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Plant Population

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Why Should We Be Planting Fewer Seeds?

Obtaining an early, uniform stand of healthy seedlings is the first, and often the most important, step in producing high yields of quality cotton. Several technological advances can be used in cotton production to help ensure a good stand of seedlings.

- Proper use of harvest-aid chemicals, timely harvest and dry field storage preserve seed viability and vigor.
- Acid delinting, cleaning and grading of seed has increased the precision with which planters meter seed and reduced the threat of seed borne diseases (i.e. bacterial blight).
- Cool-germ testing, a better indication of seed vigor, can be used for selecting seed lots for early planting or to adjust seeding rates. (See March 1990 newsletter "Seed Quality and Germination")
- Multiple seed treatment and in-furrow fungicides provide protection against seedling diseases.
- Weather forecasting, along with increased planting capacity (acres per day), allows planting to take advantage of favorable weather.
- Adherence to regional planting date guidelines and producer awareness of the detrimental effect of chilling injury on yield have encouraged planting during favorable weather.
- Planters more precisely meter and place seed where it has the best chance of emerging.

Many producers are utilizing these advances to reduce their seeding rate, plant to a stand and save money on thinning. The challenge that producers face every spring is to select a seeding rate that insures against unexpected cold or wet weather yet does not result in a yield-depressive, thick stand under favorable weather.

Optimum Plant Stand

Most extension specialists consider that 2 to 3 plants per foot of row (or about 25,000 to 40,000 plants per acre) in conventional spaced rows (38 to 40 inches) constitutes an optimum stand for picker-type varieties whereas 3 to 4 plants per foot is the optimum plant density for short-statured stripper-type cottons. Nevertheless, in most fields, yield should not be limited by a plant population (density) as low as 15,000 or as high as 60,000 because cotton can adapt its plant shape to varying spacing. Only under specific conditions would yield be noticeably reduced at either 15,000 or 60,000 plants per acre. For example, large numbers of skips more that 3 to 4 feet in length can reduce yields.

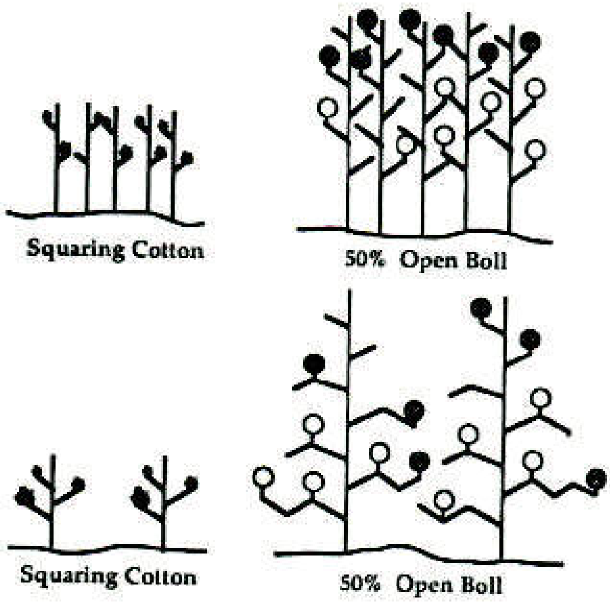
Density Effects on Plant Growth

The shape and size of the cotton plant is regulated by both variety and environment (which includes weather, soil type and management). Some plant characteristics such as fiber length and strength are mainly controlled by variety, whereas other characteristics such as plant height, maturity and yield are strongly controlled by the environment (weather, soil, management etc.). Plant density alters growth largely by the effect that roots and leaves have on the crop's environment.

Plant spacings directly influence soil moisture extraction, light interception, humidity and wind movement. These factors, in turn, influence plant height, branch development, fruit location and size, crop maturity and, ultimately, yield.

Density Effects on Plant Height

The effects of density on plant height illustrate the complexity of plant interactions. Cotton seedlings tend to grow taller in thick stands. This response is similar in other crops and weeds. As the season progresses, plant height in thick stands tend to lag behind that of thin stands. At harvest, high density stands have the lowest average plant height.



Seedling cotton generally does not lack for water or nutrients, because the root zone is still expanding across the row and down into the soil profile. At this stage, plants sense their neighbors by the light availability. Although the details have not been worked out in cotton, it has been demonstrated in lambsquarters and Datura that the sunlight reflected off neighboring plants is altered in color (more green, less red and blue), and that this shift in light color causes the plants to grow taller.

As root and leaf surfaces become larger, plants compete with each other for sunlight, moisture and soil nutrients. Since these plant growth resources are generally limited in amount, each plant in a dense stand receives less sunlight, water and nutrients and is therefore shorter and less robust.

Density Effects on Fruiting

The location of fruit on plants also can be altered by high density, which generally delays fruiting. The location of the first fruiting branch can be raised 1 node in moderate to high density plantings, thus causing a 3 to 6 day delay in crop maturity. Fruiting branches are 25% shorter in dense stands, placing more reliance on fruiting up the plant. The development of new nodes up the plant is slower in dense stands.

Low density stands set more of their bolls on second and third positions and on vegetative branches. Bolls tend to be larger in low density stands. Plants retain and mature a higher percentage of their squares when planted at low densities because light penetration to the leaves that feed young bolls is increased while attractiveness to plant bugs is reduced.

Plant Growth at Different Densities

	Plants per Acre		
	20,000	**40,000**	**60,000**
Height (SJ-2)	52.0	50.8	50.4
1st Fruiting Branch Node	6.6	6.9	7.0
Fruiting Branch Length	14.6	11.0	9.4
Days to Develop 1 Node	3.3	3.6	3.7
% of Crop on 1st Position	48.3	64.2	71.1
% of Crop on Veg. Branches	12.5	4.1	2.7
% Retention	31.2	27.4	24.9
% Dry Matter in Bolls	58	56	53

(Kerby, 1990)

Variety, Soil Type and Optimum Density

Although the differences between varieties do not justify radical changes in density, fields that produce short statured plants (that fail to lap the middles) generally can tolerate higher plant densities without incurring significant yield reduction. Some fruit shed due to interplant shading is likely to occur but it will be less extensive than in fields with solid canopies. This relationship has been clearly demonstrated with Pima cotton. Optimum plant density shifts downward as plant height increases.

Little work has been done regarding the effect of soil type on optimum density . For sandy soils, the optimum density may be approximately 5,000 less plants per acre under irrigated conditions. Sandy soils are either wet or dry with little transition. When planted to lower densities, roots expanding into the surrounding soil allow for a more gradual transition between wet and dry. Since mainstem growth is closely controlled by water availability, this gradual transition between wet and dry levels out the grow-stop-grow pattern observed in sandy fields. These fields are either growing too fast or not growing at all if water stressed. It is difficult to time irrigations in sandy fields planted to high densities because the grow-stop-grow pattern provides little warning of impending water stress.

Density Effects of Crop Maturity

Whenever fruit initiation or retention is delayed, crop maturity also is delayed. Ironically, both very thin or dense stands often suffer delayed maturity, lower yields and poor micronaire. Plants in thin stands, especially if skippy, must grow large vegetative branches to fill in the open space. Fruit set on vegetative branches is delayed approximately 2 weeks. On the other hand, dense stands suffer delayed square initiation, more fruit shed, and slower node development. As a result, more time is required to set the crop and consequently maturity is delayed.

Density Effects on Harvesting Efficiency

When mechanical strippers and pickers were introduced, harvest efficiency was researched vigorously. This research needs to be repeated as new varieties and machines come into use.

Picker efficiency is greatest at moderate to high densities. At low densities, the large plant size and vegetative branches increase the amount of lint left on the plant after a once-over picker harvest. The efficiency of stripper harvest also is decreased at low plant densities. The taller plants and longer branches result in more plant material in stripped cotton which reduces turnouts and increases the likelihood of grade discounts from excessive bark.

Drought and Optimum Plant Density

Of great concern to many producers is how to minimize the deleterious effect of drought on cotton yields. Dense stands use more water early in the season than thin stands because of greater root exploration of moist soil and more total leaf area that requires more water. In one study that evaluated density and early season irrigation, plots with thick stands (80,000 plants per acre) stressed to the point of leaf shed (25 bars) prior to the first irrigation, while thin stands (10,000 uniformly spaced) were still green and growing (17 bars). Clearly when planting into an early season drought condition — shallow soil, poor subsoil moisture, root restriction — a dense stand would be detrimental. The optimum plant density for drought conditions is approximately 5,000 to 10,000 fewer plants per acre than for non-drought. Therefore, producers should rethink a decision to replant a thin stand if anticipating a drought. Even more critical than density is spacing. Work by Bob Metzer and others in Texas clearly has shown a yield benefit from evenly spaced plants under dry land conditions. Give each plant an equal chance at the available soil moisture.

Droughts generally develop mid- to late-season after plants are fully developed. Low density may be of little benefit here because the plants have already compensated with increased branching and rooting. This increased vegetative growth will utilize as much water as would a high density stand.

Narrow-Row and Optimum Plant Density

Most researchers and extension cotton specialists agree that the optimum density, in plants per acre, for conventional row spacing is the same for narrow row cotton. The ultimate objective of narrow-row planting is to optimize each plant's ability to intercept sunlight and extract moisture and nutrients from the soil. Maintaining the same density per acre with narrow-row cotton brings the plant spacing down the row, closer to the row spacing — thus approaching an ideal orchard-like utilization of soil and sunlight.

Hill Dropping

Producers in many areas hill drop cotton. This practice of placing 3 to 4 seeds in a hill increases the pushing power of emerging plants if rains cause crusting. Density of hill-drop cotton on a plant-per-acre basis should be the same as drilled cotton. Although hill-drop cotton can emerge better through a crust, it can be more susceptible to seedling disease. If one plant in the hill becomes infected, especially with Rhizoctonia, this one diseased plant is likely to infect the remaining healthy plants.

Management of Thin Stands

Thin stands need to be managed to encourage rapid leaf and plant growth. Avoid water or nitrogen stress that would reduce the expansion rate and number of leaves. Most likely PIX will not be needed to improve light penetration on thin or skippy stands but some control of plant size may be of benefit in fields where cotton will be stripper harvested.

Management of Thick Stands

Thick stands are vulnerable to shading of lower blooms and bolls. When dense stands of large-statured plants are grown in fertile fields, shading of lower blooms reduces young boll set. Even bolls that are retained suffer low micronaire and maturity due to the shading of lower leaves. Since dense stands of large-statured plants are more vulnerable to boll shed, PIX may be highly beneficial.

Planting to a Stand

Individual field experience is the best guide in determining how many seeds will survive to produce a stand. Even the highest quality seed will only produce half a stand if the seedbed tilth is inadequate and seed depth non-uniform. Prediction of field emergence also can be improved by considering the cool and warm germ percents and the weather after planting. Taking into account the percent of seeds not properly placed in the soil, field emergence under warm conditions should be just below the warm germ while field emergence under cooler conditions should be below the cool germ percent. If germinating seed encounter cool temperatures, crusting, seedling disease or other adversities, field emergence may be well below the cool germination percentage.

Because seed size varies from lot to lot and variety to variety, inquiring about the seeds per pound from your supplier is a recommended practice. Or better yet, take the time to calibrate each planter unit to sow a specific number of seed per foot of row.

When to Replant?

Whether to replant a field or stay with a skippy stand is a decision that should be based on costs of replanting, potential yield reduction associated with late planting and the number, condition and spacing of the remaining plants. The health of the remaining plants can be determined by scrutinizing the roots, stem and growing terminal over a 3 to 5 day period of good growing weather. Flag several areas in the field where the progress of the crop will be evaluated. Look for signs of new growth. Polaroid pictures or plant maps that can be used for comparison may be helpful with the evaluations. Seedlings that show no signs of growth following 3 to 5 days of warm weather likely will produce crippled plants at best and make little contribution to yield.

Stand uniformity is almost as important as plant health in determining whether to replant. Large skips can seriously reduce yield, especially with short-statured varieties. Several research trials in Texas with such varieties demonstrated that percent yield reductions are approximately half the percent stand losses. Studies in the West and South-East, with medium- to full-statured plants show a much greater tolerance for skips, often no yield loss with a 30% stand reduction or skips up to 3 feet long. Furthermore, where healthy rows border large skips (greater than 3 feet), the yield loss in the skip area can be minimal (13% loss) due to the skip-row effect. When making a replant decision, evaluate each part of the field and record the percent area in skips and thin stands separately. This will facilitate a calculation of potential yield loss is each area and guide replanting if necessary.

Costs associated with replanting include not only the extra planting operation but also the potential yield and quality loss resulting from the delayed planting. Calendar dates are an important consideration in making replanting decisions. Regional date of planting studies can serve as guides in estimating potential yield reductions for late plantings.

If the potential yield from a perfect stand of a late planted crop is less than what might be expected from a thin or skippy stand, then replanting is not warranted. Cotton has a tremendous capacity to recover from adverse situations. If still in doubt after assessing the existing stand, it is usually best not to replant.

Wrap Up

Many of this newsletter's co-authors have written extensive articles on plant density, from which this issue was assembled. For a copy of these articles, please give us a call at NCC, Memphis.

About the Authors

Tom Burch (LA), Lawrence Harvey (SC), Tom Kerby (CA) and James Supak (TX High Plains) each have the responsibility of leading the extension cotton program in their area. These extension cotton specialist conduct the field research and develop the production practices that producers rely on for continued improvement in yield, quality and profit.

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