the farmer stock peanuts delivered to the buying point dictates to a large degree the value of peanuts to the producer. The producer is the first step in the process and probably the most important component within the chain as peanut quality is established at the farm level. Peanut shellers and manufacturers strive to maintain the quality throughout the supply chain. The quality concerns of the entire peanut industry; namely microbiological contamination, chemical residues, foreign material, aflatoxin, flavor and maturity, are all affected by management practices at the farm during the growing season.

Management practices to minimize the risk of physical, chemical and microbial contamination in peanuts need to extend from the field all the way through shelling, processing, packaging and delivery of the finished product to the consumer. Good Agricultural Practices (GAPs) provide guidelines to producers on how to minimize these hazards during production and harvest. They also serve as the first step in the overall food safety system for the peanut industry. To the producer, GAPs focus on reducing rather than eliminating potential sources of contamination with the understanding that elimination of all potential risks is considered impractical.

This document is designed to outline best practices for growing and harvesting peanuts. It provides information for the management of both quality and food safety. The following practices implemented into an overall management and production program should produce <u>the safest and highest quality peanuts under current technology.</u>

B. CRITICAL AREAS

1. <u>Land Selection and Rotation</u>

- Well-drained, sandy to sandy loam soils are best for quality peanut production. In most locations peanuts should be grown on the same land no more often than one year out of three. On this schedule, peanuts should be rotated with crops that are not viable hosts for *Cylindrocladium* black rot (CBR), nematodes, white mold or stem rot, Sclerotinia blight and other diseases affecting peanuts. Recommended rotational crops include corn, sorghum, grass sods, small grains, and cotton. Avoid rotating with legumes including soybean and certain vegetables since those crops may build up nematodes and soil borne diseases.

TABLE 1. <u>EFFECT OF ROTATION LENGTH ON YIELD OF RUNNER MARKET TYPES</u>

	Previous crop			
Rotation length	Corn	Cotton	Soybean	Peanut
1 year	3460	3150	3360	-
2 years	3750	3370	3550	-
3 years	4270	4230	3680	-
Continuous peanut – 3 year average				2840

Flowers, R. A. University of Georgia, Unpublished

TABLE 2. <u>VIRGINIA MARKET TYPE RESPONSE TO ROTATION</u>

Rotation (1997-2006)	Peanut Yield in 2006

Peanut-Corn-Corn-Corn-Corn-Corn-Peanut	5540
Peanut-Cotton-Corn-Peanut-Cotton-Corn-Peanut	4840
Peanut-Corn-Corn-Peanut-Corn-Corn-Peanut	4850
Peanut-Cotton-Cotton-Peanut-Cotton-Cotton-Peanut	4730
Peanut-Corn-Peanut-Corn-Peanut-Corn-Peanut	4170
Peanut-Cotton-Peanut-Cotton-Peanut-Cotton-Peanut	4200
Peanut-Soybean-Corn-Peanut-Soybean-Corn-Peanut	4130
Peanut-Soybean-Cotton-Peanut-Soybean-Cotton-Peanut	4330
Peanut-Peanut-Peanut-Peanut-Peanut-Peanut-Peanut	3050

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- Good rotations improve both peanut yield and quality by reducing diseases, foreign material and chemical residue. Long rotations usually reduce the severity of diseases in peanuts and thereby permit more efficient production by reducing pesticide applications. Planting a disease-resistant variety can partially compensate for disease that develops in a short rotation. The use of effective fungicide programs can also help to battle disease outbreaks. Crop rotation can often help overall weed management systems and reduce potential for weed resistance development. Weed control efficiency is often improved because many weed species that are difficult to control in peanuts can be more easily controlled in rotational crops. Ultimately reducing weed problems, permits easier harvest, and lowers overall foreign material.

TABLE 3. EFFECT OF CBR-RESISTANT VARIETY AND ROTATION ON PEANUT YIELD

Rotation (2001-2006)	Susceptible variety (Gregory)	Tolerant variety (Perry)
Corn-Corn-Corn-Corn-Corn-Peanut	3310	3540
Corn-Corn-Tobacco-Corn-Corn-Peanut	3670	3940
Corn-Corn-Peanut-Corn-Corn-Peanut	2330	3030
Tobacco-Corn-Peanut-Tobacco-Corn-Peanut	2000	2970

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- Peanut is a crop that typically responds better to residual fertilizer rather than direct applications. Following recommended fertilization practices in rotational crops will reduce the need for direct fertilization of the peanut crop. The deep tap-rooted peanut plant is very efficient in using residual soil fertility. Indirect fertilization lowers the potential problem of having high potassium levels in the fruiting zone. High potassium levels in the pegging zone interfere with calcium uptake by the peanut plant, which can result in lower kernel quality, increase pod rot, and increased number of empty pods (pops). However, farmers should apply potassium fertilizer based on plant need. If potassium is applied at planting, the fertilizer should be incorporated as deep as possible in the soil profile.

- When selecting fields to plant peanuts consider removing sources of foreign material such as remnants of old building materials or collapsed structures.

- Carefully identify and eliminate potential sources of contamination for fields selected for planting (i.e. animal habitats and contaminated water sources).

2. Land Preparation

Providing optimum soil conditions for rapid germination, good root penetration and growth, and continuous plant and pod development is essential to peanut culture. In recent years reduced tillage production of peanut has become more popular. Pod yield is often similar under conventional and reduced tillage production. The key regardless of tillage method is to start with a clean field at planting. Finer textured soils should be avoided for in-shell market types like Valencia and Virginia. Pod loss will typically be higher with these market types on finer textured soils. Soil from finer textured soils will also more often remain on the pod that will reduce the peanut's value for the in-shell market.

3. Soil Fertility

A major benefit of an effective crop rotation program is that peanuts respond better to residual soil fertility than to direct fertilizer applications. For this reason, the fertilization practices for the crop immediately preceding peanuts are extremely important.

- Soil test in the fall and apply sufficient lime to maintain a soil pH of 5.8-6.5. If a soil sample analysis recommends additional fertilizer, apply it before final land preparation and deep turn it prior to planting. Avoid over-liming peanut soils to an excessively high pH. Increasing soil pH reduces the plant's ability to absorb manganese and iron. Deficiencies can lead to leaf chlorosis, yellowing and slow vegetative growth. If soil pH is too low zinc levels can become toxic and cause retarded plant growth, stem splitting and in some cases plant death.

- Utilize a balanced fertility program that maintains adequate levels of phosphorus, potassium, calcium, magnesium and micronutrients based on soil testing.

- Avoid high levels of potassium fertilizer in the upper four inches of soil. This can lead to increased incidence of "pops" and pod rot that will affect peanut quality and yield. Soil testing is critical to insure that unneeded potassium fertilizer is not applied to soils that already have adequate potassium.

- Monitor the pegging and fruiting zone for calcium and potassium nutrition. A lack of calcium can lead to empty pods and darkened plumules in seed (concealed damage), poor germination and potentially increased risk of aflatoxin when soil conditions are favorable for *Aspergillus flavus* mold development. Adequate calcium must be available in the pegging zone during seed and pod development. Excessive potassium can interfere with calcium uptake by pods. Irrigated producers should test irrigation water for potential calcium being applied with the irrigation water. In some cases, irrigation water may provide the calcium needed for peanut development.

- Take a soil test 10-14 days after planting at a 3" depth to monitor pegging zone calcium levels. Supplemental calcium (gypsum) should be applied to all Virginia type peanuts and all peanuts grown for seed purposes regardless of soil test results. Newer large seeded runner varieties are more sensitive to calcium levels in the pegging zone and supplemental calcium may be beneficial on these varieties. Again irrigation water should be analyzed to determine if adequate amounts of calcium for Virginia and larger seeded runner varieties are being applied with the irrigation.

- Use finely ground gypsum or granular gypsum rather than gypsum by-products to minimize gypsum contamination in shelled peanuts and to avoid detecting undissolved by-product gypsum in peanuts prior to roasting. In addition, course gypsum products may not be available to the plant during pod and kernel development.

- Peanuts are efficient legumes that synthesize their own nitrogen requirements through association with specific *Rhizobium* soil bacteria that is already present in most peanut soils. However, peanuts should be inoculated at planting with a commercial hopper box or in-furrow granular or liquid spray regardless of previous rotation. Depth of planting can influence peanut response to in-furrow application of inoculant. Shallow planting on soils exposed to high temperatures can result in death of *Rhizobium* and lack of inoculation. *Rhizobium* will not survive in dry, hot soils.

Therefore, planting depth is critical to insure that *Rhizobium* is maintained moist and cool during germination and stand establishment. *Rhizobium* should be scouted to approximately 30 days after planting to determine effective nodulation. If peanut are not adequately nodulated additional nitrogen may need to be applied. Supplemental nitrogen should only be applied at 30 lbs. of actual N per acre to reduce the risk of increasing the incidence of pod rot. In situations where N deficiency is properly accurately diagnosed, 120 lbs. actual N/acre is required to obtain yields equivalent to inoculated peanut. This occurs in new peanut fields when inoculant fails to perform.

- Soil test and accumulate a history of soil nutrient levels in your cropping systems. Tracking your fields' fertility history can help to avoid overlooking potential soil fertility problems which can lead to reduced yields and inferior quality peanuts.

TABLETABLE 4. PEANUT YIELD RESPONSE (LBS./ACRE) TO INOCULANT IN NEW PEANUTS FIELDS OR IN FIELDS PREVIOUSLY ROTATED WITH PEANUT.

Inoculant treatment	New peanut fields	Fields with a previous history of peanut production
No inoculant	3414	4184
In-furrow inoculant	4895	4370
Difference	1482	185
Trials	32	32
Years	1999-2013	1999-2013

- When using organic or inorganic fertilizer and soil amendments (materials worked into the soil to enhance the soil's properties), be sure that the material does not contain heavy metal residues or excessive nutrient amounts that could be phytotoxic to the plant and predispose it to disease and damage.
- Growers should make every effort to avoid applications of large quantities of manure to soils with low existing microbial activity. Crop rotations with high residue crops increase soil organic matter leading to better soil aggregation, which provides more aeration and water infiltration. These soils also support high soil microbial activity and generally poor persistence of introduced microorganisms.
- The use of raw manures is not recommended for peanut production. However, if raw manures are used, there are some specific things to consider:
    - Stacked and aged manure is not the equivalent of properly composted material.
    - If raw manure is part of a fertility program, application should be made to a rotational crop preceding peanut. If needed for the peanut crop that year, application of material should occur and be incorporated into the soil at least 30 days prior to planting.
    - Raw manure piles should not be stored on or near peanut fields or in areas where water runoff could carry manure into peanut fields.

4. <u>Seed Selection and Planting</u>

Erratic emergence and irregular plant growth can lead to non-uniform pod set and uneven maturity which can result in harvest problems and reduced grades.

- Use high quality seed of a recommended variety. Plant at the recommended plant population based on a given row spacing and seed count. Shellers typically avoid seeds that have poor shelf life, poor milling quality, or inferior flavor.. Consult with shellers on market acceptance of peanut varieties.

- Plant sound, well-matured, disease-free seed of known pedigree, purity and performance.

Certified seed, which are grown under stringent regulations and close supervision, are true to variety and of high quality.

- Plant peanuts as soon as soil conditions are favorable for rapid germination and development. Late planting dates generally reduce yield and quality and increase the risk of freeze damage and late season drought to peanuts. Contact local Cooperative Extension personnel for optimum planting dates for tomato spotted wilt management, avoid late season freeze, and reduce maturity issues

- Prepare seed beds carefully to assure uniform seed germination and emergence. Seedbeds should be free of weeds and sufficiently smooth to provide good soil-to-seed contact at a uniform, optimum depth. Planting equipment should be operated at a speed to insure uniform seed depth. Planting equipment operated too fast will lead to varying seed depth and germination resulting in management issues season long. Soils should have sufficient moisture and temperature for quick emergence. Adjust planting depths to soil type, temperature, moisture conditions and planting date. If soils are extremely dry, irrigate, if available, prior to planting to obtain favorable soil moisture and seed environment rather than planting and then irrigating. When planting in a conservation tillage system, surface applied herbicides can be applied through the irrigation water (check label for chemigation) or irrigated immediately following planting, where irrigation is available.

5. Crop Protection – Quality Enhancement

There are many pests that reduce both yield and quality of peanuts. Flavor, wholesomeness, and gross value are affected if these pests are not controlled to manageable levels. Growers utilize pesticides, cultural practices, and biological controls to help prevent these pests from economically impacting peanut quality and yield. Pesticides must be used according to their label requirements. Pesticide residue levels in foods (tolerances) have been set by the Environmental Protection Agency (EPA) to assure the wholesomeness of the food supply. Tolerances are based on extensive residue research studies and are established with many-fold safety factors taken into account. The major pesticides used on peanuts fall into the following classes:

Herbicides	-	weed control
Nematicides	-	nematode control
Insecticides	-	insect control
Fungicides	-	disease control
Fumigants	-	disease control

Integrated Pest Management (IPM) is an effective approach to pest control using all of the best available methods to prevent pests from adversely affecting crop yields and quality. The goal of IPM is to blend pest control methods to reduce costs, keep pests below economically damaging levels, reduce unnecessary pesticide use, assure food safety and help growers produce the most profitable crop possible. While there are many variations in IPM definitions, the following definition was developed by the Southern Region IPM Center (http://www.sripmc.org/). Integrated pest management is socially acceptable, environmentally responsible and economically practical crop protection. Traditionally a pest is defined as any organism that interferes with production of the crop. We generally think of pests as insects, diseases and weeds, but there are many other types including nematodes, arthropods other than insects, and vertebrates. We now also deal with pests in many non-crop situations, such as human health and comfort.

Implementing IPM programs can be characterized by **"The PAMS Approach". This approach suggests that IPM** systems normally occur along a continuum from largely reliant on prophylactic control measures and pesticides to multiple-strategy biologically intensive approaches, and are not usually an either/or situation. It is important to note that the practice of IPM is site-specific in nature, with individual tactics determined by the particular crop/pest/environment scenario. Where appropriate, each site should have in place a management strategy for Prevention, Avoidance, Monitoring, and Suppression of pest populations (the PAMS approach). In order to qualify as IPM practitioners, growers should be utilizing tactics in at least three of the four PAMS components. The rationale for requiring only three of the four strategies is that success in prevention strategies will often make either avoidance or suppression strategies unnecessary.

PREVENTION in peanut involves keeping a pest population from infesting a field or site and should be the first line of defense. It includes such tactics as using pathogen-free seeds, preventing weeds from reproducing, irrigation scheduling, where available, to avoid situations conducive to disease development, cleaning tillage and harvesting equipment between fields or operations, using field sanitation procedures, and eliminating alternate hosts or sites for insect pests and disease organisms.

AVOIDANCE in peanut is practiced when pest populations exist in a field or site but the impact of the pest on peanut can be avoided through some cultural practice. Examples of avoidance tactics include crop rotation, choosing varieties with genetic resistance to pests, choosing varieties with maturity dates that may allow harvest before pest populations develop, fertilization programs to promote rapid crop development, and simply not planting certain areas of fields where pest populations exist. Some tactics for prevention and avoidance strategies may overlap in most systems.

MONITORING and proper identification of pests in peanut occurs through surveys or scouting programs, weather monitoring and soil testing where appropriate as the basis for suppression activities. Records should be kept of pest incidence and distribution for each field or site. Such records form the basis for crop rotation selection, economic thresholds, and suppressive actions.

SUPPRESSION of pest populations may become necessary to avoid economic loss if prevention and avoidance tactics are not successful. Suppressive tactics may include cultural practices such as narrow row spacing or optimized in-row plant populations, alternative tillage approaches such as no-till or strip till systems, and cover crops. Physical suppression tactics may include cultivation or mowing for weed control. Where naturally occurring biological controls exist, effort should be made to conserve these valuable tools. Chemical pesticides are important in IPM programs, and some use will remain necessary. However, pesticides should be applied using the following sound management approach: 1) cost: benefit of the pesticide should be confirmed using economic thresholds and weather-based advisories where available); 2) pesticides selection should include understanding of products with the least negative effects on environment and human health in addition to efficacy and economics; 3) precision agriculture or other appropriate new technology should be utilized to limit pesticide use to areas where pests actually exist or are reasonably expected; 4) sprayers or other application devices should be calibrated prior to use and occasionally during the use season; 5) chemicals with the same mode of action should not be used continuously on the same field in order to avoid resistance development; and 6) vegetative buffers should be used to minimize chemical movement to surface water.

General Pesticide Use

- Contact local Cooperative Extension Service offices for recommended pest control materials and methods.

- To assure optimum product performance, calibrate all pesticide sprayers and granular applicators to deliver the recommended rate of pesticide per acre. Check nozzle tips and other metering parts of application equipment often to ensure that they function properly. Make sure the pesticide is delivered only to the target area by avoiding applications when high winds may cause the product to drift into other non-target areas.

- Properly identify the pest and use the most efficient pest control method. When considering potential impact upon the environment, read all labels thoroughly. Some products may serve multiple purposes and therefore reduce the number of total applications or amount used. Use recommended surfactant or stickers to ensure that the pesticide does not wash off nor drift to a non-targeted area.

- Apply pesticides only as directed. Read the label on each pesticide container before each use. Apply pesticides only to labeled crops in amounts specified and at times in the plant growing cycle as specified by the label. Label instructions are developed through extensive testing and are approved by the EPA to assure efficacy and to avoid harmful residues or negative environmental effects.

    - Avoid drift by delivering pesticides only to the target area.

    - Pesticide handling should be controlled through every phase of use. Application should only be performed by individuals that meet local, state, and federal guidelines for using and applying restricted use pesticides.

    - Thorough training and documentation of personnel responsible for using and applying pesticides is extremely important. Personnel should also know the dangers and food safety risks when pesticides are handled or applied inappropriately.

    - If a pesticide is applied to a crop that does not meet the label requirements, growers should immediately contact the appropriate local and state agencies.

    - Never mix pesticides or drain tanks near wells, streams, or other surface water sources.

    - All pesticides should be stored safely away from people, crops, and animals. Pesticides should be stored in their original containers with labels intact. The storage facility should be well ventilated and secure to prevent any unauthorized entry.

    - Some soil pesticides (nematicides/insecticides) enhance crop growth and promote uniform maturity, (i.e., indirect benefits). Protect groundwater by properly storing unused pesticides; disposing of empty containers in a manner specified on the label; and never mixing pesticides near wells, ditches and streams or other water sources where ground water may become contaminated by spills.

- If cultivation is used in weed control, avoid throwing soil onto the peanut plant. This "dirting" of peanut plants can lead to increased disease problems and inhibition of normal flowering and pod development thus reducing quality and yield.

- If available, consider using disease forecasting to reduce the need for pesticides. Forecasting has been especially effective in helping reduce fungicide applications for leafspot and other diseases in all production areas.

- If disease forecasting is not used, leafspot disease control management should usually begin no later than 30 days after planting or follow recommended practices for the production area. In these areas, leafspot diseases must be controlled by timely applications of a fungicide applied at regular spray intervals.

- Control soil insect pests that damage pegs and pods since they reduce yield and quality and may predispose peanuts to invasion by *Aspergillus flavus* that can result in aflatoxin contamination. Lesser cornstalk borers, cutworms, wireworms and southern corn rootworms are significant economic problems in peanuts and therefore must be controlled.

- Follow recommended guidelines to prevent resistance development to pesticides. The overuse or reliance on one particular pesticide or pesticide family will result in resistance development ultimately leading to the loss of an effective tool in pest management programs.

Animal Exclusion

All animals, both wild and domestic, are potential sources of food contamination. Feces are usually considered the primary source of pathogenic organisms from animals, but since animals come in contact with soil, manure and water, they can easily pick up other contaminants from these sources. Therefore the exclusion of animals from peanut fields is an important component of the growers overall sanitation program

6. <u>Irrigation</u>

Irrigation is helpful in maintaining yield and quality during drought years when natural rainfall is inadequate during the peg and pod filling period. Irrigated fields should have a good weed and disease control program to prevent excessive losses in yield and quality. There are three major stages in the peanut life cycle when moisture stress can cause a significant reduction in the quantity <u>or</u> quality of peanuts produced:

1. Germination through early vegetative growth.

2. 50-110 days after planting (the critical flowering, pegging, pod initiation, and pod fill period.) The pegging zone must be kept moist to insure that pegs are able to enter the soil and start pod initiation. Hot dry soils can result in pegs being damaged, delaying maturity, and lowering yields.

3. 110 days until harvest-water requirement is reduced; however, extreme drought and high temperatures during this period can predispose the pods to increased aflatoxin levels.

- Use irrigation (if available) to avoid reduced peanut yields and poor nut quality from prolonged drought stress during the critical flowering, pod set and pod maturation growth periods.

- Irrigation should be scheduled as recommended by your County and State Extension Service. Properly scheduled irrigation will result in more uniform pod set, uniform crop maturity, improved yields and higher quality.

- Maintain adequate moisture to reduce lesser cornstalk borer damage, improve herbicide effectiveness and seed germination.

- Water according to needs dictated by the growing conditions. The actual amount and frequency of water required will depend on the growth stage of the plant, soil type, and predominant weather conditions (temperature, rainfall, wind speed and relative humidity). Do not wait until drought symptoms occur to irrigate. This will result in loss of yield and delay maturity ultimately reducing quality. It is also best to maintain adequate soil moisture during the fruiting period. Drought during this period can often lead to a split crop that makes harvest and crop management more difficult and expensive.

- Contact the county Cooperative Extension Service for more detailed information on irrigation systems and scheduling and to evaluate feasibility and the economic impact of adding irrigation to non-irrigated fields.

Computer models such as Irrigator Pro used to schedule irrigation are also available through many county extension offices (especially in the SE). These are good tools in the efficient application of irrigation as well as fungicides. Chemical cost may be reduced and aflatoxin risk is minimized if not eliminated. Irrigator Pro was developed by the USDA/ARS.

Irrigation Water Quality

Salinity is an issue in many areas of the peanut belt. As water quality and cropping patterns change, some areas may experience injury and reduced yields as a result of marginal quality water. 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: 1) salinity hazard, and 2) 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 three major factors: total soluble salts, sodium hazard, and toxic ions. If possible it is best to take this sample at the end of the season prior to planting peanuts the following year. Often times water quality issues will become more severe later in the season as well levels are lowered and soluble salts become more concentrated.

Total soluble salts measures salinity hazard by estimating the combined effects of all the different salts that may be 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.

TABLE 5. CRITICAL VALUES FOR SALTS IN IRRIGATION WATER FOR PEANUT

Measurement	Critical Value for Peanut
Total dissolved salts (EC)	1344 ppm
Sodium Adsorption Ratio (SAR)	5 to 7 (no units)
Boron	0.75 ppm
Chloride	400 ppm
Sodium	400 ppm

Lemon, R. G. and M. L. McFarland, Texas Cooperative Extension Service

Food safety aspects of agricultural water are outlined in the Food Safety Modernization Act (FSMA) for produce safety. Under the final rule as of 25 August 2014, raw peanuts are exempt from this rule. However, it is advisable to consider some key provisions for prevention or reduction of the introduction of pathogens. Some of the key requirements for agricultural water are:

- Assure that all agricultural water is of safe and sanitary quality for its intended purpose.
- Inspect, maintain, and monitor water sources and water distribution systems used for growing, harvesting, packing, and holding of raw peanuts.
- Treat agricultural water if there is reason to believe that the water is not safe and of adequate sanitary quality.
- Test the water used during growing activities using direct water application methods using an appropriate analytical method.
- Keep records of inspection findings and information relied on to support the adequacy of water treatments methods.

Additionally, below are suggested guidelines to help ensure that microbial food safety risks are low:

- Review location of all sources of irrigation water if used, both wells and surface. Ensure there are no open, deep-water percolation channels for underground aquifers. These could provide a point of entry for contaminated surface water to infiltrate the aquifer. Ensure there are no large, confined animal feeding or other livestock operations nearby that could allow runoff of animal waste to contaminate water sources.
- Protect groundwater from chemical contamination by mixing and loading pesticides away from wells or other water sources.
- If chemigation practices are used during the course of the growing season to apply approved pesticides, all necessary equipment should be in place per local, state, and federal guidelines for such applications. This typically includes the proper installation and operation of check valves and other backflow prevention devices.

7. Determining When to Harvest

The indeterminate fruiting nature of the peanut makes timing crucial to obtaining maximum yield, grade and quality. Immature peanuts have poor flavor, are more difficult to cure, often deteriorate faster in storage and are more likely to be affected by undesirable mold growth. Immaturity may result from digging too early or from a split crop on the plants. A split crop can result from pod set occurring during two or more periods of favorable weather that occurs several weeks apart, separated by a period of drought stress.

Digging at optimum maturity is extremely important for achieving maximum yield, grade, dollar return, and consumer quality. It is not unusual for peanuts to gain from 300-500 lbs. and 1-2 percent in grade in the last two weeks prior to the optimum harvest date. The following data illustrates the average loss over four years from digging too early or too late:

TABLE 6. HARVESTING RUNNER MARKET TYPE PEANUT AT OPTMUM MATURITY

Timing of digging operation	Pounds per acre lost	Value per acre lost ($0.25/pound)
2 weeks early	744	186
1 week early	253	63
Optimum maturity	0	0
1 week late	500	125
2 weeks late	541	135

Williams, E.J. USDA/ARS Tifton, Unpublished

_ **TABLE 7.** HARVESTING VIRGINIA MARKET TYPE PEANUT AT OPTIMUM MATURITY FOR THE VARIETY GREGORY WHEN AVERAGED OVER 18 TRIALS FROM 2003-2012.

Days after emergence	Pod yield	Percent of maximum yield	% Extra large kernels	% Total sound mature kernels
122	3300	84	39	62
128	3840	99	44	65
138	3940	100	50	68
144	3813	96	52	69
153	3350	80	54	71

Jordan, D. L. North Carolina State University, Unpublished

- Target to harvest peanuts using the "Hull Scrape" maturity assessment; however, timing of harvest frequently depends on risk-benefit analysis. Adverse weather at harvest can result in the loss of the more mature peanut pods due to weakened pegs, pod rots and digging losses. Producers must consider the first freeze date in relation to digging. Damage from freeze may reduce quality and economic outcome more than digging early. However, in the event that a freeze is predicted and peanuts have not been dug it is best to wait until freezing temperatures have subsided and then dig peanuts.

- Target to harvest when pods of runner types are 70-80% mature, and when Virginia types are 60-65% mature, to maximize milling quality and flavor of peanuts. Harvesting peanuts prematurely results in yield and grade loss, flavor problems, increased costs of curing and risk of aflatoxin.

The state Cooperative Extension Service has detailed information on determining when to harvest including a description of and instructions for using the "Hull Scrape" method for determining optimum maturity. Many extension offices and shellers have pod blasting equipment available for use by growers that will help reduce the time required to run the “Hull Scrape” maturity assessment.

8. Digging, Combining, and Curing

Peanut handling starts each year with digging and ends with peanut products in the homes of consumers. Each handling process will either maintain the peanut quality it receives or reduce it.

- When harvesting, you may want to consider separating irrigated and non-irrigated peanuts in curing trailers for separate monitoring.

- Harvesting involves digging, shaking, and combining--all mechanical operations, requiring proper setup and operation for both maximum yield and quality. Harvesting equipment should be maintained and set properly to minimize damage to pods and kernels. After harvesting, the peanuts must be properly cured if desirable flavor, texture, germination and overall quality are to be maintained.

- Peanuts should be loaded on wagons level across the top and not mounded to provide uniform curing.

- Peanuts, in regions where applicable, should be put on mechanical controlled temperature dryers as soon as possible after harvest to beginning the curing process. Green peanuts that sit too long on trailers without air movement through them often have elevated alcohol levels leading to off-flavor as well as increased aflatoxin risk.

- Storage facilities for peanuts should be weatherproof and free from insect and disease bearing litter.

These three principles are elaborated in the following checklist.

CHECKLIST FOR HARVESTING AND DRYING TOP-QUALITY PEANUTS

- Dig for maximum maturity and dollar value per acre. Delay harvest until the greatest amount of nuts reach maturity but before excessive sprouting or over-maturity occurs. Digging when 75-80% of pods have turned dark inside the shell will usually give the best grade and yield. Utilize the "Hull Scrape" method if at all possible. However, do not risk freeze damage waiting on an increase in maturity or grade.

- GPS-based guidance systems or the plant growth regulator prohexadione calcium (Apogee) can improve digging efficiency and accuracy and reduce yield loss in this process when vines are rank and rows are hard to track.

- Clip vines (Only on those fields that have excessive weeds or vine growth). Use a rotary or flail type cutter with sharp blades to clip about 1/3 to ½ of the vines about 2-5 days or just prior to digging. Harrow field borders to rid the ends of fields of weeds and grasses. It is best not to allow weeds to become large or dense enough to require shredding.

- Inspect and adjust digger and sharpen blades - Set the blades with a slight pitch so that they will cut the taproot just below the pods. The forward speed of the digger must be synchronized with the PTO speed to get a smooth flow of vines over the lifter-shaker. Going too fast will cause pods to be ripped from the vines, whereas going too slow may result in soils not "flowing" properly over the blades.

- Ensure uniform, fluffy, well aerated windrows during the digging and inverting process. Pods should not touch the ground. If re-shaking is required, use very gentle action and extreme care.

- Allow peanuts to dry to 18-24% moisture in windrows. Peanuts are normally between 35 and 50% moisture at digging. Depending upon weather conditions, the peanuts will dry to 18-24% moisture in 2-4 days. Evaluate peanut on a daily basis especially in areas of low humidity combined with hot windy conditions. These environmental circumstances can lead to very quick drying of peanuts. Rainfall occurring on windrow peanuts with below 20% moisture provides excellent conditions for mold growth and an overall reduction in milling quality. In addition, peanuts that are rained on are more difficult to harvest and often time yield losses occur.

- Stop digging operations at least 3 days prior to frost to avoid freeze damage.

- Carefully adjust combine for your field conditions. Read your operator's manual for specific adjustments. The combine ground speed and the pickup speed reel must be carefully synchronized to lift the peanuts into the combine. Proper combine adjustment and speed will reduce pickup losses, percent of loose-shelled kernels, hull damage, and foreign material. Excessive dirt and trash blown into the basket during combining will cause airflow restrictions during the curing process and may result in uneven drying and mold development.

- Combine efficiency depends upon several variables including windrow condition, cylinder speed, forward travel speed, internal adjustments, and special modifications required for handling large-seeded peanuts. Impact and mechanical injury during harvest is largely associated with fast moving parts of the picking cylinder.

- Experience has shown that poorly adjusted combines, having loose belts, too little or too much picking action, or too rapid cylinder speeds are inefficient and may be responsible for excessive loose-shelled kernels and other mechanical damage. Variable moisture conditions of pods and vines within the windrow are a predominating factor affecting combine efficiency. A favorable moisture condition is best assured by uniformity of the windrow. Peanuts combine with minimum damage when kernel moisture is approximately 20% and where vines and pods have cured <u>uniformly</u> in the inverted windrows.

- Machine adjustments, such as cylinder speeds, should be set within manufacturers' recommendations as given in the instruction manual. Adjustments must be made as windrow moisture and picking conditions change within a field, or during the day as humidity varies. Operate at the lowest cylinder speeds that give good pod separation. A better measure of combining efficiency is evidenced by the quality of the peanuts coming into the bin rather than the amounts harvested in a given time.

- <u>Speed can be the enemy of peanut quality.</u> Fast moving combine parts may damage a high percent of hulls and kernels. Both visible and non-visible damage opens the door to insect and mold infestations. These molds may be present at time of grading and result in a serious price penalty. Loose-shelled kernels are most readily infested by insects and are a serious storage problem encouraging infestation by insects and molds as well. Mechanical damage is the "number one" potential problem in machine harvest and only the grower is in position to exercise the care needed to avoid or reduce this damage. Grading procedures penalize the grower for loose-shelled kernels and damage and substantially reduce the price of peanuts that contain visible mold (*Aspergillus flavus*).

- <u>Prevent peanut contamination</u> by cleaning out all wagons, combines and other hauling equipment prior to harvesting. This will eliminate potential sources of aflatoxin and foreign material from previous crop residues. This will also prevent cross-contamination from other commodities i.e. pecans which may cause food allergy reaction.

- <u>Avoid holding wet peanuts on trailers.</u> After combining, be sure curing begins immediately. Leaving peanuts in wagons without curing greatly increases the opportunity for aflatoxin contamination.

9. <u>Observe proper curing practices.</u>

- <u>Provide adequate airflow to peanuts.</u> Provide enough fan capacity in the curing system to ensure a minimum airflow of approximately 50 cubic feet of air per minute per square foot of floor area while operating against static pressure of one inch of water.

- <u>Proper Curing Temperatures.</u> The proper curing temperature and relative humidity of the curing air will vary with the weather conditions. Proper curing requires frequent checking and adjusting the temperature controls to prevent over-drying. In normal weather, no heat will be needed during the daytime. At night, the temperature rise of the heated air passing through the peanuts should generally be no more than 15ºF above ambient, and in no case should the temperature exceed 95ºF. Desirable curing temperatures for varying temperature and relative humidity conditions are given in the table below.

TABLE 8. DESIRED CURING TEMPERATURE

Outside + Temperature (F)	Outside Relative Humidity (%)					
	Desired Temperature Rise (added heat)			Desired Curing Temperature		
	90	60	30	90	60	30
50	20	15	10	70	65	60
60	15	10	5	75	70	65
70	10	5		80	75	
80	5			85		

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- Limit Curing Depths. Under no circumstance should drying depths exceed 5 feet in trailers or bins. Peanuts should be dried at the following depths and moisture: 5' at 25% moisture; 4' at 30% moisture; 3' at 35% moisture; and 2' above 35% moisture. If peanuts are harvested above 35%, do not put peanuts any deeper than 2 feet into the trailer. (A safe rule to follow is to lower the peanut depth by one foot for each 5% of moisture above 25%.) More uniform drying results when peanuts are distributed evenly over the entire drying trailer. Avoid mounding or heaping to increase trailer capacity.

- Avoid over-curing. Quality control depends on frequent moisture checks as peanuts approach 12% moisture. Under average conditions, the curers should be cut off when the peanuts reach 11.0-11.5% moisture. Curing continues as the "coasting" effect lowers the moisture content 1-1.5% below the cut-off point. This effect is due to unequal moisture levels between the hulls and the kernels. Do not allow average moisture content for any lot to go below 8.5%. Also, no part of the lot should contain less than 7% moisture or more than 10%.

10. On-Farm Storage

Some growers may store peanuts on the farm for marketing later in the year. The same principles apply to on-farm storage as warehouse storage (see chapter 3). Growers must be conscious of, and practice, good sanitation, ventilation and particularly insect control.

Peanuts stored in curing trailers should be placed under shelters that are adequate to prevent blowing rain from wetting the peanuts. Two to three weeks after harvest when peanut moisture has dropped to 7-8%, close the ducts to the plenum to prevent continual circulation of air through the peanuts. Such circulation will usually lower moisture content even more and may result in excessive splits during shelling.

Peanuts in trailers should be protected from birds and insects. It may be necessary to spray the surface layer of peanuts to prevent insect infestation. Hardware cloth or some other screening material should cover the peanuts to protect them from bird damage. Plastic or canvas covers should not be used since they may cause condensation and moisture build-up that can lead to molds.

11. Equipment Maintenance and Sanitation

Peanut handling starts with digging and ends when the shelled peanut kernels reach the food manufacturer. Growers start the process at the farm level with harvest. Harvest operations include digging, combining, and curing. The equipment used during harvest is complex and performs many functions during the process. Peanuts are removed from the soil, excess dirt is removed from the pods and they are inverted and allowed to dry before combining. Peanut combines remove the pods from the plants and then separates any excess plant material or debris from the peanut pods, which are then dumped into trucks to be sent to a peanut buying point for grading and additional cleaning and possibly more curing. The complexity of the equipment requires extensive maintenance and sanitation prior to harvest. Maintenance and sanitation helps the grower ensure that a minimal amount of foreign material and debris enters the shelling plant from the field and microbial contamination is kept to a minimum. Some guidelines to consider when preparing your equipment for harvest:

- Carefully inspect equipment for mechanical problems that could cause metal to end up in the farmer stock peanuts.

- Properly clean harvest equipment and trailers prior to harvest to remove old peanut crop debris; rodents, insects and bird nests that may be present, and remove all dirt that accumulated on the harvest equipment while being stored in the off-season.

- Inspect and clean trailers to prevent cross contamination from other crops such as corn or pecans.

- Adjust equipment to minimize the incidence of loose-shelled (LSKs) and damaged kernels. Loose-shelled kernels are peanut kernels that are inadvertently removed from their outer shell during the harvesting and handling process and are often higher risk for microbial contamination.

C. APPENDIX

1. Documentation

Adequate documentation not only benefits the individual grower in their operation, but also provides key elements to the basic food safety system. Many growers already maintain documentation for various aspects of the farming operation but should also view documentation in the context of food safety. Documentation standards described in many HACCP training programs can be applied to peanuts. In addition, many of the current activities related to pesticide licensing and use; participation in USDA farm programs and crop insurance require much of the same information often included in many GAP programs. Developing a documentation system as part of GAP is an on-going process that will change as the individual operation changes. Important documentation records include, but are not limited to:

- Detail of prior farm ownership and cropping history
- Information regarding variety and plant date
- Crop management activities during the growing season
- Pesticide application information
- Worker training
- Fertilizer and soil amendment use history
- Pest reports from scouts or consultants
- Equipment maintenance and sanitation schedules

2. Employee Training

Trained, efficient employees are an asset to any operation. Employees that fully understand the operation and their roles and responsibilities within the operation are critically important to the production of safe, high quality peanuts. If possible, written training programs for proper operation of equipment and application of pesticides should be made available to farm workers. Many local and state agencies offer training programs for pesticide application and worker safety issues. Employee training should include:

- Pesticide application and worker safety
- Proper equipment calibration, maintenance and operation
- Proper equipment sanitation

3. Aflatoxin Control

Land selection is a very important factor in the prevention of aflatoxin contamination. Certain types of soils, such as light, sandy soils can favor the growth of the source fungus under dry environmental conditions while heavy soils with higher water holding capacity can contribute to the prevention of drought stress that is known to promote growth (United Nations FAO and WHO, 2004). Crop rotation is important to prevent build up of high populations of *Aspergillus* in soils. Appropriate nutrient application for promotion of healthy plants, including adequate pH, and proper calcium and potassium levels, will help insure low aflatoxin levels (United Nations FAO and WHO, 2004). Other factors to combat drought stress include proper irrigation and soil moisture, proper plant density and weed control. Prevention of fungal infections due to insect damage should include practices that limit soil insects, mites, and nematodes through the use of approved insecticides, herbicides, and fungicides (United Nations FAO and WHO, 2004).