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Modifying the Soil Environment - Conservation Tillage and Narrow Row Cotton

In the 1990s, producers will be challenged to simultaneously meet productivity and environmental demands. This challenge will encourage producers to evaluate nontraditional farming practices. For certain regions, practices such as conservation tillage and narrow row cotton may be of significant value. In this issue of Cotton Physiology Today we will discuss some of the principles behind these two departures from traditional cotton growing methods. Interest in these practices has increased recently due to the introduction of narrow row pickers and environmental requirements in the farm bill. James Supak, Extension Cotton Specialist for Texas wrote the article on Conservation Tillage and Tom Kerby, Extension Cotton Specialist for California provided information for the article on Narrow Row Cotton.

Conservation Tillage

Since the beginning of cotton culture, tillage practices have been used to modify the soil environment to improve stand establishment and crop growth, and control weeds. Typically, a dozen or more tillage operations are required to produce a cotton crop. Although these operations are usually agronomically and economically justifiable, they are also associated with increased susceptibility of soils to wind and water erosion and, ultimately, to declining productivity.

In recent years, there has been a surge of interest in conservation tillage systems which reduce the number of tillage operations and maintain cover crops or crop residues on the soil surface for all or some portion of the crop year. Touchton and Reeves reviewed the status of conservation tillage for cotton (copies of this 1988 article are available from the NCC Memphis office). They concluded that cotton can be successfully grown with conservation tillage on most soils but noted that there are many forms of conservation tillage and that the most successful systems have been specifically adapted for individual farms.

It has been suggested that conservation tillage systems may intensify pest problems, hinder timely stand establishment and require higher levels of fertilizer and pesticides. Concerns about increased insect and disease pressures, especially in systems that utilize high levels of surface residues, have, in general, not been warranted. Crop fertilizer requirements are essentially the same for both systems. In conservation tillage systems, however, the use of starter fertilizers may aid early crop growth and band placement of fertilizer materials may result in better overall crop responses.

Surface Residues Cool the Soil

Maintenance of crop residues on the soil surface typically results in wetter, cooler soil during spring planting. This could delay planting and slow early growth. Seed beds are warmed in the spring by sunlight and contact with warm air. Soil moisture delays spring warming by evaporative cooling, heat conduction to cold subsoils and increased soil heat capacity or its resistence to temperature change. A poorly drained, flat, no-till seed bed stays cold longer due to the insulating effect of the residue and increased moisture content. Planting into heavy residues also may require planter modifications such as the use of fluted coulters to cut through the residue and insure proper seed depth and good seed-to-soil contact. In the northern part of the Cotton Belt where temperature is most limiting, no-till planting of cotton into cotton stubble resulted in a 6 and 8.5% yield decrease when compared to conventionally planted cotton—Phillip Hoskinson, 1987, 1988, Jackson TN.

Weed control is usually the single most important factor in determining the success or failure of conservation tillage. The specific weed control programs vary considerably. Because of the reduced tillage, conservation tillage in general requires higher inputs of herbicides (especially contact herbicides), specialized equipment such as shielded sprayers, and frequent monitoring of weed growth to insure timely herbicide applications.

What are the primary reasons for grower interest in conservation tillage systems for cotton? These vary from area to area but, generally, such systems are being adapted to minimize soil erosion by wind and water, improve productivity and increase profitability. Conservation tillage systems which minimize soil erosion tend also to reduce certain plant stresses imposed by environmental factors such as wind.

Surface Residues Reduce Wind Damage

Until recently, wind was not regarded as a serious stress factor in cotton production. On the Texas High Plains, USDA researchers used slat fences to reduce normal wind movement across cotton by 50%. Wind sheltering of dryland and irrigated cotton has resulted in greater leaf area, earlier fruiting, higher fruit retention, increased water use efficiency and yield increases of 12 to 35%.

Wind-blown sand poses a far greater hazard to young cotton plants than wind alone. Cotton is especially vulnerable to wind and sand damage during the first 3 weeks after emergence. Various cultural and mechanical practices are used to provide some level of crop protection in conventional cropping systems. Although generally successful, such systems do break down periodically resulting in crop injury and yield loss. On the Texas High Plains, researchers are evaluating continuous cotton planted into terminated wheat (wheat seeded into shredded cotton stubble, which after it "joints" is chemically terminated in the spring prior to planting cotton) and rotations with wheat and sorghum to protect cotton from wind and sand. Benefits from planting into stubble under windy conditions include faster early season growth, earlier and more prolific fruiting, earlier crop maturity and significant lint yield increases (42.6% in a 1989 study at Lubbock). For the Texas High Plains, higher yields in the limited and no-till systems were attributed in part to increased soil water storage as well as protection of seedlings from wind and sand injury.

Surface Residues Decrease Water Runoff

Several other benefits of leaving crop residues on the surface have been evaluated by the USDA Cotton Research Station in Shafter, California. California soils are inherently low in organic matter due to the warm weather and low rainfall. Organic matter is further decreased upon mixing with moist soil where microbes rapidly degrade crop residues. Leaving crop residues on the surface sustains higher organic matter levels that contribute to improved soil structure. The surface organic residue increases water infiltration and decreases runoff by maintaining large soil pores and protecting the soil surface from sealing. Planting systems such as the "Cross Slot Opener" are being developed to open up cover crops and stubble for precision placement of seed and starter fertilizers.

Conclusions

Conservation tillage systems for cotton are viable alternatives to conventional practices in many regions of the U.S. Cotton Belt. Such systems can reduce soil erosion, contribute to more efficient use of soil water, decrease costs of production and increase profitability. In certain areas, conservation tillage systems can be used to minimize wind and sand damage to seedling cotton. Weed control is the prime limiting factor to further adoption of reduced tillage systems.

Narrow Row Cotton

Narrow row cotton has been one of the most extensively researched management systems in cotton. Work over the past 25 years in Arizona, California, Mississippi, Missouri and Texas has evaluated the yield and quality of narrow row cotton. Many aspects of production have been scrutinized: stripper vs. spindle harvest, broadcast vs. various row spacings, varieties, irrigation and plant growth regulators. The economics of narrow row cotton was intensely scrutinized by Tom Kerby and Dave Parvin with 3 year projects in Mississippi and California. These trials were supported by a Cotton Foundation grant from Case IH and demonstrated that the narrow row system is no more expensive than the conventional 40" system. Significant reductions in cultivation costs were noted with the smaller bed size of narrow row cotton and the subsequent reduction in lateral soil movement. Despite the massive amount of work that demonstrates an economic benefit from narrow row cotton (see table below), this production practice has not been widely adopted. We believe this is due to the misconception that narrow row cotton is only beneficial on soils that produce small compact plants. On the contrary, the greatest benefit of narrow row cotton may come from soils that produce healthy robust plants, but only if the current production system is properly adjusted.

Yield Increase with Narrow Row Cotton Compared to 40" Rows (Recent Trials Only)

State	% Yield Increase	Year	Researchers
California	10	87,88	Kerby, Weir
Tennessee	7	87,88	Hoskinson
Texas, LRGV	14	84,85,86	Heilman, Namken
Mississippi			
Bosket fs loam	8	87,88,89	Williford
Dundee sc loam	20	87,88,89	Williford
Missouri			
Irrigated	6	84,85,86	Sappenfield
Non-irrigated	1	84,85,86	Sappenfield

Production Practices Change Slowly

Cotton production practices usually change gradually with small incremental improvements that build upon a successful program. The dollars tied up in a cotton field, along with the ever changing weather patterns, dictate that producers move slowly when it comes to adopting new production practices. Small incremental improvements — although constructive — do not allow for radical changes in production practices, primarily due to the detriment in yield often associated with new technologies when first put into practice. Only after a system is fine-tuned can these radical changes be properly evaluated.

Narrow Rows Increase Light Interception

Planting narrow row cotton on soils that produce small plants represents a successful incremental improvement. Just by narrowing the row spacing in fields where plants never closed the rows, growers have been able to realize a 10 to 15% yield increase, without any other modification in the way they grow cotton. For fields that do close the rows but only during mid **bloom**, some yield benefit may also be derived just from narrowing the rows, because it is desirable to intercept maximum sunlight for boll filling during the entire bloom period. For fields that have closed the rows by **early bloom**, the anticipated benefit of narrow row cotton is minimal, if that same plant size continues to be grown. Narrowing the rows with these large, wide plant types only will produce extra photosynthate when the plant does not have bolls to fill. Building stalk beyond what is necessary for full canopy during boll filling does not contribute to the harvestable product.

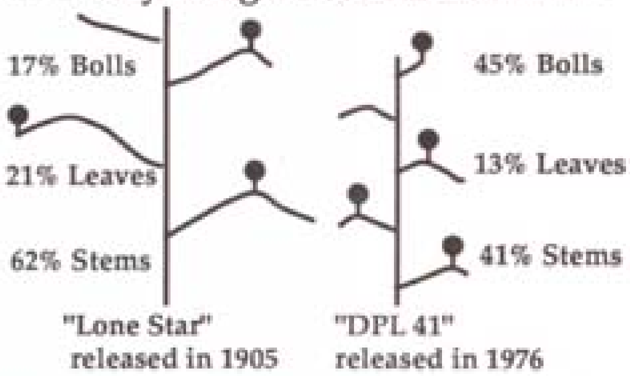
30" Rows on Highly Productive Soil

Adoption of narrow row cotton on vigorous ground represents a radical change because just narrowing the rows on these soils will not necessarily increase yields. In fact, it may decrease yields. To realize the yield benefit from narrow row cotton on our better soils will require a change in the way we grow cotton, from variety to irrigation to fertilization to harvesting. Yield benefits from narrow row cotton on better soils require a systems approach, where all of the management decisions are adjusted to maximize plant efficiency. The ability to increase plant efficiency with narrow row cotton is where the big yield increase will come from.

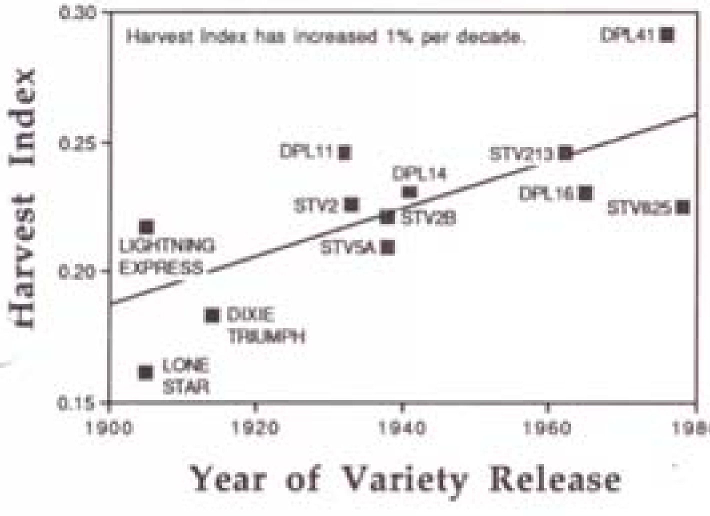
Narrow Rows Increase Plant Efficiency

How efficiently a plant produces lint and seed is called the "harvest index". The harvest index is the ratio of harvested product (lint and seed) to the above ground plant dry weight or biomass (stems, leaves and fruit).

------ Dry Weight Distribution ------



Yield per field derives from the total dry weight and the harvest index — by increasing one or the other, yields will increase. Unfortunately, new varieties produce the same amount of dry weight as the varieties released 80 years ago. But we have made gains with cotton's harvest index. In fact, we have increased the harvest index by 40% over the last 80 years.



One way we can increase harvest index with management is by stressing plants for water and producing what growers call "smurf" or "bumble-bee" cotton; cotton that is only 1 foot tall and sets 2 or 3 bolls. These stunted plants have a high harvest index but very low biomass per acre. Even in 30" rows they are unable to intercept much sunlight, nor make much cotton. The trick is to increase harvest index, without decreasing biomass. Narrow row cotton can accomplish this trick, because it allows us to use varieties and plant growth regulators that increase harvest index and still intercept all of the sunlight during bloom. Stated another way, narrow row cotton allows the use of highly efficient varieties and plant growth regulators that increase plant efficiency without suffering a loss in biomass.

Wide Branching Plants are Inefficient

Modern cultivars have been bred for maximum yield under conventional row spacing (38 to 40") and must be wide enough to close the rows. This width comes at a loss in harvest index as the plant produces more branches, stems and leaves to intercept all the sunlight in conventional row spacing. For example, the optimum plant height for conventional row spacing in California is 6 to 8" taller than for narrow row cotton. Additionally, to intercept sunlight, a conventional row plant has to produce ⅓ more leaves and branches than narrow row plants. The biomass savings experienced with narrow row cotton can instead be put into more bolls and increased yield.

Narrow Row Cotton System

The successful narrow row cotton system on vigorous soils is going to be very different from conventional systems. Narrow row varieties will be shorter and thinner, with improved harvest indexes. Plant growth regulators such as PIX, will play a major role in narrow row cotton until shorter/thinner varieties are adapted. To maintain management flexibility, it may not be desirable to use only variety selection for control of plant shape. Rather, the combination of variety with plant growth regulators to determine plant shape allows the producer to adjust each field to the weather and insect pressure. Using conventional varieties in California, the PIX yield response for narrow row cotton is 38 lbs of lint/acre more than for conventional row cotton. Prior to mid bloom, narrow row cotton uses more water than conventional row spacing and may suffer more under drought or inadequate irrigation. Due to the enhanced earliness with narrow row cotton, the total seasonal water use is comparable to conventional row cotton.

Management of Narrow Row Cotton Will Be Critical

Management of early fruit set with narrow row cotton is critical. Narrow rows shade each other earlier and can suffer boll shedding problems if allowed to get too tall. In fact, where experiments with narrow row cotton have decreased yield, the 30" row cotton was taller than the conventional cotton. If narrow row cotton suffers early square damage, height has to be controlled promptly or the plant will go into a self perpetuating shade induced shed. This is especially true with dense stands (60,000 plants per acre). Because of this shading problem with narrow row cotton, it responds better to the early low-rate multiple applications of PIX.

Besides greater sensitivity to early square shed, other components of the conventional row system will have to be changed for maximum yield under narrow rows. The smaller bed is susceptible to drying where growers plant to moisture, because there is less bed to push off to get down to moisture. Soil compaction has been a problem with narrow rows due to the close spacing between plant rows and tires. Switching to narrow tires is one option where wheel traction is not a problem. Nitrogen and potassium fertilization may need to be increased to supply extra nutrients for the increased yield and to compensate for the reduced leaf mass of high harvest index narrow row cotton. Along with increased harvest index comes reduced storage of nutrients in the leaves. Remobilization from leaves to bolls can provide 30-40% of boll N demands. On the other hand, narrow row cotton explores the root zone more uniformly and may minimize nitrate leaching. Control of early season weeds is improved with narrow row cotton because of the early canopy closure. Narrow row cotton that is not allowed to get too tall also canprovide earlier harvest and cleaner cotton, due to the more uniform distribution of plants and improved defoliation.

Narrow row cotton offers increased yield and quality potential for the producer who is willing to make the necessary changes in the entire cotton production system. But unless the soil severely limits plant size, just switching to narrow rows will probably be of limited value without a parallel switch in the way we grow cotton. We believe that narrow row cotton will be a key component to U.S. competitiveness in the next decade.

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The National Cotton Council (NCC) is the central organization representing all seven sectors of the U.S. cotton industry: producers, ginners, warehousemen, merchants, cottonseed crushers, cooperatives and manufacturers. A majority of elected delegates from each sector must approve all NCC policies, thus assuring unity of purpose and action.

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