The Most Critical Period in Cotton Production

Expert Recommendations of
Best Management Practices
for an Efficient, Cost-Effective
Cotton Production System
through

Fruiting to Finish SM

National Cotton Council OF AMERICA

The Cotton Foundation

Focusing on
Best Management Practices

The U.S. cotton industry is in a state of transition, as more and more technology is integrated into production agriculture, domestic markets disappear, and market forces, such as the need for bio-fuels, alter the mix of crops produced across the U.S. Cotton Belt.

One of the most worrisome developments in production agriculture for the cotton research and Extension community involves the negative ramifications of *"convenience"* farming. The convenience and efficiency of producing a crop with herbicide- and insect-resistance traits has created an erosion of basic agronomy within the cotton production system – as well as a negative impact on grower profitability. A number of negative effects are emerging from this near-total reliance on systems that are implemented for the sole purpose of convenience. These issues are wide-ranging and include the emergence of herbicide-resistant weeds, increased opportunity for insecticide-resistant populations of arthropod and insect pests, changes in pest status (plant bugs and spider mites), interactions of cotton germplasm, and perceived fiber quality value, All of these problems pose significant concerns for producers and professional consultants, as they drive up production costs and decrease crop values.

The transition of the cotton industry and several major production issues were catalysts for the development of *The First Forty Days*™ initiative and the subsequent workshops. Identifying emerging and potential problems, as well as proposing recommendations to mitigate these problems, was paramount among the team of multi-disciplinary workshop participants. Several key points were realized throughout the discussions of various issues, and together served as a foundation to support a series of best management practices (BMPs) for cotton production. These include:

- Farmers are in a "sustainable mode of ag operations" – fighting for survival – which is driving their decision process for production inputs and practices, such as varietal selection, weed control system, seed-applied vs. in-furrow pest control, aggressive early season foliar insecticide applications, etc.
- Speed and convenience have become primary decision factors, despite their potentially less-than-optimum value to an overall cotton enterprise system.
- The greatest opportunity for profits result from cotton planted during the early window of the optimal planting period.

The first workshop, *The First Forty Days*™ initiative, had a simple objective:

To bring focus to selected Best Management Practices in the new, contemporary cotton production systems by addressing the changing pest spectrum, season-long pest management systems, and overall plant health and earliness, with the ultimate goal of high yield and superior quality fiber.

This publication summarizes BMPs developed by a multi-discipline, multi-state congress of research and Extension agronomists, pathologists/nematologists, entomologists, physiologists, weed scientists, economists, and crop consultants. Two independent work groups, representing similar agronomic production systems, convened in a coordinated planning process: once in 2005, twice in 2006, and once in 2007. The Lower South Agronomic Zone includes South Texas to Georgia. The Upper South Agronomic Zone includes New Mexico to Virginia. Participants in *The First Forty Days*™ and *Fruiting to Finish*™ Workshops generally agreed that a forum for multi-disciplinary discussion was valuable and worth the time and effort put forth for discussion and BMP development.

Although an ideal crop production system consists of many components, several inputs and practices are more valuable – indeed, critical – to yield, fiber quality, and crop profitability. These most critical inputs and practices were captured in the BMPs for cotton production discussed in *The First Forty Days* section of this publication.

The subsequent *Fruiting to Finish* Workshops, conducted after the 2006 production season, and again prior to the 2007 season, employed the same process of information exchange and collaboration among multidisciplinary participants. The work groups expanded on *The First Forty Days*' BMPs, with a keen insight into the balance of the cotton production season. The result is a holistic crop production system that optimizes crop management and production.

The BMPs described herein may not corroborate every crop consultant's recommendation or cotton producer's action. The BMPs are not designed to answer each and every problem that may develop in a production system. However, the recommendations agreed on by workshop participants demonstrate regional acceptance as general guidelines. None of these BMPs should supersede individual state Extension specialist recommendations. The general consensus of the participants, however, is that these BMPs should be promoted within each state's research program and extended through Extension specialists and crop consultants to producers.

The *Fruiting to Finish* workshops expanded on the work of *The First Forty Days*, with specific focus on:

- Developing and prioritizing BMPs specific to mid- to late-season needs;
- Creating measurement criteria for the plant/crop growth stages during the *Fruiting to Finish* time period;
- Gaining consensus on contemporary cropping systems that best meet the stated goal; and
- Determining research and development needs for this production time period.

Three primary areas of discussion for *The First Forty Days* and *Fruiting to Finish* initiatives included:

- The impact of at-planting decisions on optimal season-long crop protection strategies.
- The shifting arthropod pest spectrum, including the emergence of plant bugs (primarily *Lygus spp.* and cotton fleahoppers) and spider mites as significant pests, and the importance of the crop protection choices during *The First Forty Days*.
- The impact of crop uniformity, plant health, and timely development on crop management, yield, and fiber quality.

The First Forty Days after planting is the most critical stage of the cotton crop. The crop's yield potential is determined during this period. As plants move into the midseason fruiting period, they must be healthy and uniform in order to produce optimum yield and fiber quality.

The Fruiting to Finish period spans the balance of the crop season and is an important time for capturing yield and maintaining fiber quality potential.

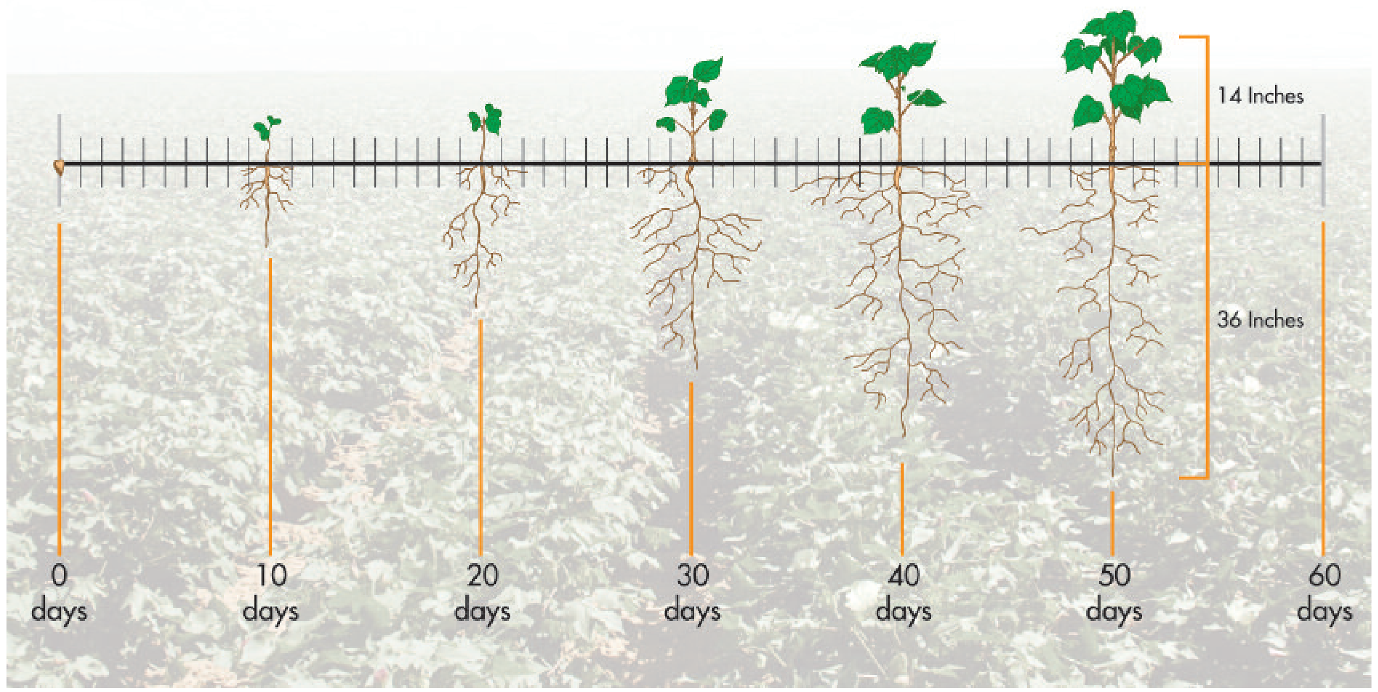
The First Forty Days

The Most Critical Period in Cotton Production

(BMPs)

Best Management Practices

Early Season Cotton Development



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Seed germination and plant development during the first 40 days after planting:

- **Environmental stresses.** Regardless of the tillage and crop production system, the optimum cotton crop would be free of stress from insects, mites, nematodes, seedling diseases, weeds, and other manageable factors, such as fertility levels and water availability.
- **Seedling and root health.** An optimum cotton crop at 40 days after planting would be a picture of health. In addition to being stress-free, the crop would exhibit healthy leaves, with roots extending into the row middles, and plants growing rapidly and uniformly. Earliness is important, with a height-to-node ratio of at least one (1:1) at 40 days after planting. The optimum plant would have seven to eight nodes and would be in the early stage of squaring.
- **Uniform stand; adequate plant population.** Crop uniformity has a significant impact on season-long crop management. A uniform crop allows for a more efficient crop management system, which ranges from application timing of herbicides and plant growth regulators to harvest aids. An adequate plant population would be at least 30,000 plants per acre and would not exceed 60,000 plants per acre. The minimum stand would have at least two healthy plants per foot, with no intra-row gaps greater than two feet.

Achieving an optimum crop 40 days after planting contributes to an efficient season-long crop management system, including weed control, plant growth regulation, arthropod pest management, fertility, and harvest aid management. The ultimate goal of BMPs is a holistic and integrated, cost-effective crop management system that optimizes yield and fiber quality.

The cotton industry is in transition, as is general agriculture throughout the U.S. The infrastructure of support for farming is shrinking in both public and private sectors, due to a lack of funding and a declining overall value of the industry. Ultimately, the farm operator suffers from this shrinking infrastructure. As a countermeasure, *The First Forty Days* and *Fruiting to Finish* Workshops recommend the following BMP to concentrate support of production agriculture.

Consider using only proven products from suppliers offering customer service, product support, and industry stewardship.

Variety & Seed
Selection

Cultivar selection and seed quality have a lasting effect on the crop's early-season vigor and on overall plant health and uniformity during *The First Forty Days*. The crop's ultimate yield and fiber quality potential at harvest begin with variety selection and seed quality. Less vigorous cultivars are more susceptible to stresses caused by inadequate moisture, cool temperatures, thrips feeding, seedling diseases, nematodes, and other pests. In addition, varieties exhibit varying levels of resistance or tolerance to diseases and pests, such as Fusarium wilt, root-knot nematode, and bacterial blight, as well as other cotton diseases and pests. Consider planting tolerant varieties, or those that have at least some resistance, where these diseases are a problem.

Choose varieties with the genetic potential for higher yield and fiber quality.

Yield still is the ultimate measure for a cotton crop, although the ever-increasing demand for higher fiber quality makes this factor a close second in priority. With more than 70 percent of U.S. cotton exported, fiber quality likely will become the single most important factor for American cotton producers in the foreseeable future. International mill standards and specifications are higher than those of domestic mills.

Choose varieties with the genetic potential to produce excellent technical fiber:
- **Long staple length;**
- **High strength;**
- **Premium micronaire;**
- **High length uniformity index; and**
- **Smooth leaf with a plant conformation that is efficient to harvest.**

The extended fruiting period of the cotton plant and subsequent development cycle forces each boll to develop under different environmental conditions than other bolls on the plant. Fibers from a single plant, single boll, and even a single seed will vary in length, strength, and micronaire. The average fiber quality within the plant is what determines value. Plant genetics and environment provide the platform for higher lint yields and fiber quality.

Plant more than one variety; consider specific traits and crop maturity after yield and quality.

- **Consider planting three or four varieties** to determine which cultivars and combinations of traits perform the best on a given farm. Multiple varieties also reduce the risk of planting the entire farm to a poor-yielding variety or using traits that do not add value to the individual farmer's cropping system. Growers always should evaluate more than one year of data prior to planting more than trial acreage of a new variety.
- **The environment can affect the efficiency of the Bt protein production in varieties.** Conditions that stress the plant, such as moisture deficits or saturated soil conditions, influence plant development and can reduce the efficacy of Bt proteins against target pests.

Select the highest quality seed for planting. High-quality seed is critical to success in *The First Forty Days* and the crop's ultimate performance. Rapid germination and emergence is best, because it narrows the window for seedling diseases and minimizes the impact of pests. In addition to the standard warm germination test, a cool germination test is recommended. When cool germ and warm germ numbers are added together, high-quality seed will have a vigor index of at least 160 (e.g., a warm germination value of 90 plus a cool germination value of 70 equals 160). Early planting into cool soils requires a high vigor index. When planting early, plant the best vigor index available in the variety you are planting.

Cotton seedling vigor can be enhanced by optimum:
- Land preparation;
- Soil moisture and temperature;
- Planting date selection;
- Seedling disease control;
- Pest control; and
- Fertility.

Seedbed Preparation

Emergence and Plant Population

Plant with precision, not speed. A consistent concern among participants is that growers do not adequately address planting-time considerations and needs, opting instead for speed of planting as a single priority. One-half the variable costs, as well as all of the annual fixed costs, are spent prior to or during *The First Forty Days* – therefore, planting with precision pays. The trend in reduced seeding rates reflects more precise planters and the producers' desire to manage high-value seed costs by reducing the number of seeds per acre. An efficient, well-timed planting operation can result in a 10 to 25 percent savings of seed and seed treatment cost and technology fees.

The Upper South group focused on the need for strong, vigorous, uniform emergence because of cooler planting-time soils and cooler, more-fluctuating ambient temperatures. The Lower South group focused on the desired plant population of a vigorous, uniform crop.

Plant uniformly spaced seeds (drilled or hill-drop pattern) with good seed-to-soil contact, warm soil temperatures of at least 65 F, and adequate soil moisture.

- **Increase the seeding rate** when planting early into cooler soils.
- **The minimum plant population** in the final stand should be about two plants per foot, or about 30,000 plants per acre, with a maximum of 60,000 plants per acre. Planting less than 2 or 2.5 seeds per foot can significantly delay maturity, as cotton tends to develop more bolls on outer positions and on higher nodes in less dense populations.
- **Consider the plant's architecture,** by variety, when adjusting planting rates. Plants with a tendency to produce more vegetative growth will perform better with lower plant populations.
- **Soil and air temperatures** should be optimum, following state Extension guidelines. A soil temperature of 65 F at a depth of four inches for three consecutive days and a favorable five-day forecast following planting is best, although not always realistic for early planting. Although dependent on growing conditions, a delay in planting of four weeks can equate to only a one-week delay in flowering. Adequate soil temperature for a vigorous plant is critical.
- **Ensure soil moisture is optimum** and seedbeds are firm for good seed-to-soil contact.
- **Plant higher-quality seed first in cooler soils.**
- **Plant to a depth of 1 to 1 1/2 inches,** depending on adequate moisture for germination and the moisture-holding characteristics of the soil.
- **Create a pest-free seedbed environment.** Pre-plant, burndown herbicide applications should be made at least three weeks prior to planting to ensure no green matter is on the seedbed.
- **Practice farmscape vegetation management.** Control all potential host plants/weeds in and around fields to eliminate sources of insect and mite pests. Most of the pest problems in cotton originate in other crops or on native vegetation sur rounding cotton fields. Managing weedy host plants on field borders can greatly reduce pest problems in adjacent cotton fields, but take care to avoid off-target pesticide problems.

NOTE: Replanting is discouraged unless there is a significant loss of stand. A plant population of one plant per foot would be more desirable than replanting later in the planting season.

Seedling Disease

Management

Seedling diseases in U.S. cotton account for approximately $200 million in yield losses annually. Pathogens to control include *Rhizoctonia solani, Pythium spp.*, *Fusarium spp.*, and *Thielaviopsis basicola*.

Growers recognize lethal infections by loss of stand, which if severe enough may require replanting, but sublethal infections also rob growers of yield and earliness, and disrupt efficient crop management. Research indicates that environmental conditions are the most important factor in seedling disease development. Cool, wet soils result in greater seedling disease losses.

The key to minimizing the impact of seedling disease is to limit the window of vulnerability to pathogen infections by planting into warm, moist soils, which will speed up germination, emergence, and early plant development.

Many of the BMPs recommended for seed quality and seedbed preparation will minimize seedling disease losses by encouraging rapid germination and emergence. Plant high-quality, broad-spectrum fungicide-treated seed into a firm, moist seedbed that's at least 65º F. The five-day forecast should indicate a warming trend. It is vital that a good broad-spectrum fungicide seed treatment be used every year.

For cotton that must be planted in cooler (< 65º F) soil, or when the five-day forecast is for cool weather with a high probability of rain, apply an in-furrow fungicide with active ingredients against both *Pythium spp*. and *Rhizoctonia solani.*

Insect Pest

Management

Early Season

Choose an at-planting systemic insecticide capable of providing long residual efficacy, based on the field/farm history and experience of the pest manager.

- **Evaluate systemic inputs** based on the range of pests to be controlled, including nematodes, mites, and thrips. Ideally, the best at-planting systemic pest control input would provide control of thrips, cotton fleahoppers, spider mites, and other arthropod pests throughout *The First Forty Days*. The increased incidence of spider mites in localized areas across Rain Belt cotton states may be attributed to broad acceptance of insecticide seed treatments and a greater reliance on foliar applications of broad-spectrum insecticides. Spider mites can be an "induced pest", due to the effect of insecticides on beneficial and natural enemies – particularly in reduced-tillage fields. Problems with spider mites can be lower where Temik® insecticide-miticide-nematicide is used in the seed furrow at planting.

  Where a side-dress treatment of Temik® is applied for control of nematodes, growers also may expect systemic protection from piercing and sucking insects, such as Lygus (plant bugs), cotton aphids, whiteflies, and spider mites, which may reduce the need for broad-spectrum foliar insecticides and acaricides.
- **Avoid pesticide "convenience application"** programs, and use caution with systems that require "automatic" oversprays for thrips and plant bugs. Such practices can create pest problems, particularly from cotton aphids and spider mites, as the season progresses. Avoid co-applying insecticides with Roundup® as a convenience; use only when insect pest control is needed. Avoid unnecessary applications when thrips, cotton fleahopper, and plant bug numbers and damage ratings are below action thresholds, because nozzles used for herbicides may not be effective in targeting insect pests. Unnecessary insecticide applications often flare secondary arthropod pests and contribute to insect resistance. Spray tips creating small droplets, such as hollow-cone nozzles, usually are most effective for insecticide applications.
- **Eliminate host plants and insect breeding sites** with pre-plant weed control and seedbed preparation, as well as weed management around cotton field perimeters. For example, spider mite populations can build up on pigweed or henbit, and tarnished plant bugs can feed on marestail or primrose.
- **Keep seedbeds free of all green plant tissue** for at least three weeks prior to planting.

Recognize the residual limitations of insecticides. Scout and overspray as required, ensuring insect control through *The First Forty Days* – especially during periods of cool temperatures or extremely dry conditions.

- **Use proper scouting techniques** and apply insecticides on an as-needed basis, according to state Extension action threshold guidelines. Note that poor environmental conditions or slow management decisions also can interfere with timely foliar applications.
- **The length of control** of various at-planting insecticides ranges from a low of 14 days after planting with some insecticides applied as seed treatments, up to five weeks after planting with an in-furrow granular.

It is critical to protect the plant from insects and keep it healthy through *The First Forty Days*. This BMP results in:

- Economic efficiency;
- Effective pesticide resistance management;
- Beneficial insect preservation; and
- Reduced probability of flaring of secondary pests, such as spider mites.

Nematode
Management

Infections by nematodes during *The First Forty Days* can be very detrimental to root development, vigor, and earliness. With the potential for significant loss of yield, fiber quality, and earliness at the end of the season, the need for prevention is paramount.

Nematode damage is much more costly than many growers recognize. Nematodes collectively are responsible for yield losses that exceed $400 million annually across the Cotton Belt. The root-knot nematode is found in all cotton production areas of the country and can be particularly problematic in light-textured, sandy soils. Over the past 20 years, a relative newcomer, the Reniform nematode, has expanded its range from the southern Gulf Coast into most of the Southeast and MidSouth states, and is found as far west as the Texas Panhandle. This nematode alone cost the industry an estimated $839.2 million in lost yield from the 2001-2006 seasons (at $0.55 per pound). On a more regional scale, but also a serious production constraint, Columbia lance and sting nematodes are common in the sandy soils of the southeastern coastal states.

There are few management options during the season, so management decisions must be made before or at planting. Symptoms of nematode pressure and the stress they place on the plant are readily seen at fruiting – when it's too late.

Diagnose and recognize nematode problems in the field during the growing season, and be prepared to address them the following spring.

The most visible symptom is stunted growth. Infected plants may show nutrient deficiencies, but the symptoms often are not very pronounced. Root-knot nematode produces the characteristic galls on the roots. Root-knot and lance nematodes reduce taproot growth and cause stunted taproots and forked secondary roots. Reniform nematodes stunt the entire root system. Root-knot nematode pressure tends to be found in "clumps," while Columbia lance and Reniform may be more uniform across the field.

Use soil sampling techniques to verify the presence of nematodes and determine population levels. Apply a nematicide as recommended by state Extension guidelines and consider rotating crops; under extreme nematode pressure, use a fumigant.

Sample for nematodes after harvest or as close to harvest as possible, and when adequate moisture is in the soil. Allow time for soil analysis by a state or private lab.

- Handle samples correctly, according to Extension guidelines; and
- Quickly deliver to lab.

Crop yield maps, soil electrical conductivity (SEC) maps, and remote images can be useful in identifying and marking problem areas or zones within fields. These maps can be useful in **creating intra-field zones for management.** Where nematodes are identified as possible factors in the problem areas, appropriate treatment tools – ranging from seed treatment nematicides and in-furrow and side-dress applications of Temik® to soil fumigants – can be targeted more efficiently, providing a cost-effective strategy.

Plan for the following year

- **Plant tolerant or resistant cotton cultivars.** There are no Reniform, lance, or sting nematode-resistant cotton varieties. There are cultivars with moderate resistance to the root-knot nematode. If reliable information is available, plant varieties that claim "tolerance" to nematodes.
- **Use crop rotations.** Crop rotation is extremely helpful. Plant selected summer crops that are not nematode hosts. Peanuts are not a host for the cotton root-knot, Reniform, or Columbia lance nematodes, although the legume is a host for the sting nematode. Corn is a host for root-knot, Columbia lance, and sting nematodes, but is not a host for Reniform. Grain sorghum is a relatively poor host for root-knot and is not a host for Reniform and sting nematodes. Soybeans are a host for lance, Reniform, and root-knot nematodes, but there are root-knot resistant soybeans available. Many weeds are susceptible to these nematodes, so fallowing is only effective if weeds are controlled.
- **Other cultural practices.** Sanitize equipment to minimize the spread of nematodes from infested fields to new fields. Nematodes are moved readily by anything that moves soil. Washing field equipment after it has been used in infested fields, before entering new fields, will decrease the chances that nematodes are introduced into new areas. Similarly, driving or walking into infested fields when they are muddy increases the opportunity for transporting nematodes to new sites, so use common sense in washing shoes and field vehicles. Proper water management also can minimize the spread and impact of nematodes, by minimizing nematode transport in tailwater or drainage systems.
- **Use a nematicide.** Seed treatment nematicides and low rates of Temik® are recommended only for low populations of nematodes. If populations are high, rotate crops, increase the rate of Temik®, or consider pre-plant fumigation with Telone II®, Vapam®, or K-Pam™.

During the season, management options are few

- **Manage fertility and irrigation** to avoid conditions that stress the crop. Losses from nematodes are greater under conditions of drought stress.
- **Root health is critical to minimize the impact of nematodes.** In addition to the use of nematicides, seed-applied fungicides and in-furrow fungicides can encourage healthy root growth and reduce nematode losses.
- **In fields or management zones that support moderate to heavy nematode populations, side-dress the recommended label rate of Temik® at 14 to 28 days after planting, by the pinhead-square stage.** This is particularly important in continuous cotton and where the Reniform nematode is present. If a seed-applied nematicide is used, the earlier side-dress application timing of Temik is recommended to avoid lapses in nematode protection. When Temik is side-dressed for extended nematode control, growers may expect extended protection from *Lygus,* aphids, whiteflies, and spider mites. The higher the rate, the longer nematodes, insects, and spider mites are controlled.

Nematodes, and the stress they cause to the plant, can be minimized by following the BMPs. Overall crop management becomes extremely important where nematode problems exist, since there is no curative, in-season method for their control past the stage at which Temik® can be side-dressed.

Weed
Management

Weeds should be controlled for at least three weeks prior to planting to ensure planting efficiency and pest control. Weed resistance to glyphosate and changes in problem weed species develop rapidly. Palmer amaranth (pigweed) and marestail (horseweed) have become more problematic. Other weeds, including Johnsongrass, pose a threat to developing resistance.

Maintain a totally weed-free crop, using all available tools — including residual herbicides, glyphosate, herbicides with modes of action different from glyphosate, and herbicide-tolerant traits — to minimize competition, improve yield, and preserve quality.

Treat weeds in a timely manner and eliminate weed competition for six to nine weeks after planting. Allowing weeds to grow after this period may not reduce yield, but weeds can adversely affect crop management and harvest and lint quality (leaf grade and trash content).

- **Carefully plan the weed control program for the entire farm prior to planting.** Understand the strengths and weaknesses of your season-long weed control system and choose residuals to address gaps or weaknesses in the system.
- **Start the season clean and weed-free.** Survey weed escapes at season end.
- **Understand emergence patterns of your weed spectrum.** It's important to scout for weeds weekly.
- **Stop universal reliance** on glyphosate-type products, to reduce weed selectivity to the chemistry. Avoid repeated, excessive use of glyphosate-type products.
- **Rotate chemistries and engage multiple modes of action.** Consider other technologies, such as the LibertyLink® trait or a conventional, soil-applied herbicide system.
- **Use appropriate rates,** as stated in the label guidelines. Do not reduce rates.
- **Consider use of residual** herbicides and weed populations when developing a program, including lay-by applications.
- **Keep a field record** of weed species and locations within the field. Historical problems by field and areas within fields should be the focus.
- **Manage the seed bank.** Do not allow weeds to mature. Spot-spray herbicides as needed in fields. Mow field borders and ditch banks to prevent weeds from going to seed.
- **Sanitize equipment** to reduce transfer of weed seeds or residue to other fields.
- **Recognize that the weed spectrum** on a farm may require residual herbicides. Do not rely solely on a post-applied herbicide program.
- **Size of weeds and timing** of oversprays are very important when selecting the appropriate co-applications of products.
- **Spray by weed size, not by crop stage.** A common mistake is to make a post application when weeds are too large, thereby losing yield potential because of weed competition. Target weeds less than four inches in height for optimum control and to protect crop performance.
- **Base herbicide applications on the presence of weeds and the appropriate stage of growth** – not on presence of insects. Avoid the temptation to add glyphosate to the tankmix when making an insecticide application for thrips.
- **Manage possible weed flushes** after furrow-irrigation by spot-spraying the ends of the rows that are most problematic.

- **Where there is a proven benefit,** consider the use of an appropriate, high-quality surfactant/adjuvant to improve consistency and efficacy.
- **Be aware of tankmix antagonism** when selecting herbicide combinations.
- **Use proper nozzles and spray volume** for optimum herbicide performance.

Prevent the onset of resistance or manage resistance by not relying primarily on glyphosate or ALS-inhibiting herbicides for cotton weed control. Use residual herbicides to reduce the pressure on glyphosate performance and prevent weeds from producing seed that will contribute to the soil seed bank.

Weed resistance is a significant concern for all U.S. crops, not just cotton. The advantages and advancements made with conservation tillage production systems will be lost if resistance to available herbicides is allowed to quickly develop. Weed resistance management is extremely crucial to agriculture. The alternative to replace the current weed control systems, if they completely fail, is to reintroduce cold steel in full-tillage systems.

Pigweed and marestail provide useful illustrations to support weed resistance management. One female Palmer pigweed plant produces approximately 400,000 seeds, which makes an additional five percent control extremely beneficial. Many weeds, such as pigweed, are host plants for mites, beet armyworms, and other hard-to-control pests.

To sustain the current weed control technology, don't rely totally on a single system. Too much use of a single chemistry, such as glyphosate in the Roundup Ready® Flex system, increases selection pressure for resistant weeds.

Rotate weed control strategies and use residual herbicides. The incidence of herbicide-resistant weeds is increasing faster than originally forecast by weed scientists, making herbicide rotation extremely important on every farm and on all crops on that farm.

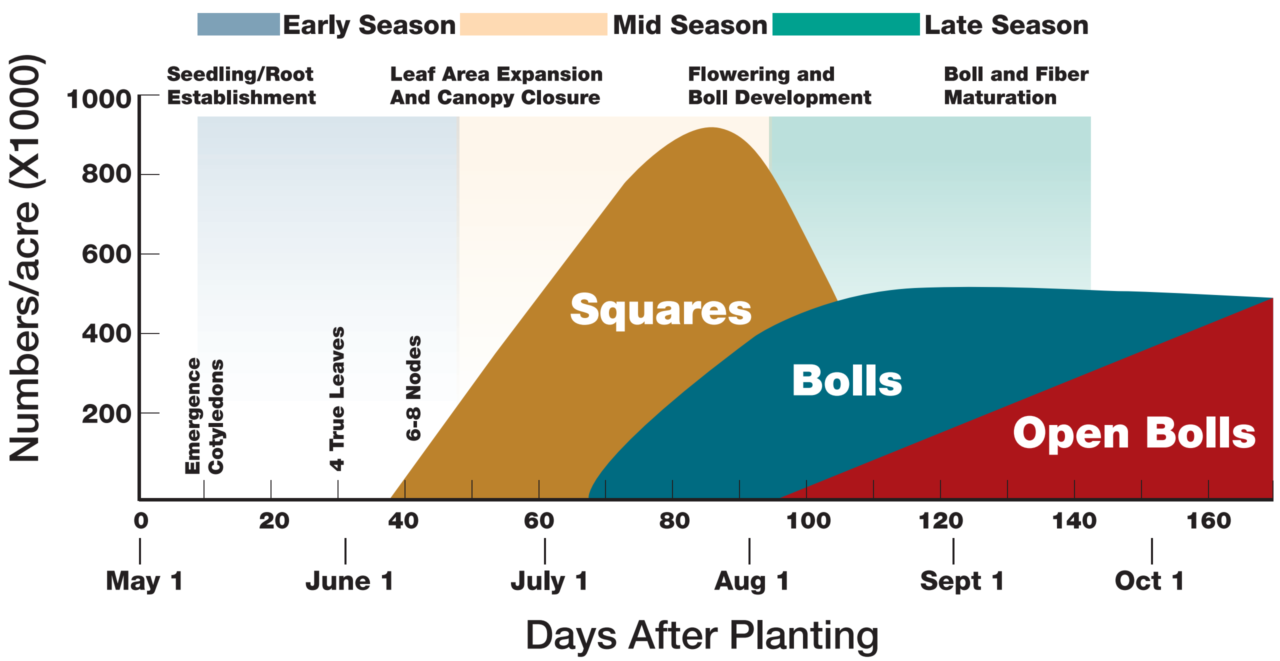
- **Early detection of weed resistance is very important.** Note weed escapes and possible resistance to herbicide applications. Develop a resistance management plan and stick to it by rotating herbicide modes of action and avoiding excessive use of glyphosate.
- **At defoliation, the objective is to kill or desiccate weeds** that can reduce harvest efficiency or contribute to the weed seed bank for the following season.

Fruiting to Finish

Maintaining Yield and Fiber Quality

The period from *Fruiting to Finish* is important in maintaining the strong foundation for yield and fiber quality that was created during *The First Forty Days*. At 40 days after planting, the yield potential already is established; the crop should be healthy and uniform, characteristics that aid crop management through defoliation and harvest.

A holistic crop management program brings together the BMPs of *The First Forty Days* with those designed to maintain and protect the crop for the remainder of the season. The *Fruiting to Finish* phase has been adopted to characterize this seasonal period of cotton reproductive development and crop maturity, and associated BMPs.



Note: Image credit to Derrick Oosterhuis, Ph.D., University of Arkansas

As with *The First Forty Days*, measurement criteria are very important in a holistic crop management program. Even considering different growing environments, the benchmarks for success are similar.

The optimum cotton crop during the *Fruiting to Finish* period:

- **Square retention.** Square retention during this period should range from 70 to 80 percent. The goal is to manage the crop for a minimum of 60 percent square retention, equally distributed up and down the plant by the end of the season. Square retention would be monitored during insect scouting.
- **Boll distribution.** Strive for a compactly fruited plant with harvestable bolls evenly distributed across 10 to 14 nodes. The plant would be in effective bloom for four to five weeks. Boll retention rates generally should range from 50 to 65 percent, with 80 percent of the yield in the first position.
- **Plant Height.** Final plant height would be within 10 percent, plus or minus, of row width. If the crop is taller, there is potential for boll rot. The exception would be the height of Southwest stripper cotton, which would not exceed row width. For ultra-narrow-row cotton, the final plant height should be less than 28 inches.
- **Senescence.** The plant would be senescing naturally with a visual decline in leaf number. Fertility plays a major role, with most available nitrogen used before senescence.

Aerial imagery can be a very effective diagnostic tool to determine stresses caused by nematodes, poor water management, mites, insects, diseases, and fertility issues during *Fruiting to Finish*. Once stresses are identified and confirmed, they can be adequately addressed or plans developed to manage for those problems before or during the next crop season.

Fertility

Optimum fertility management is a key practice in crop development and performance, in foliar disease management, and in managing the profitability of the crop. In many cases, excess nitrogen is applied to the crop and is not utilized, or becomes a pollutant in ground and surface water. With soil sampling, residual nitrogen and other nutrients and trace elements can be managed for specific needs of a crop while shaving variable costs, which may contribute to better overall profitability.

Know the soil pH and level of residual nutrients. Establish a base level of residual nutrients in the soil, applying sound sampling techniques for nitrogen, phosphorus, potassium, and trace elements, and update at least every two years.

- **Sampling depths up to six inches** are satisfactory for pH, other nutrients, and trace elements.
- **A deeper sampling depth is required for nitrogen.** Texas A&M University recommends a depth of 12 to 18 inches. Deep testing can be done at planting for residual nitrogen.

The Sampling Procedure is very important. Nutrients will tend to be more concentrated near the surface and in the drill row on established beds in reduced- and no-till production. Consistent sample collection in relationship to the bed is essential for accurate assessment of the nutritional status of the field and for long-term nutritional evaluation.

Studies indicate approximately 60 to 65 pounds of nitrogen and potash (K_2O) and 20 to 25 pounds of phosphate (P_2O_5) typically are required to produce a bale of cotton. However, these levels represent nutrients for the entire above-ground plant, including plant, seed, and fiber. Typically 30 to 40 pounds of nitrogen, 18 to 20 pounds of potash, and 15 to 20 pounds of phosphate are removed from the field as seed cotton to produce a bale of lint. Consideration of residual or native fertility levels is critical in establishing fertility recommendations.

Follow established fertility recommendations based on local soil types and soil analysis . . . "Don't guess, soil test!"

Avoid the temptation to use foliar application of fertilizers as a part of a planned fertility program. Use of foliar fertilizer materials by small plants is insignificant, because of limited leaf area for absorption. Use of foliar fertilization on large plants seldom will satisfy nutrient needs of the plant. Most if not all nutrients that will be used by the crop can only be supplied by bulk dry or liquid materials.

- **Availability of most nutrients** depends on soil pH.
- **Use split applications of nitrogen for best crop utilization** – pre-plant and before first bloom.
- **Consider the impact of the previous crop's residue on nitrogen application.** In many cases, increasing nitrogen rates is advisable to allow for nitrogen used to decompose the residue.
- **Fast-fruiting varieties show potassium deficiencies more readily.**
- **Analyze animal-manure fertilizer to match crop needs by field.** Soil pH and utilization of phosphorus and other nutrients are the most affected by manure.
- **Nitrogen and potassium uptake is best with healthy roots,** which can be adversely affected by weather, nematodes, seedling diseases, deep sand, and other soil deficiencies.
- **Foliar-applied nutrients rarely correct deficiencies and generally are much less cost-effective than soil-applied fertilizers.** Soil test for macronutrients and micronutrients and follow Extension recommendations.

Factors to consider:

- Healthy root development and utilization of residual nitrogen deep in the soil profile are important in cost-efficient crop production. Fertilizer residual can suddenly become excessive when nematodes are controlled, resulting in rank growth and an increased need for plant growth regulators.
- Foliar feeding will rarely, if ever, correct a nutrient deficiency. Nutrient-deficient plants are inefficient at uptake, translocation, and use of foliar-applied nutrients. Foliar feeding would be considered a salvage tool, but is no substitute for soil-applied nutrients and trace elements prior to planting.
- A lack of root system development can be a result of weather, nematodes, and seedling diseases, and will negatively impact utilization of fertility.

Insect Pest
Management

Following *The First Forty Days* model can reduce insect pest carryover – including *Lygus spp.*, spider mites, and cotton aphids – during the early stage of *Fruiting to Finish*. *The First Forty Days* is critical for many reasons, but the balance of the season also is important for maintaining optimum yield potential and protecting the crop from insect and mite pests. One example of this relationship can be observed with side-dress applications of Temik for nematode control, which can contribute additional insect control value by reducing problems with plant bugs, spider mites, and other pests during *Fruiting to Finish*. The use of residual insecticides minimizes the need for foliar applications, particularly in Bt cotton varieties.

Each year, many unwarranted insecticide treatments are applied to cotton. Unfortunately, these wasted applications increase variable input costs, flare secondary pests, and contribute to insecticide resistance. Resistance reduces the number of valuable insecticides available to farmers. To preserve the diversity of available insecticides and acaricides, and to ensure the most cost-effective crop, growers and consultants are encouraged to determine insecticide application needs using sampling protocols and action thresholds published in Extension Insect Control Guides within their respective states.

Optimum square retention is crucial prior to bloom, and can require intense insect pest control. In many ways, the most effective fruiting period is the first three to four weeks of flowering. This also is the time when many of the primary pests, such as *Heliothines* and *Lygus*, become major factors in cotton insect pest management. Proper scouting methods and attention to established action thresholds are essential during this period to avoid misuse or overuse of pesticide applications. Product overuse or mistimed applications can flare secondary pests, induce insecticide resistance, and decrease economic yields. Action thresholds currently are being updated in each state to accommodate Bt cotton-stacked traits and novel insecticides.

Thorough coverage of the crop with insecticide applications is important, but so are the limitations of new insecticides. Many of the new products not only require more time for pest mortality, but they also have a more limited spectrum of control compared to the older products, such as organophosphates and carbamates.

Criteria for success in controlling insects and mite pests during this period:

- Proper crop monitoring;
- Preserving populations of beneficial insects;
- Avoiding unnecessary applications of all insecticides;
- Using recommended label rates (do not reduce rates);
- Timing applications of insecticides based on action thresholds and recommended scouting protocols;
- Optimizing coverage with proper volume, tips, pressure, and nozzle configuration; and
- Practicing class-to-class rotation of insecticides for insect resistance management.

Insect Pest

Management



Recognize the potential relationship and contribution of alternate crops and native hosts to pest and natural enemy populations in cotton fields. Manage vegetative growth around cotton fields and consider crops adjacent to cotton fields as sources for insect pests and natural predators.

- **Manage insects in alternate weed hosts and crop refuse** by providing border herbicide applications for broadleaf weeds or selective insecticide treatments, following label guidelines. Be particularly careful to avoid drift or runoff to nearby streams, creeks, bayous, or waterways.
- **Match the scouting protocols to the technology and region,** dependent on specific pests.
- **Maintain traps to track flights and presence of moths and potential *Heliothine* problems.**

Action thresholds (to initiate treatment) change during the season and depend on the interactions of crop development stages, yield potential, insect pest complex, and recommended products. Refer to action threshold recommendations published by your state's Cooperative Extension Service.

- **Use insecticides at recommended rates on specific target stages before economic injury has occurred.** The doses of insecticides recommended in Extension Guidelines are the minimum levels that will provide satisfactory control.
- **Many recommended insecticides have labels that restrict the total active ingredient per acre per season.** Using products when they are not needed reduces producers' options for late-season pest problems.
- **Product misuse may induce pests such as spider mites and cotton aphids.** A combination of narrow-spectrum insecticides may be necessary where the potential for flaring insect or spider mite pests is high.
- **Using products when they are not needed just adds to input costs.** When pest populations are not at action levels high enough to trigger insecticide applications, no economic yield loss is occurring. Mistimed insecticide applications only add to overall production costs.
- **Insecticidal traits (Bt) in varieties do not perform equally in varying environments.** Varietal selection and local crop conditions can affect scouting and insect control plans. Limitations of transgenic traits could influence pest priority, detection methods, and action thresholds. Pest occurrence and Bt efficacies of commercial transgenic cultivars vary regionally. Each trait has the potential of requiring a slightly different pest management strategy.
- **Bollworm usually is a primary pest in both Bt and non-Bt cotton.** This insect usually is the most common Lepidopteran pest found within and across regions, injuring cotton and requiring supplemental control measures during mid to late season. Armyworms and loopers generally are more localized problems during this time of the season.




Disease
Management

During the *Fruiting to Finish* period of cotton growth, boll rots, foliar leaf spots, *Fusarium wilt*, and Verticillium wilt are the primary diseases encountered, in addition to continued nematode parasitization.

There are few disease management options for these diseases during the *Fruiting to Finish* period. Implementing proper BMPs during *The First 40 Days* is important in reducing disease incidence and severity. Healthy, vigorous plants will sustain lower disease losses.

Boll rots are encouraged by rank, vegetative growth. Excessive nitrogen and irrigation promotes rank growth that will increase their incidence. Proper fertility, particularly nitrogen fertilization, and irrigation management, will reduce the severity of boll rots. If conditions are conducive to rank growth, proper application of PGRs can help to control growth and reduce their potential. In areas of higher incidence, consider wider rows. Controlling insects that feed on bolls will also reduce boll rots.

Many late-season foliar diseases are associated with poor fertility, especially potassium deficiencies, and moisture stress. Make sure fertility is adequate, and when possible irrigate to avoid moisture stress.

Fusarium and *Verticillium* wilt diseases are difficult to manage during the season, but proper fertility can reduce the incidence and severity of wilt diseases. Excessive nitrogen fertilizers tend to increase wilt diseases, while potassium tends to reduce the incidence of wilt.

Incidence and severity of *Fusarium* wilt is greater in the presence of the root-knot nematode. Planting cotton cultivars that have resistance to the nematode and applying nematicides will reduce *Fusarium* wilt.

During *Fruiting to Finish*, management of fertility – particularly adequate availability of potassium and avoiding excessive nitrogen – and irrigation are the best means to avoid disease losses. DO NOT harvest diseased fields for seed.

Water
Management and Irrigation

Although the environment, soil types, and other factors must be considered across a diverse Cotton Belt, the one common denominator is that a cotton crop needs ample moisture throughout the growing season. This can come from rainfall, supplemental irrigation, or full irrigation.

Avoidance of water-deficit stress beginning at first square is critical in establishing adequate plant structure to facilitate yield goals, especially with early-maturing varieties grown in northern locations with a limited growing season. Begin early bloom at or near field capacity and maintain adequate water supplies at least through cutout by constantly monitoring crop water use and soil moisture conditions, and by irrigating before the crop stresses.

Monitor plant growth, fruiting, and soil moisture to ensure adequate moisture from early squaring to avoid plant stress. Initiate irrigation prior to first square, if needed.

- **Node development is the best evaluation.**
- **The fruiting period is critical for water.**
- **Moisture should be at or near field capacity at first bloom.**
- **Terminate irrigation when adequate water is available at 500 heat units past cutout.**

Primary Factors:

- Water quality is very important.
- Monitor node development to evaluate stress.
- Optimum drainage is important – linked to irrigation practices.
- Don't delay irrigation; be timely.
- A replacement range of 70 to 75 percent of evapotranspiration is optimum in the Southwest.
- Plant with adequate moisture in the soil profile.
- With supplemental irrigation using LEPA (Low Energy Precision Application) systems in the Southwest, it is critical to start with a relatively full moisture profile in the soil.
- Maintain a minimal amount of stress on the crop through first open boll.
- Manage possible weed flushes after furrow-irrigation.
- Once the crop starts squaring, do not let it stress. A wilted plant indicates too much stress.
- Hot spots in fields can be used as a diagnostic indicator to initiate irrigation, although they also might indicate the irrigation may be too late.
- Use soil probes to monitor soil moisture.
- Monitor weed populations closely after flushing a furrow-irrigated cotton field. New weed flushes and the breakdown of residual herbicides could require post-emergent herbicide applications.

Check out state Extension guidelines to assist in irrigation planning and scheduling.

Plant Growth
Regulation

Plant growth regulators (PGR) discussed in this paper are limited to chemicals applied to cotton that contain mepiquat chloride or related products. They are useful as management tools to limit rank, vegetative growth and to help produce a compact, more manageable plant. Several products are marketed as PGRs, but only those containing mepiquat have shown to have a repeatable, beneficial impact on cotton growth and development. Each year, many dollars are essentially wasted on products that claim PGR properties, but that have little or no impact on growth, development, or yield.

The best PGR is a good fruit load. In many cases, higher organic soils, too much nitrogen, and early-season stresses from diseases and insects can result in increased vegetative growth. The BMPs from *The First Forty Days* are valuable in maintaining a stress-free crop in a fruiting mode.

The number one goal of PGR use is to manage plant height and fruit retention, not to increase yield, although yield increases can be an advantage of PGR use. It's been established in measurement criteria for *Fruiting to Finish* that the optimum crop height would be within 10 percent of row width. It is commonplace in West Texas drip-irrigated cotton for a four- to five-bale crop to be only about 28 inches in height – within 10 percent under a 30-inch row width. In other parts of the Cotton Belt, achieving an optimum yield on cotton that is less than 30 inches in height could be a challenge.

Beginning at the match head square stage, closely monitor plant growth, environmental conditions, and reproductive load; use a PGR as a management tool to restrict rank growth, promote earliness, increase harvest efficiency, and facilitate the deposition of other crop protection products.

Start PGR applications at 9 to 10 nodes – with a height-to-node ratio of no less than 2 on cotton that's stress-free and well-fertilized.

Use variable rates of a PGR to optimize crop performance, particularly in fields of varying soil types, seedling disease pressure, and other stresses.

On larger cotton that's closer to bloom, base PGR applications on internode length. The threshold for the PGR application would be an internode length of 2.5 inches or more on the longest of the third or fourth internodes from the terminal.

- **PGR applications should be made ahead of the growth curve, to more effectively manage vegetative growth.** Mepiquat will not shrink cotton plants; it will only restrict vegetative growth after application.
- **Monitor the crop for growth, square size, and fruit retention** when scouting for insects. Do not base PGR applications on calendar dates.
- **Based on the environment,** determine need, timing, and rate to control size of the plant.
- **Use the height-to-node ratio or internode length** as measurement tools and follow the PGR label guidelines.
- **Avoid high rates of any PGR prior to blooming** to minimize the potentially negative impact of high plant concentrations of PGRs, in case an extended period of less-than-favorable growing conditions occurs.
- **PGR applications during flowering stages require higher rates.** More product generally is required to reach required plant concentrations to achieve desired results.
- **Applications after cutout are not recommended.**
- **Significant varietal differences can exist for vegetative growth;** follow recommendations by variety.
- **Use a conservative application on moisture-stressed or dryland cotton** – delaying applications may be wise.
- **First position square retention of 70 to 80 percent during the season is optimum.** By season-end, the goal is a minimum of 50 to 60 percent boll retention, equally distributed up and down the plant.
- **Proper management of rank growth positively affects fiber quality of a crop** by enhancing the retention of a higher percentage of first position bolls and by contributing to reduced boll rot.

Primary Factors:

- Know the variety and its growth habits. Some irrigated varieties, for instance, can be handled much more aggressively than others.
- Know and understand the history and capacity of soils to produce excessive growth.
- Consider the total nitrogen available to the crop and the amount yet to be applied.
- Poor root systems resulting from environmental stresses and nematodes generally do not have excessive growth problems.

Harvest
Management

Harvest management efficiency, whether picking or stripping a crop, starts during *The First Forty Days* with a healthy, stress-free, uniform crop, but management during *Fruiting to Finish* is important as well. Fertility, water management, weed control, and other factors definitely have an impact on cost-effectiveness of a harvest aids program.

Defoliate as early as possible by balancing the realistic yield potential of the crop with the need to preserve quality, schedule harvest equipment, and minimize losses from weathering.

The bottom line for growers is simple: Harvest as early as possible to minimize environmental risks without sacrificing yield or lint quality.

To determine the correct timing for defoliation, dissect the uppermost harvestable bolls and check seeds for maturity. Mature seeds feature dark or black seed coats and would indicate that the crop is ready for defoliation.

Gauge crop maturity to schedule harvest aids timing to:

- Preserve yield and lint quality in the field by facilitating timely harvest scheduling;
- Optimize picker/stripper efficiency and capacity;
- Prevent bale contamination; and
- Manage micronaire. Defoliation timing represents the last opportunity a grower will have to influence micronaire and possibly avoid discounts.

Achieve the best defoliation possible by using a combination of herbicidal and hormonal-type defoliants, coupled with a boll opener, for a quick, clean harvest that preserves both lint yield and quality.

The two primary categories of harvest aids, hormonal and herbicidal, provide a broad range of results. Hormonal products generally fall into the categories of defoliant or boll opener. As a general rule, hormonal products tend to be more temperature-sensitive than herbicidal defoliants. Increasing rates of herbicidal products, in turn, makes them desiccants

Select chemistries and rates appropriate to the local field environment and crop condition.

- Use previous experience and confidence in treatments.
- Consider weather forecasts when selecting treatments. Some treatments are more temperature-sensitive than others.
- Consider yield and fiber quality potential of the field.
- Take note of current-season results in similar fields.
- Consider the need for and availability of technical support and service from manu facturer sales and technical service personnel.

Consider the desired result:

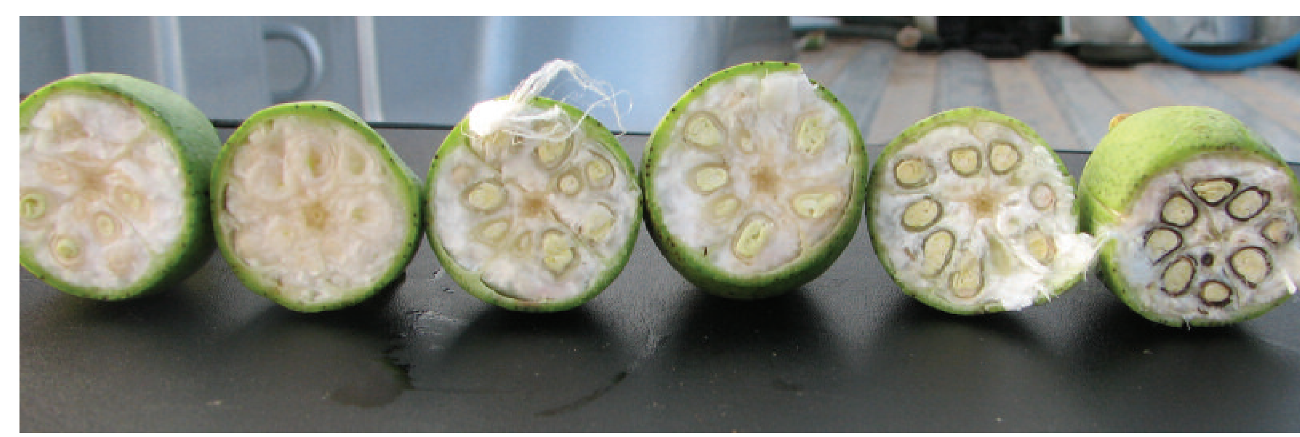
- Defoliation or desiccation (picker or stripper, respectively);
- Desiccation of weeds;
- Removal of mature leaves versus juvenile leaves;
- Regrowth inhibition;
- Boll opening; and
- Harvest schedule.

Post-harvest, proper and effective turn-row management protects yield and fiber quality.

- Construct tightly packed modules.
- Use watertight tarps that are well-anchored against wind and weather. The National Cotton Council reports a $400-per-module savings for proper tarping to protect seed cotton in the presence of adverse environmental conditions.
- Place modules in a high, well-drained area.
- Manage against lint contamination from foreign material.

Primary Factors:

- "Unsliceable" bolls are a proven method to define last harvestable bolls. Perhaps a better indicator is seed maturity. Mature seed in the uppermost harvestable boll would feature a dark or black seed coat.
- Optimum timing for crop maturity may be considered as 4 to 6 mainstem nodes above a first-position cracked boll – up to the last boll you expect to pick.
- Harvest-aid chemicals cannot increase the rate of fiber development.
- Grow varieties that tend to produce premium micronaire.
- Chemistry selection is very important – consider interactions.
- Pick when the last "harvestable" boll is open – 95 percent or an "acceptable" level.
- Consider the condition of plant and environmental factors, including residual nitrogen, rainfall, irrigation, and field history.
- Ethephon can help open bolls.
- Target 60-70 percent open bolls for harvest aids applications to maximize yield and fiber quality. On high micronaire varieties, target 50 percent open bolls to minimize discounts.
- Most cotton crops are produced on a 10- to12-node range on the plant. Use this rule of thumb to avoid waiting too long on "phantom bolls" – which are at the top of the plant and contribute little to total yield.
- Problem weeds can be managed at this stage.
- Avoid leaf desiccation in cotton to be harvested with a picker.



Seeds ranging from immature to mature stages.

Pesticide Applications

and Spray Technology

The most expensive application made is one that fails to reach the target in a timely and efficacious state. Careful consideration should be given to accurate mixing of pesticides in the spray tank and calibration of the sprayer.

For insecticides, harvest aids, and some herbicides, thorough spray coverage is of critical importance; applications should be made with a minimum of 10 GPA by ground and 5 GPA by air, using appropriate nozzles.

For glyphosate and other herbicides that do not require thorough spray coverage, drift-reducing nozzles should be used to minimize off-target movement.

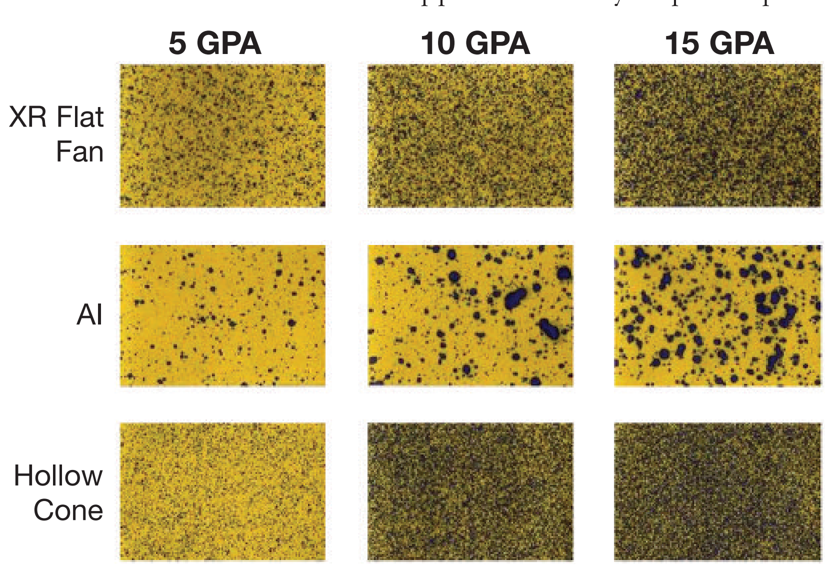
- **Use application-specific nozzles, pressure, and spray volume for uniform pattern** (follow manufacturer specifications).

For ground application:

- Flat fans for fungicides;
- Hollow cone for insecticides; and
- Flat fans for herbicides.

Select the proper equipment to get the best coverage. One nozzle is not workable for all targets. Cost of tips is insignificant compared to the investment of inputs. For example, a turret nozzle can be changed quickly to properly match the product to be applied.

- **Reduce ground speed** to ensure better coverage.
- **Don't spray when wind is greater than 10 mph.** Droplets less than 200 microns will drift. Drift minimization is paramount, both for the cost-effectiveness of the application and because of the potential liability of an off-target application
- **Monitor wind direction.** For both ground and aerial spraying, it is likely some pesticide drift will occur; always make the wind work in your favor. Be sure the wind is blowing away from sensitive targets, such as houses, buildings, and sensitive crops.
- **Pay attention to weather patterns.** Most products are not rainfast immediately after application. They require a period of time to dry or to be absorbed into the plant. For many contact insecticides, residual efficacy is severely limited by rainfall, even if the spray has been allowed to remain on the plant for several hours. Some applications must be re-done after a wash-off, if satisfactory performance is expected.
- **Follow pesticide label requirements.** The application guidelines for optimum performance of a product are described in detail on the label. Deviation from these procedures could greatly reduce product efficacy.



Courtesy LSU AgCenter

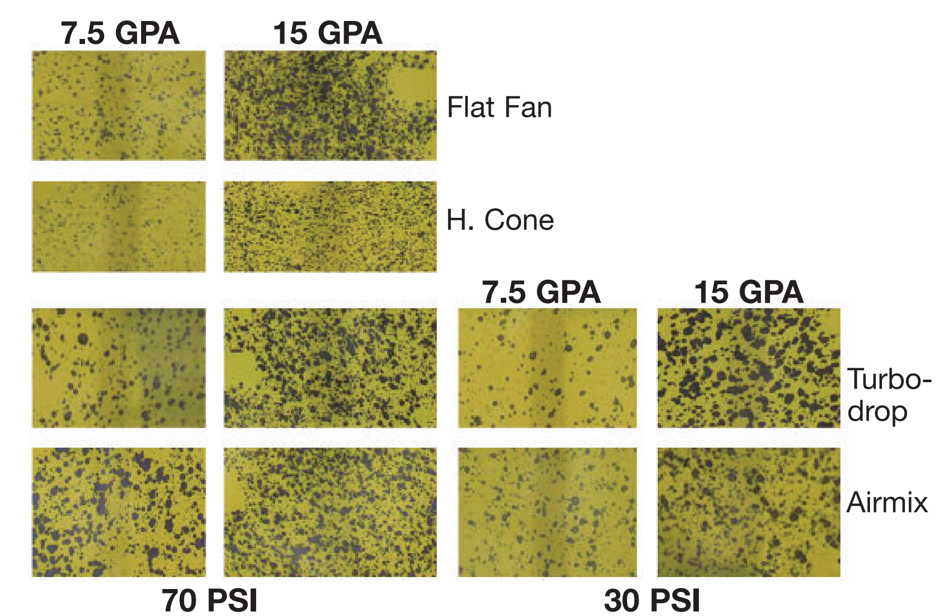
Primary Factors:

- Follow label guidelines for application rates.
- Coverage and droplet size by crop protection product are critical to overall efficacy.
- Calibrate sprayers at the beginning of each season and after equipment modifications. Adjust water quality to maximize effectiveness of crop protection inputs. Know the pH of the water.
- Adjust pressure, nozzle configuration, and boom height for optimum coverage.
- Variable-rate technologies are integral for economics and efficiency.
- Follow label directions to ensure tankmix compatibility.
- Multiple target applications need specific techniques for:
  - Timing of application for target;
  - Calibration and recalibration;
  - Sanitation and cleaning of applicators; and
  - Application immediately upon mixing.

Evaluating Post-Treatment Performance

Evaluating the performance of any crop input can improve crop production efficiency and cost-effectiveness. The evaluation process should focus on the efficacy of the application and desired result, whether evaluating a specific product or the accuracy of delivering the product to the target.

- Do not expect immediate results. Pesticide performance usually will be optimal 2 to 10 days after application.
- Retreatment may be needed.
- Always evaluate performance before triggering the next treatment.
- Recognize the potential of wash-off and losing residual activity after rainfall.



Courtesy LSU AgCenter

Research
and Development Needs

The future of agriculture depends on continued research and development in both public and private sectors. It's critically important to push for advances in crop production technology, varieties with higher quality fiber, and other developments that benefit the grower. Research-based companies and Land-Grant institutions must work together in this effort. Specific to the BMPs discussed in *The First Forty Days* and *Fruiting to Finish* Workshops, the participants identified the following needs:

- More economic analyses of crop production systems are needed. One example is the University of Arkansas Farm Enterprise model.
- Verification trials of BMPs in commercial fields with consultants and growers.
  - Use as awareness and training tools.
  - Promote through "coffee shop" comparisons.
  - Economic and yield comparisons to farm and state averages.
  - Training tools for Extension agents and consultants.
- Potential for site-specific management within fields (nematodes, fertility, herbicide, growth regulator, and defoliant applications).
- National protocol for seed treatment research to facilitate accurate interpretation of results.
  - Set treatments for Beltwide data, and
  - Ensure seed lot consistency.
- Facilitate the rapid development of crop production/crop protection products through cooperation and collaboration with the agro-chemistry industry and the commercial cotton industry.

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