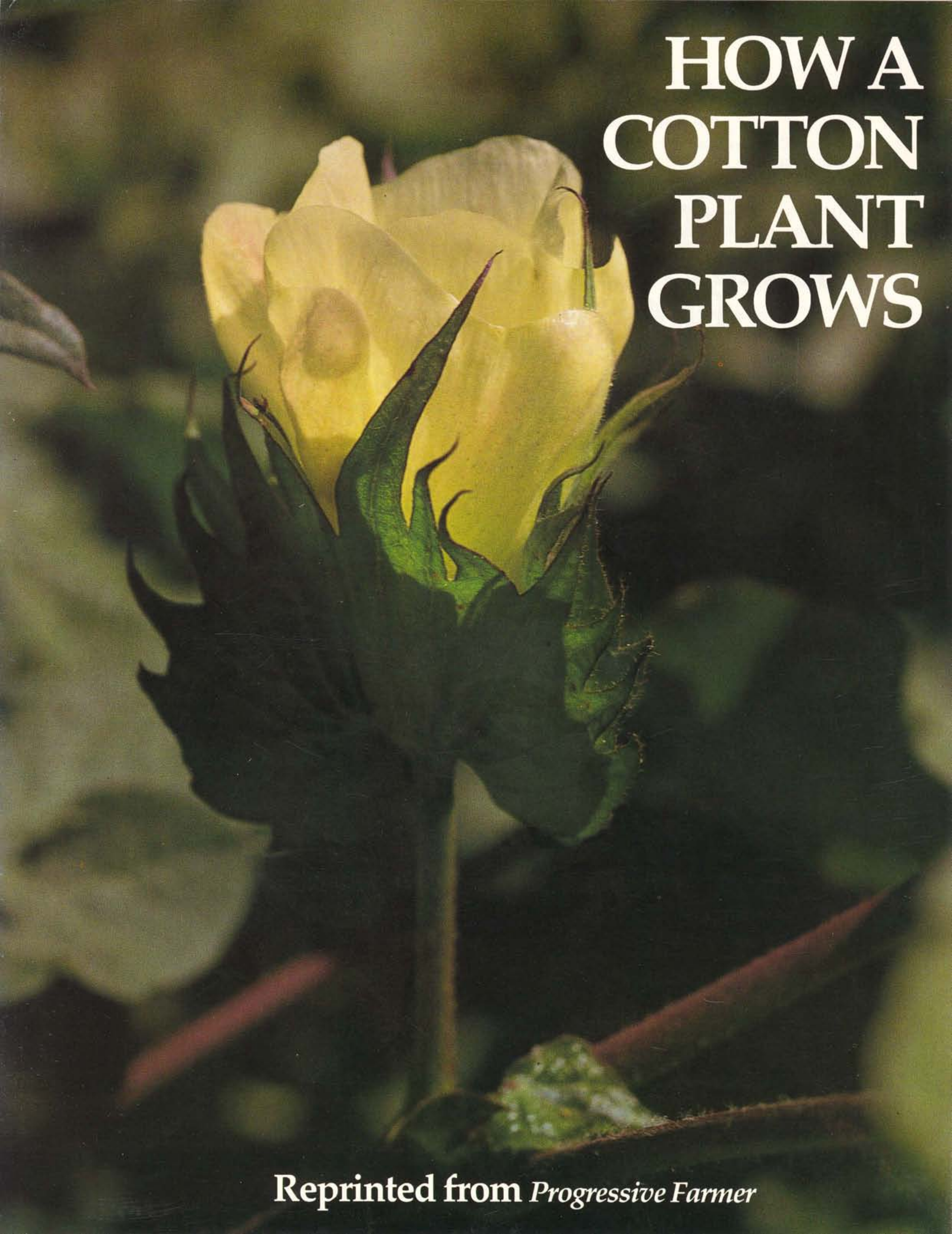
HOW A COTTON PLANT GROWS



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How a Cotton Plant Grows

Photo: Beth Maynor

A cottonseed can be likened to a bomb. However, when that small seed explodes into life, it brings not death and destruction, but food and fiber.

Only days after a sleeping cottonseed is planted, it awakens to become a wonder plant. In addition to producing food protein, it offers fibers that can be spun into fabric that's tough enough to withstand fire, wind, and water—or that's as soft as the wing of a butterfly. Ancient records from India tell of cotton fabrics so delicate that they were described as "webs of woven wind."

Man has taken the cotton plant for granted, enjoying its benefits without fully understanding its growth.

Now, scientists are closely examining the amazing cotton plant to help this unusual crop produce more food and fiber.

In a series of articles to be published in *Progressive Farmer*'s Cotton Special Sections, we will take you on a fascinating journey through the life cycle of a cotton plant. We believe that when you have a better understanding of how a cotton plant grows, you will be able to use more efficient management practices and create a better environment for high yields. The result should be a crop that works more efficiently for you—and for mankind.

Seed Germination and Seedling Emergence

If we had X-ray vision and could peer inside the sleeping cottonseed, we could see there all of the essential parts that form the mature plant.

We could see the two well developed cotyledons that will form the seed leaves that will manufacture food for the young seedling. Located between the cotyledons are the epicotyl (the shoot that will form the main stem), the hypocotyl (later to form the "crook"), and the radicle (from which will spring the roots).

These tiny parts make up the embryo or kernel. It lies quietly within the protective confines of the tough seedcoat, poised like a tiny missile waiting to be launched from its underground silo.

Finally, the seed is placed in the ground and the miracle of the birth of a new plant waits to be performed. Moisture from the surrounding soil seeps through the chalaza, an area of specialized cells at the broad end of the seed. The path of the water follows the tissue around the embryo to the radicle cap at the narrow end of the seed.

As it moves, the water massages the tiny cells, softens and penetrates the tissues, and triggers a blitz of reactions. By now, moisture is oozing through all parts of the seedcoat, and the swollen embryo appears ready to burst.

The primary root begins to form from the radicle cap. As it expands, it forces its way through the tiny opening at the pointed end (micropyle) of the seedcoat and pushes downward into the soil.

At the same time, the hypocotyl has begun to stretch and forms an arch or crook near the cotyledons. As it rapidly becomes longer, it rams the cotyledons and the epicotyl (shoot) through the soil surface. The protective seedcoat, no longer needed, is discarded much as an emerging butterfly sheds its cocoon. This permits the crook to straighten up and lift the cotyledons above the surface of the soil. Exposed to light, the newly unfurled seed leaves turn green and begin to manufacture food—a short-term function that

they will perform until the true leaves take over.

Soon the bud above the cotyledons enlarges and unfolds to form the stem. The true leaves and branches will develop there.

Under favorable conditions, seedlings emerge 5 to 15 days after the seed are planted. Temperatures below 60°F will slow germination, emergence, and seedling growth. During the first 60 to 100 hours of germination, the radicle tip is easily damaged by chilling, lack of oxygen in the soil, or too much moisture. If the tip is killed, a shallow system of secondary roots develops that makes the plant more subject to moisture stress later in the season.

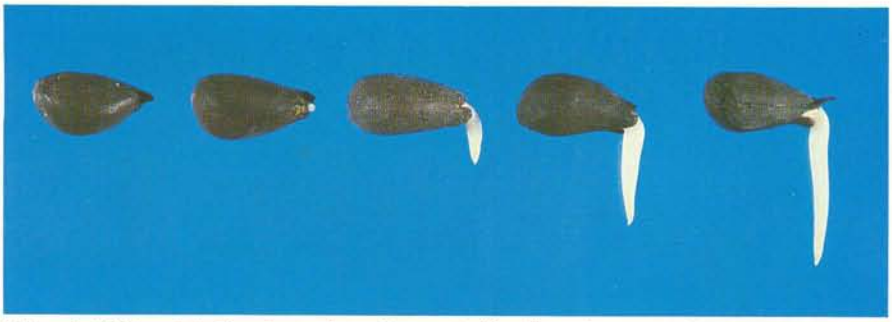
Thus cotton specialists generally recommend that you wait to plant until soil temperatures at seed depth are at 63° to 65°F or above at 8 a.m. This cuts the time needed for germination and seedling emergence and helps to ensure healthy, uniform stands.

It also is important to use high-quality seed and plant in a smooth, well prepared seedbed with adequate moisture. Seed should be planted at a depth of 1 to 2½ inches, depending on soil type and availability of moisture. It is better to delay planting than to plant seed too deep in the search for moisture.

Seed germination and seedling emergence are the foundation of your total crop. Understanding these activities will help you to lay the groundwork for a vigorous crop.

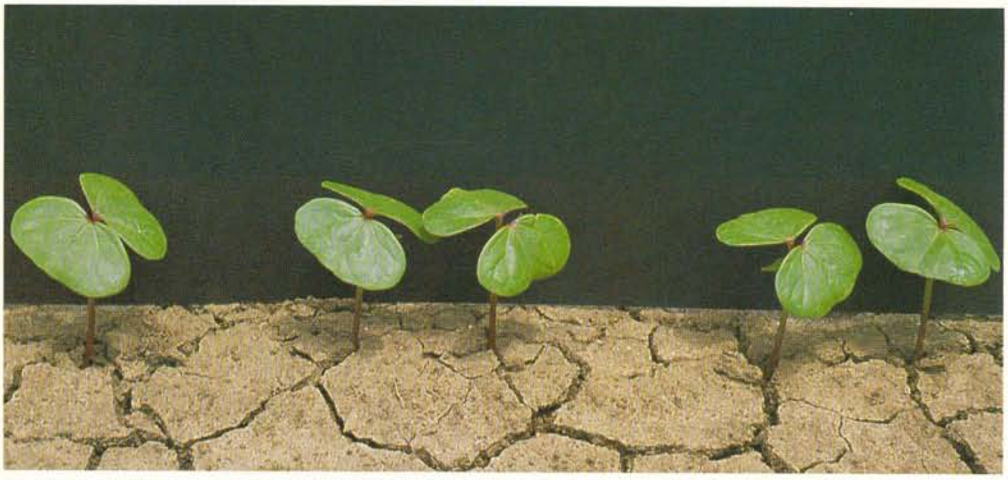
Produced by DEL DETERLING with DR. KAMAL EL-ZIK; photographs by BOBBE BAKER

Editor's note.—Dr. El-Zik is a research scientist with the Department of Plant Sciences at Texas A&M. Bobbe Baker is a professional freelance photographer who is doing graduate work at Texas A&M.



(Above) Moisture lets the dormant seed come to life. The primary root begins to form and expand, forcing its way through the seedcoat and pushing downward into the soil.

(Right) Closeup shows the primary parts of the germinating seed. As the radicle stretches downward to form the root system, the hypocotyl (crook) pushes the cotyledons upward through the soil surface. As the cotyledons expand, the protective seedcoat is shed, usually before emergence occurs.



(Left) Like a tiny David—but with the strength of a mighty Samson—the fragile seedling shoulders aside a volume of dirt hundreds of times its own weight to break through the soil crust.

(Above) Once seedlings have pushed above the soil surface, the cotyledons unfurl and begin to manufacture plant food until the true leaves emerge.

Why Getting a Stand Is So Important

Insects and weeds may be the visible enemies of a good cotton crop, but what you do at planting time is even more important. The potential of a cotton crop is determined in the first 30 to 40 days after you put seed into the ground. Everything that occurs after you get a stand can only maintain or decrease yields.

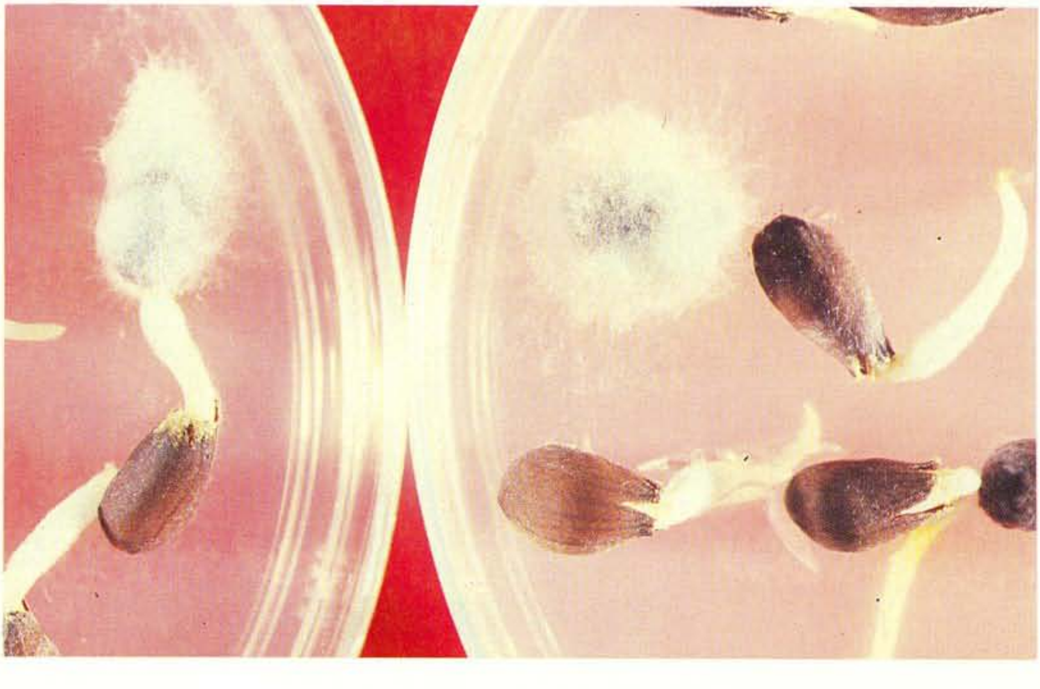
A "good stand" refers to the number of healthy, vigorous seedlings that are evenly distributed in the field. This may be 1 to 4 plants per foot of row depending on soil type, row width, planting date, and moisture during the growing season.

Getting a stand is like walking through a minefield. Many factors—by themselves or in combination—can boobytrap your efforts. Included are such things as improper seedbed preparation, low soil temperature, planting too shallow or too deep, soil compaction, too much or too little moisture, chemical injury, high winds and blowing sand, insects and diseases, and low seed quality.

Actually, seed quality should be listed first. Poor planting seed are the chief cause of stand failure. Anything bad that is lurking in the environment of the germinating seed is doubly damaging if seed are damaged or decaying. If the seedling comes up at all, it is poorly equipped to withstand the bombardments of diseases, insects, wind, and weather, including moisture stress and heat later in the season.

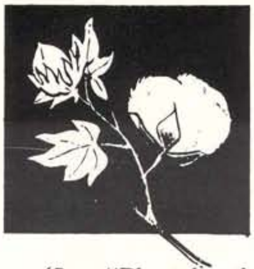
For that reason, you should use only seed that have a germination percentage of 85% or higher and that have passed a cold or vigor test.

Cotton should be planted in well prepared seedbeds that are firm, warm, and moist. Planting should be based on soil temperature and the weather outlook for a month after planting. Specialists generally recommend that you plant only after soil temperatures at seed depth average 65°F or higher at 8 a.m. several days



(Above) Your first goal: To get a healthy, vigorous, uniform stand.

(Right) Here's where a good stand starts—with high-quality seed. Micro-organisms in the soil and on and in the seed can cause seed rot or decay. Note visible mold growth on rotted seed in center.



in a row. (See "Plant by the Thermometer, Not by the Calendar," page Cotton-5.) Weather outlook is important because rain and cool temperatures following planting can slow germination and reduce stands.

Your next hurdle is getting the seedlings past a host of problems that are waiting to pounce on the tender young plants as they poke up through the soil.

The same factors that delay germination and seedling growth encourage seedling disease and insect problems.

The first enemy they are likely to encounter is the seedling disease complex made up of one or more soilborne fungi.

You may know these seedling diseases by more familiar names: pregermination decay or seed rot; seedling rot; preemergence damping-off; and postemergence damping-off or sore shin.

Don't plant seed too deep in soils that are overly wet, cold, compacted, or high in chemical concentrations. It's important to place herbicides and fertilizers just right to reduce direct contact with seed and seedlings and to avoid root pruning.

Treating planting seed with protectant fungicides often helps ward off seedling diseases.

You also need to be on the lookout for early season insects such as thrips, cutworms, leafminers, and aphids. Seed treatments, in-furrow applications of fungicides and systemic insecticides (if needed), and foliar pesticides applied at low rates cost only a few dollars per acre. But they can more than pay for themselves in helping get your crop off to a quick, trouble-free start.

Produced by ***DEL DETERLING*** *with*
DR. KAMAL M. EL-ZIK,
photos by ***BOBBE BAKER***

Editor's note.—Dr. El-Zik is research scientist with the Department of Plant Sciences at Texas A&M. Bobbe Baker is a professional freelance photographer who is doing graduate work at Texas A&M.

(Right) Early plant growth is slowed by excessive concentrations of preemergence herbicides in the seed and root zone and by over-the-top treatments with some postemergence chemicals. Symptoms include loss of green color and speckling or mottling of the leaves.

(Above) Normal, healthy taproot on left contrasts sharply with those of diseased seedlings. Girdling and decay of roots on plants second from left and at far right are signs of seedling root rot. Lesions on the plant second from right show early symptoms of postemergence damping-off or sore shin.

(Left) Thrips distort and crinkle seed leaves (left leaf), slowing down early growth of the plant. This complicates postemergence weed control and may delay fruiting and crop maturity. Leafminer (right leaf) seldom does economic damage. Beneficial ladybug (center) feeds on eggs and small larvae of damaging insects.

(Left) Rain shortly after seedling emergence and cool temperatures often stimulate fungi that cause postemergence damping-off. Seedlings are stunted, then they wilt and often die, leading to skimpy stands.

HOW A COTTON PLANT GROWS

Building the Framework–Roots, Stem, and Leaves

Deep inside the cotton plant is an invisible computer that directs the architecture of the plant and engineers its response to the environment.

Throughout its lifespan, the plant is constantly manufacturing new, specialized cells to form the organs that carry out growth and reproduction. The four organs are the roots, stem, leaves, and fruits (squares, flowers, and bolls).

Root System

The roots are both the anchor and the life-support artery of the plant. They form the foundation that holds the plant firmly in place, and they channel moisture and dissolved nutrients from below the ground to the manufacturing system above.

The cotton plant has a primary (or main) taproot with many branches or with lateral roots. The taproot grows downward for several days without branching. It may reach a depth of 9 inches by the time the cotyledons (seed leaves) have emerged from the soil. Branching of the taproot begins about the time that the seedling straightens up and the seed leaves begin to unfurl.

Soil type and texture, moisture, and aeration determine how deep taproots penetrate. A few will grow as deep as 8 feet. Normally, however, about half of the total root length is confined to the top 2 feet of soil.

The mass of roots, large and small, that branch from the taproot make up the main absorption and anchoring structure of the cotton plant. Their distribution depends on a combination of weather, plant, and soil factors. Roots grow most rapidly when there is enough, but not too much, moisture; when there are no compacted soil layers; and when other environmental conditions are ideal for plant growth.

Tillage operations, proper use of fertilizers, and irrigation can improve conditions for healthy root development.

The basic root system normally is in place by the time the plant begins blooming, or by about 8 to 10 weeks after planting.

Stem

If the roots are the foundation of the plant, the stem is the framework that supports the vegetative and reproductive organs. It also serves as the plumbing system—carrying moisture and minerals from the roots to the leaves, and distributing food to the various parts of the plant.

A fully developed cotton plant has a prominent, erect main stem consisting of a series of nodes (branching points) and internodes (open stalk). The cotyledons are located at the lowest node on opposite sides of the stem. As the plant grows, the internode above the cotyledons extends, and a new node is formed from which the first true leaf unfolds.

This process continues at 3½- to 4-day intervals. A single leaf forms at each node in a spiral arrangement. In American upland cotton, each new leaf commonly develops three-eighths of a turn above the preceding leaf. The course of the spiral may be clockwise or counterclockwise.

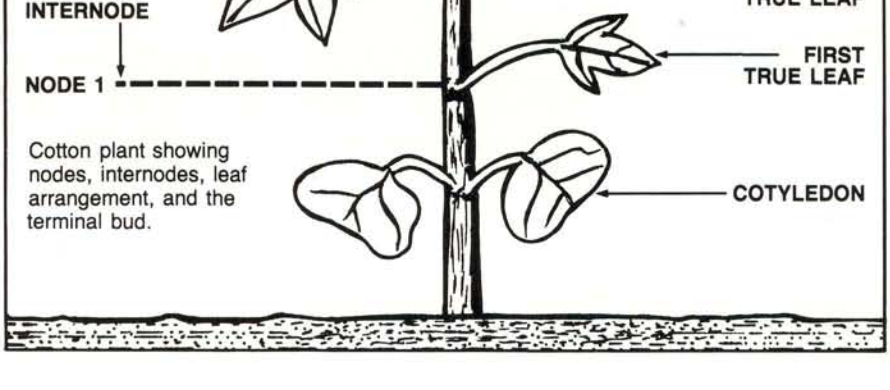
At the center of this growth activity is the terminal bud. It is at the fork of the main stem and the petiole that supports the blade of the top unfolded true leaf.

The terminal bud controls the upward pattern of stem, leaf, and branch development. If it is damaged—by hail, insects, or mechanical operations—the entire growth sequence of the plant is upset. The branch below the terminal bud will take over as the main stem, but it generally is weaker. The branching arrangement of the plant will be irregular, and growth will be delayed.

Leaf System

The leaves are the factory. Through the miracle of photosynthesis, leaves use the fuel of sunlight to convert water, carbon dioxide, and minerals to the sugars, starches, and proteins that the plant needs to survive, grow, and reproduce.

Leaves may vary in size, texture, hairiness, and green color, depending on the variety. However, weather conditions and cultural practices such as fertilization and irrigation management can also influence size, thickness, and color of the leaves.



Cotton plant showing nodes, internodes, leaf arrangement, and the terminal bud.

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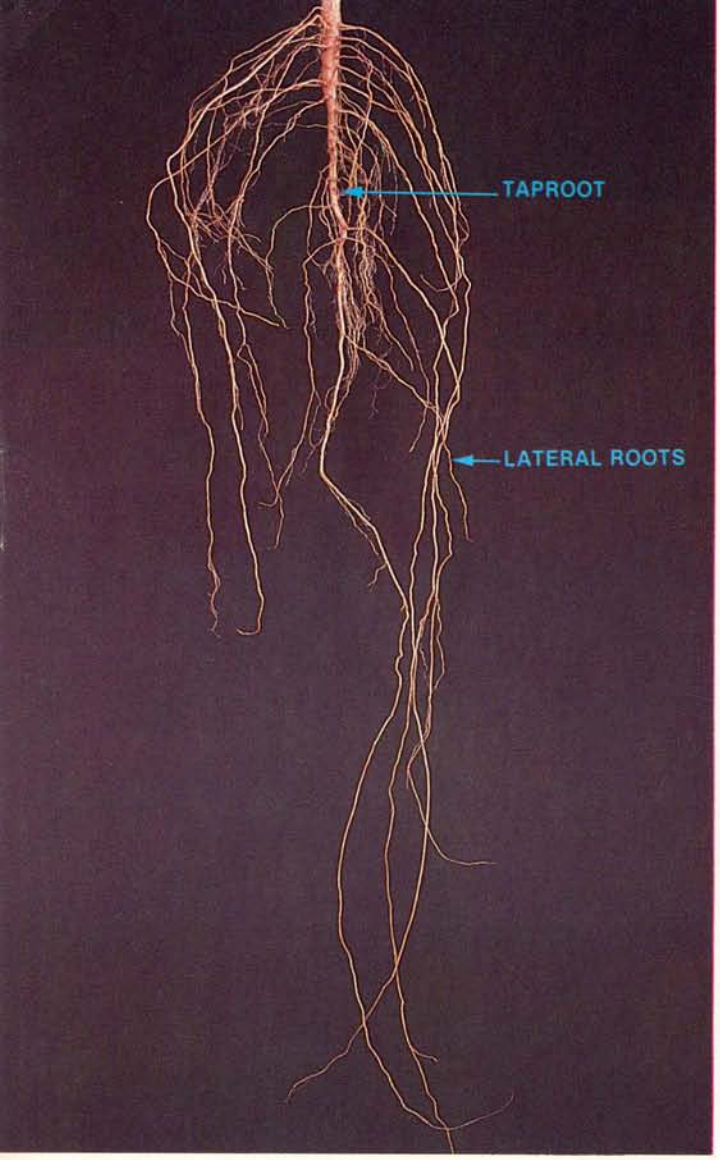
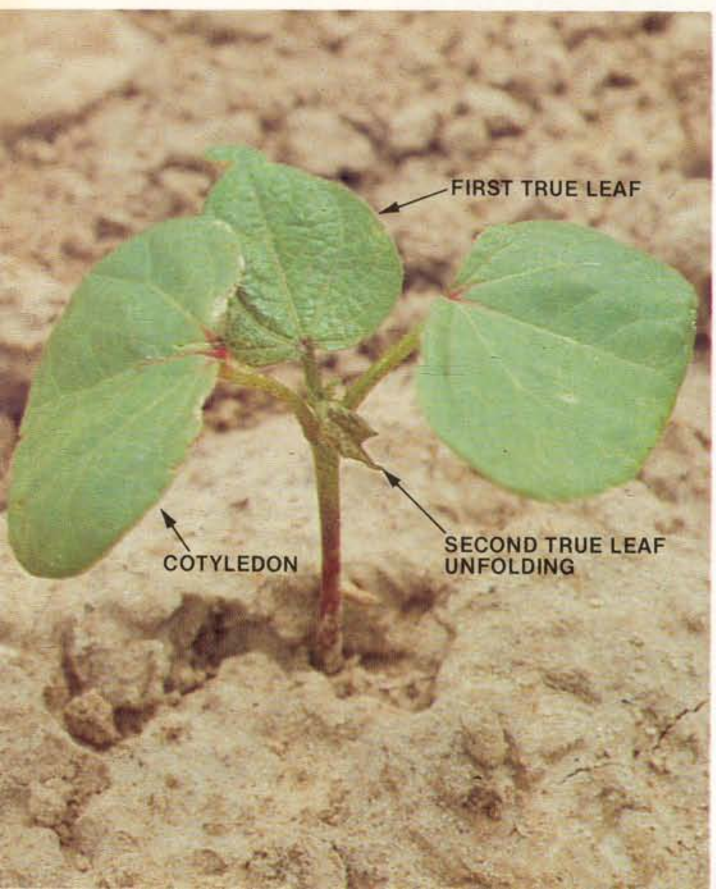


(Left) A healthy system of primary and lateral roots firmly anchors the cotton plant. It also absorbs and ships vital raw materials of water and minerals to the aboveground "plant food factory."

(Below) The terminal bud is the key to plant growth and leaf and branch arrangement. If the bud is damaged, the normal development cycle of the plant is thrown off balance.

(Above) As the plant grows, internodes continue to extend, and new leaves are formed at each node (see sketch). The number and length of internodes, which determine plant height, are influenced by the variety and also by soil type, moisture, nutrients, insects, and diseases.

(Left) The internode (stem) above the seed leaves begins to lengthen about nine days after the seedling emerges, and the first true leaf is formed on the first node (top center). From then on, the second true leaf (center) and succeeding leaves develop at four-day intervals.



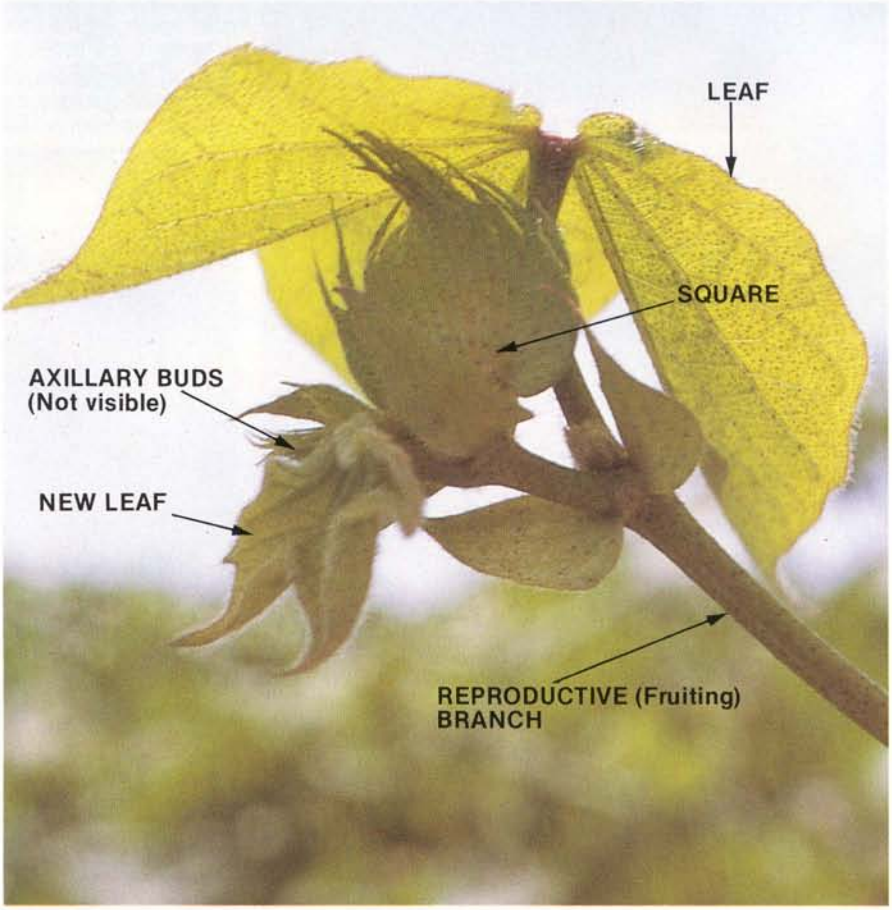
HOW A COTTON PLANT GROWS:

Vegetative and Fruiting Branches

Its basic framework in place—an erect main stem anchored by a solid root system and fed by an efficient factory in the leaves—the cotton plant begins to expand sideways. About four to five weeks after planting, it begins to form vegetative and reproductive (fruiting) branches.

Vegetative branches produce primarily that—vegetation, mostly leaves. A certain number of leaves are necessary to carry out photosynthesis or production of plant food. But too much vegetative growth siphons off valuable energy and food that are needed to produce fruit. It delays your crop and makes pest control and harvest harder. There must be a balance between vegetative and reproductive growth.

A branch develops from a bud formed in the angle between the leaf stem and the main stem node to which the leaf is attached.



Here is the foundation of the reproductive mechanism in cotton. Clearly visible are the fruiting branch, a leaf, a square, and a new leaf. A new bud will form at the junction of the square and the new leaf, starting the process all over again.

Vegetative branches usually develop only at the lower nodes of the main stem (nodes 4 through 8). They grow nearly upright; and like the main stem, each has a single terminal bud at its tip. If the terminal bud of the main stem is damaged by insects or hail, one or more of the vegetative limbs near the tip takes over as the main stem. If the injury occurs early in the plant's development, the entire plant may become bunchy and unproductive. That makes protection of the plant from excessive damage by early season insects very important.

At some point, the plant's "internal computer" signals it to kick into the reproductive phase. Short-season or so-called "Texas" varieties may set the first fruiting branch at the fourth or fifth node. Rain Belt varieties usually form first fruiting limbs at the sixth to eighth node, while Acala and other long-season varieties may not set the first reproductive branch until the eighth node.

In addition to genetic differences, plant population, temperature, and stress also influence the location of the first fruiting branch. Cotton plants growing close together will have fewer vegetative branches and lower fruiting branches than will cotton plants spaced out farther in the row.

Excessive moisture (from rainfall or irrigation) and too much nitrogen early in the plant growth period also will cause the plant to set its first reproductive branch too high on the stem. The higher the first fruiting branch, the longer the plant will take to complete fruiting and to mature its bolls. On the other hand, moisture stress or drouth early in the season can kick the plant into its "survival mode." It will begin setting reproductive branches too low on the stem, thereby also reducing yields.

After the first reproductive branch has formed, new branches will develop every 2½ to 3½ days.

Unlike vegetative branches, fruiting limbs do not have terminal buds. Each new internode on the branch results from a bud that is formed in the axil (junction) of the leaf on the branch. Here's what happens:

The first part of the reproductive branch to become visible as the branch develops from the axillary bud is the floral bud; it forms the square.

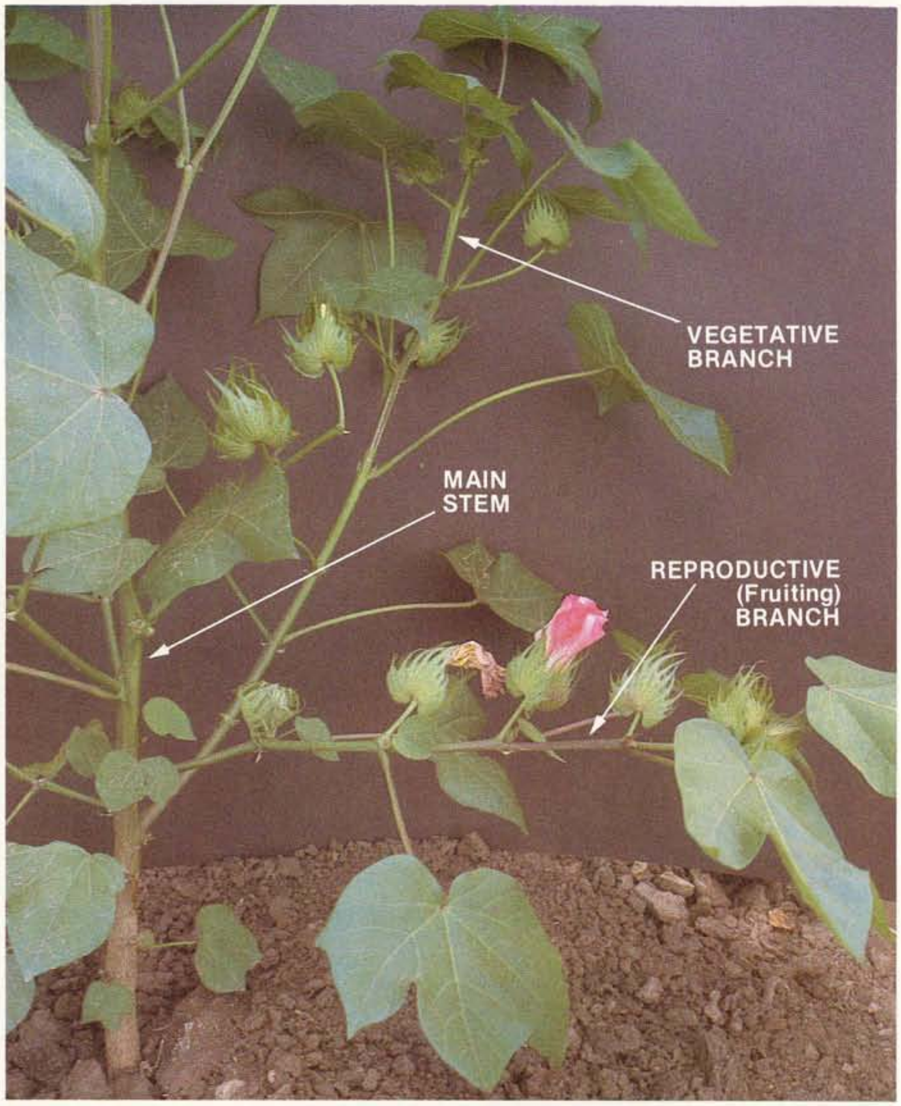
As the branch grows and the internode lengthens, the square is moved away from its original position next to the main stem. A leaf develops beside the square but remains very small for four to seven days. Then, as this leaf enlarges and unfolds, a new axillary bud is formed and develops with its own floral bud to form the second internode and square of the reproductive branch.

The process continues over and over throughout the season—leaf, axillary bud, internode, square, leaf, new axillary bud, internode, square, leaf, and so on.

This type of growth results in the distinctive zigzagging form of reproductive branches that can be seen in photo at right.

Vegetative branches do produce some squares. But the process is much slower and very inefficient. So it's important that your management practices stimulate and protect the early reproductive growth of your crop. The results should be a larger, and certainly earlier, crop.

By DEL DETERLING** with **DR. KAMAL M. EL-ZIK**, photos by **BOBBE BAKER



(Above) Heavy lygus damage promoted thick, bunchy growth in this cotton. This field should already be at the peak of flowering, but no flowers are visible. Photo: Kamal M. El-Zik

(Above right) Note the distinctive difference between the upright vegetative branch and the laterally growing fruiting branch. Vegetative branches may produce some squares, but the more reproductive branches you have, the better.

(Right) Damage from insects or hail early in the season can disrupt the normal branching and fruiting pattern of the cotton plant. Early thrips damage to the terminal bud caused excessive vegetative branching in this plant.

The Squares

Squares—the first stage in cotton fruit formation—follow a definite pattern in their development on the reproductive branch. The leaf next to each square provides food needed for growth and maturity.

No matter how many cotton crops you've raised, you probably still feel a thrill when you spot the first square each new season. That's not surprising. You've nursed your toddling crop through the "creep, crawl, and walk" stage. Now you're eager to see your "baby" break into a full trot.

Under normal conditions, you can expect to sight the first square between five and eight weeks after cotton is planted. This depends on the area and temperature. Farmers in the Delta usually find the first square 35 to 44 days from planting (39 days is average). On the High Plains, the first square normally appears between 43 and 47 days; in California's San Joaquin Valley, it's 60 days after planting.

Watch for white blooms about three weeks later.

The first square is formed on the lowest reproductive branch of the plant. This branch may be located at the fifth to the ninth main stem node. (See "Vegetative and Fruiting Branches," April 1982.)

If you don't have squares by the ninth node (as an average of the field), your crop may be in serious trouble. One of the main reasons for delay of the first square and first bloom is lower-than-normal temperatures.

The critical period for producing squares is from June through mid-July. The squaring rate should increase 1½-fold to 2½-fold or more each week through the fourth week of squaring. This rate usually levels off during the fifth and sixth weeks, then drops sharply during the seventh through the ninth weeks.

You need to avoid any situation that may cause the squaring rate to drop off sharply at any time up through the fifth week. Research shows that as many as 85% of the total bolls that eventually are harvested come from squares set during the first four to five weeks of squaring.

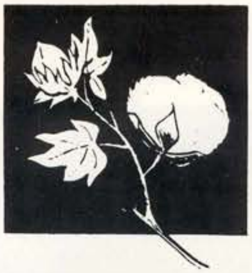
Some shedding of squares is expected. In fact, under the best management, the cotton plant will slough off 40 to 50% of all squares that it produces. The important thing is not to lose too many of the early squares. Extensive shedding—especially if it occurs early in the season—can upset the vegetable/fruiting balance of the plant and reduce yields.

Experts suggest that plants should be holding 60 to 75% of the early pinhead squares (⅛-inch in diameter).

The first three positions on each reproductive branch are the key sites for fruiting. They account for most of the yield.

According to research, over 50% of the total lint is produced from the first square on each reproductive branch. To put it another way, the squares nearest the main stalk on each fruiting branch will make up over one-half of your total yield. The second series of squares accounts for another one-third or more of the crop. Those squares farther out produce 15% or less of the final number of mature bolls.

Square shed may be the result of insect damage or poor growing conditions. Conditions that can cause a plant to drop its squares include very dense stands, rank plant growth, extended cloudy weather, too much nitrogen, low root oxygen because of



water-logged soils, and temperatures below 60°F for several nights.

Dense stands or rank growth shade the lower fruiting branches. They either stop growing or shed a large portion of their squares. Avoid planting too thick or fertilizing or irrigating excessively.

Damage from plant bugs (lygus, fleahoppers, and tarnished plant bugs) also can cause square shed. Inspect fields every three to seven days beginning at the pinhead square stage. This lets you monitor the squaring rate and status of both damaging and beneficial insects.

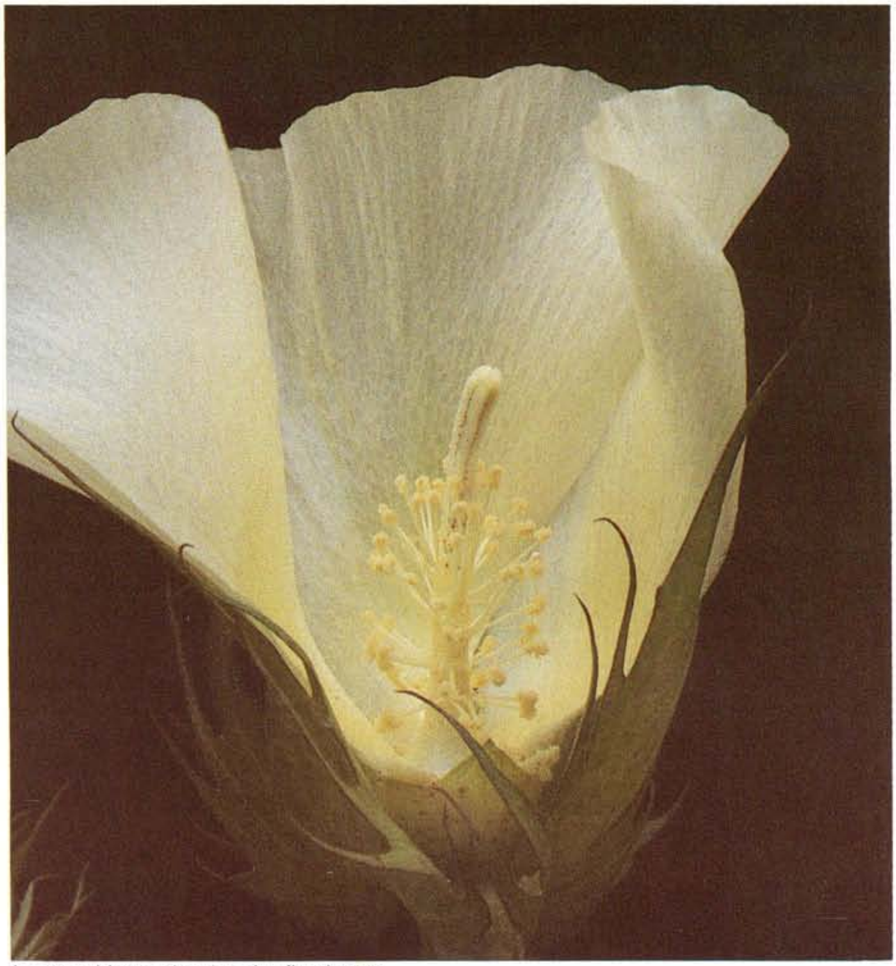
The cotton plant has a tremendous capacity to make up for square shedding. It is very forgiving of mismanagement, pest attack, and poor growing conditions—but to a limit. Using those practices that will stimulate a high fruiting rate and square set provide a stern test of your management ability.

Produced by DEL DETERLING with DR. KAMAL M. EL-ZIK, photos by BOBBE BAKER

Insect damage to square and blooms may cause them to be sloughed off by the plant. Plant bugs (fleahoppers or lygus) generally are the cause of the loss of pinhead squares (center left). The two older squares were attacked by either boll weevils or tarnished plant bugs. The flower shows worm damage.

Here are the various stages of square development: pinhead, 7 days, 14 days, and 21 days. A white bloom will have formed by the morning of the 22nd day.

The Blooms



A cotton bloom showing the floral parts.

Seeing the first bloom in the field is as significant to the cotton grower as spotting the first swallow is to the bird watchers at San Juan Capistrano. It is the signal that nature's calendar is on target.

The cotton plant develops in an orderly, predictable pattern. If you are familiar with the fruiting stages, their sequence, and the time required for each stage, you can tell if your crop is on schedule (see table).

For example, you should spot the first white bloom 60 to 80 days from planting. That will be from 20 to 27 days (23 days average) after the square or bud develops.

It will take about 3 days between the opening of a flower on one fruiting branch and the opening of the bloom in the same position on the next higher fruiting branch. That's known as vertical flowering. About 6 days pass between the appearance of two consecutive blooms on the same branch (horizontal flowering).

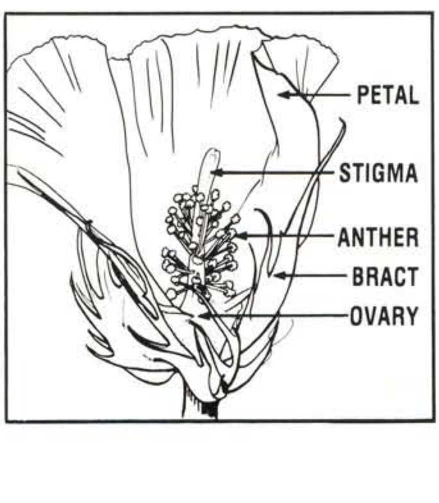
The cotton bloom is a perfect flower (see sketch). It has both male parts (pollen-producing stamens, each with a double-lobed anther) and female parts (stigma, style, and ovary) in the same flower. The ovary has 4 to 5 carpels or locks. Each lock contains 8 to 12 ovules that may develop into seed. The outside parts of the flower include the calyx with its five leaf-like divisions or sepals; three bracts; and five petals that are fused at the base.

The petals of American upland cotton flowers are white or creamy colored. Those of Pima or extra-long-staple cotton are yellow.

Flowers open during the morning, and pollination usually occurs within a few hours. Pollen grains from the anther drop to the sticky surface of the stigma. Fertilization—the union of a male reproductive cell from a single pollen grain and a female cell in the ovule—normally takes place within 24 to 30 hours after pollination.

The fertilized ovule develops into a seed. Some of the ovules may not develop fully or are aborted. If a majority of the seed abort, the boll will fall off the plant within 7 to 10 days after flowering.

Cotton flowers usually are self-pollinated. However, bees or other insects may increase the frequency of cross-pollination. Temperatures above 100°F and moisture—rain or high humidity—reduce pollination. A bloom will not pollinate after the first day.



The creamy or white petals of the flower turn pink after 24 hours and shed within a week as the fertilized ovules of the ovary grow into a boll.

In most of the Cotton Belt, the effective bloom period occurs from late June or early July to mid-August. Water stress during this period will cause the largest loss of yields.

As has been noted in previous articles, many factors influence fruiting, blooming, and shedding. These include variety, temperature, length of the growing season, soil moisture and fertility, and insects and diseases.

It is especially important to keep the plant developing and holding its fruit early in the season.

Research shows that in the Southeast and the High Plains, about 85% of the total bolls are set during the first three weeks of blooming, 10%

during the fourth week, and less than 5% from the fifth through the seventh weeks.

In the San Joaquin Valley of California, 64% of the bolls are set during the first five weeks of blooming, 28% during the sixth and seventh weeks, and less than 8% during the eighth through eleventh weeks.

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(Above) Pink petals mean the bloom is already one day old and is no longer capable of pollination. The next square on the branch will form an open flower in about five days.

(Above right) This plant shows all fruit stages: squares, white blooms, and bolls. You also can spot the vertical and horizontal fruiting arrangement.

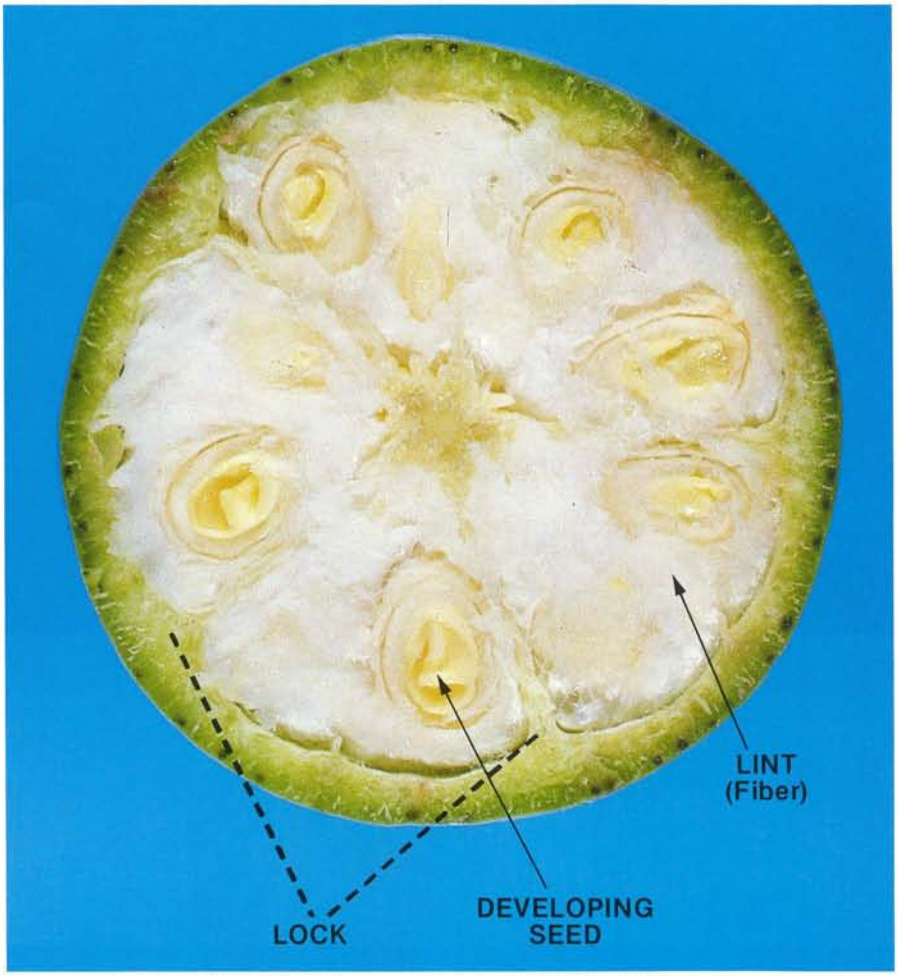
Growth Cycle of the Cotton Plant*

Stage of Growth	Number of Days: Range		Average
Planting to emergence	5–20		10
Emergence to square	27–38	Southeast	32
	33–38	High Plains	35
	40–60	West	50
Square to first bloom	20–27		23
First bloom to peak bloom	26–45		34
Bloom to open boll			
Early and midseason bloom	45–55	Southeast and High Plains	50
	45–65	West	58
Late-season bloom	55–70	Southeast and High Plains	60
	65–85	West	70
Growing season	120–150	High Plains	140
	130–170	Southeast	150
	180–210	West	195

* Based on normal growth rate and no severe adversities such as insects, diseases, moisture and heat stress, and other environmental setbacks.

The Miracle of Fiber Development

This is the last in a series of articles that has detailed the secrets of a remarkable plant that has served mankind for thousands of years.



Cross section of a full-sized boll shows seed, lint, and individual locks. Upland cotton varieties have four to five locks; each mature lock contains seven to nine seed.

The growth of a seed into a bearing plant consists of a series of microscopic miracles performed by nature. None of these events is more remarkable than the development of the cotton fiber.

Once the tiny ovules that will become the seed have been fertilized, the young boll grows rapidly. It will reach its full size in about 24 days. But an additional 24 to 40 days are needed for the fibers inside to stretch, thicken, and mature and for the boll to open.

Not every boll that is formed on the plant makes it to this stage. If not enough of the ovules are fertilized, the boll will fall from the plant 7 to 10 days after flowering. Insects, especially bollworms and boll weevils, bore into the boll and use it as a cafeteria for themselves and as a nursery for their young. Severely damaged bolls will abort.

Bolls also are shed when the demand by various plant parts for food, principally for carbohydrates, exceeds the supply. This commonly occurs when several bolls on the same stalk have reached their maximum size, exhausting the plant's food reserves in the process.

At some point late in the fruiting period, the cotton plant starts to "cut out." This means no new fruiting branches or squares are formed.

"Cutout" may be a natural process—a response to an internal signal that the plant is nearing the end of its mission. The remaining energy stores in the plant must be reserved to mature those bolls it is now carrying.

However, if the plant is stressed

Age of Bolls in Days

Bolls reach full size in about 24 days but require another 24 to 40 days to mature.

for moisture, it may cut out prematurely, before it has set as many bolls as it is capable of bearing. Extremely high or low temperatures also can trigger this response. Yields will be reduced if cutout occurs too early.

Meanwhile, inside the dark confines of the closed boll, the factory is manufacturing fiber. Individual cotton fibers are formed from tiny cells located on the outer surface of the seed. Keeping one end firmly anchored to the seedcoat, the fiber stretches out, growing longer day by day. It will reach its maximum length 15 to 25 days (18 days on an average) after fertilization of the ovule.

Fiber length is largely controlled by the genetic code passed along by the plant's parents. But length also can be influenced by the environment. Stress during this period, especially a moisture shortage, may cause fibers to be shorter than normal.

When the strands have stopped growing lengthwise, they begin to thicken. A cotton fiber is like a hollow tube. Each day, successive layers of cellulose are deposited on the inner surface of the fiber wall in a spiral fashion. The amount and pattern of cellulose growth determine fiber strength, fineness, and maturity. Fiber quality traits are controlled by the genetic makeup of a variety, but they also are influenced by environment and management.

Unfavorable growing conditions during the "filling" period may result in weak, immature fibers with low micronaire (a measurement of fineness). Cool nights late in the season before bolls are mature are especially damaging. They slow down and often cause gaps in the cellulose filling process.

First bolls generally begin to open 105 to 130 days after cotton planting. Bolls set later in the season often take 12 to 25 days longer to mature than do those set early and in the middle of the fruiting season.

If harvest-aid chemicals are applied too early, they prevent deposit of enough cellulose to produce a strong, well developed, mature fiber. Yields also may be reduced. An accepted rule of thumb is to defoliate when 60% of the total crop is open. Desiccants are applied when at least 80% of the bolls are open.

More than 100 days into your crop management program, you still face disaster if insects damage bolls. Boll weevils punctured the boll on the right; bollworm damage is visible in the other bolls.

Earliest set bolls at bottom begin to open 105 to 130 days after planting. As a general rule, defoliants are applied when 60% of the bolls are open, desiccants when 80% are open.

Your ultimate goal: An abundance of clean, well developed, mature bolls.

Produced by DEL DETERLING** with* **DR. KAMAL M. EL-ZIK;** *photos by* ***BOBBE BAKER