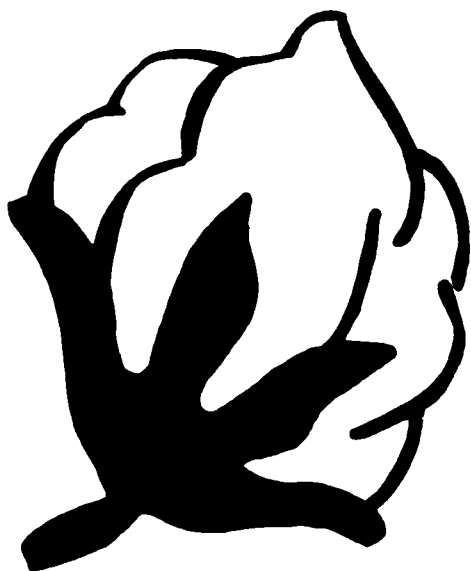




THE ICAC RECORDER

International
Cotton
Advisory
Committee

Technical
Information Section

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- **Update on cotton production research**
- **Nouvelles recherches cotonnières**
- **Actualidad en la investigación de la producción algodonera**

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Introduction

The first article in this issue of *THE ICAC RECORDER* is on micronutrients with emphasis on boron. Boron is required in only a small amount in cotton but plays an important role in root tip development, synthesis of DNA and RNA, and elongation of the pollen tube, in addition to influencing many other interactions like the conversion of nitrogen and carbohydrates into more complex substances such as proteins. Deficiency symptoms can be seen in the form of inhibition of cell division in apex tissues. The growing tip may remain alive but show wilting and even chlorosis of younger leaves. Boron does not move in the plant, thus there is a need for a continuous supply. Boron can be applied with fertilizers or in insecticide sprays. There is a need to monitor the boron level in soil, as an excessive supply of boron from high-boron irrigation water or excessive fertilizers could be toxic.

The second article is on genetic engineering, currently the hottest issue in cotton production. It is estimated that about 2.6 million hectares were grown under genetically engineered cotton in the world during 1998/99. In addition to Australia and the USA, Argentina, China (Mainland), Mexico and South Africa have gone into commercial production of transgenic cotton. Though there is a fee for the technology, many countries are ready to pay for the sake of avoiding insecticide applications and are conducting trials. So far, no deleterious effects of the Bt gene on plants have been noticed except two early instances, which are considered to be exceptions. There are many more applications for genetic engineering, but there is no ongoing work yet on yield improvement through gene level manipulation.

The third article is on the ultra narrow row cotton production system in the USA. It is estimated that about 40,000 hectares

were planted under ultra narrow row (UNR) spacing (7-10 inches row-to-row spacing) in the USA during 1998/99. UNR planting can shorten the growing season, lower the cost of production and improve yield and quality under certain conditions. UNR technology is not a new concept but with the changes in production practices in the form of chemical weed control and application of growth regulators, the need for reevaluation of UNR technology has increased. Effects of UNR production on ginning, spinning and weaving have to be studied. Many other aspects of the UNR system are discussed in this article.

The Dialog search of the Agricola database on boron in cotton is also included at the end of the publication.

Meetings

- The 7th Meeting of the Latin American Association for Cotton Research and Development (ALIDA) will be held in Santa Cruz, Bolivia, from November 23-27, 1999. The National Association of Cotton Producers (ADEPA) of Bolivia will host the meeting. The meeting will include expositions from countries in the region, country reports and discussions on new technologies; however, the main emphasis of the meeting will be on direct cultivation of cotton production. More information on the meeting can be obtained from the Technical Information Section of the ICAC or from the Coordinator of the 7th ALIDA meeting at the following address:

Ing. Daniel Durán-Parada
Gerente Técnico
Asociación Nacional de Productores de Algodón - ADEPA
Av. Cumavi No. 10
Santa Cruz, Bolivia
Phone: 591-3-466264-6

Fax: 591-3-466267
Email: adepe@cotas.com.bo

- The C. T. Patel Memorial Trust at the Central Institute for Cotton Research of the Indian Council of Agricultural Research is hosting an international conference on Strategies for Sustainable Cotton Production, in Nagpur, India, from December 1-4, 1999. A major objective of the conference is a collective introspection of cotton production, technological and economic, and marketing issues, with a global partnership viewpoint in mind for making universally sustainable and, eventually, profitable cotton production a reality of our times. The conference dates include a one-day field trip to visit cotton growing and organic farming areas in Nagpur and in the adjoining areas. A number of other 4-5 day tours are also planned following the conference. The last date to receive abstracts of research papers is August 1, 1999. More information on the conference can be obtained from the following address:

Dr. Raviprakash G. Dani
Secretary
C. T. Patel Memorial Trust
Central Institute for Cotton Research
Post Bag. No. 2, Shankarnagar P.O.
Nagpur 440 010, Maharashtra, India
Tel: 91-7103-75536 Fax: 91-7103-75529
E-mail: ctptcotcon@hotmail.com
rgdani@yahoo.com

- The ICAC/CFC project on Integrated Pest Management of Cotton is concluding soon and a final workshop for the dissemination of project results will be held in Egypt during

October 3-8, 1999. Israel, Egypt, Ethiopia and Zimbabwe collaborated in the project. While major funding came from the Common Fund for Commodities, ICAC served as the Supervisory Body for the project. The project undertook extensive studies on target-oriented environmentally compatible pesticide formulations and equipment and methods for their application, in addition to biological control of whitefly and aphids. The primary objective of the workshop is to disseminate research findings of the project for economical, safe and effective control of insects. The workshop is open to everybody. More information about the workshop can be obtained from the following address and also accessed from the ICAC web page at <http://www.icac.org>.

Mr. Gadi Forer
The Israel Cotton Production & Marketing Board Ltd.,
P.O.Box 384
Herzeliya B', 46103
Israel
Phone: 972-9-9509496
Fax: 972-9-9509542
Email: gadforer@cotton.co.il

- The 58th Plenary Meeting of the ICAC will be held in Charleston, South Carolina, USA, from October 25-29, 1999. The Technical Information Section of the ICAC will organize a technical seminar on Fiber Quality Needs of the Modern Spinning Industry and Advances in Ginning Research on October 28, 1999. The TIS will update its database and report on production practices for the 58th Plenary Meeting. In addition, the Sixth Plenary Session of the meeting, also on Thursday, October 28, will focus on Reducing the Cost of Production.

Micronutrients with Emphasis on Boron

It is estimated that on average one ton of cotton lint contains approximately 100 kgs. of nitrogen, 16 kgs. of phosphorus and 60 kgs. of potassium. A chemical analysis of the cotton plant indicates the chemicals or elements present in a crop at maturity or when it is harvested. It is very important to know the availability of nutrients in the soil for proper fertilization. The cotton plant utilizes only a portion of the nutrients in the soil; however, the availability has to be higher than the quantity of nutrients removed by the plant. The important question in fertilization is what quantity of which nutrient must be added to the soil to fertilize the growing plant. Thus, whatever the target yield may be, the two criteria used in fertilization are the quantity of nutrients already present in the soil and the crop's need for a specific nutrient.

An optimum availability of nutrients in the soil is needed for achieving target yields. But, even if the quantity of nutrients to be added to the soil and the crop needs are properly determined, other production factors including agronomic management may

still cause low yields. Timely application is also an important consideration for the economical use of inputs, particularly fertilizer nutrients. If yields are only partial in relation to large amounts of fertilizers applied, many of the nutrients will be carried over for use by the next crop. It is this carryover or residual effect, from one year to the next, that makes heavy fertilizer applications practical in the face of other limitations to yield.

Even in the presence of good agronomic management, pest control, timely irrigation, cultivation of high yielding varieties and any other perfect growing condition, the application of all required nutrients based on soil analysis cannot guarantee optimum yields unless it is made in the form of balanced fertilizers. The addition of one nutrient in excessive doses and the non-application of another that may be required based on soil analysis may affect the economics of the former nutrient. For consistently balanced yields, fertilizer nutrients must be applied in a balanced form.

Nutrient Needs of the Plant

The cotton plant needs a variety of nutrients during the growth period. Some nutrients are absorbed from the air and usually go unnoticed though they may be even more important than the ones applied through soil. Among nutrients applied through soil, nitrogen is the most important and must be applied under all circumstances and every year. The other two macronutrients, phosphorous and potassium, could be applied as needed depending on their soil availability. Soil or foliar application of phosphorous may be required throughout the growing season if its availability in the soil is not enough. But, in the case of potassium, the latest research has shown that even if soil availability is more than enough, foliar applications may have a positive effect on yields. Potassium is picked up by the cotton plant in excess amounts than actually required and stored in leaves. As the plant enters into a boll maturation stage, the need for K abruptly increases. Although the leaves quickly volunteer to transfer K to maturing bolls, chances are that the transfer may still be short of needs. This is particularly true under heavy boll load for short stature plants with less foliage. High yields of top-quality crops require an abundant supply of sixteen essential nutrient elements given below.

Essential Nutrient Elements		
Nutrient	Symbol	Available Form
Non-fertilizer elements supplied through air, water and soil		
Carbon	C	CO ₂
Hydrogen	H	H ₂ O
Oxygen	O	CO ₂ , H ₂ O
Macronutrients required in large amounts		
Nitrogen	N	NO ₃ ⁻ , NH ₄ ⁺
Phosphorus	P	PO ₄
Potassium	K	K ⁺
Secondary nutrients required in moderate amounts		
Calcium	Ca	Ca ⁺⁺
Magnesium	Mg	Mg ⁺⁺
Sulfur	S	SO ₄
Micronutrients required in small amounts		
Boron	B	HBO ₄ ⁻
Chlorine	Cl	Cl ⁻
Copper	Cu	Cu ⁺⁺
Iron	Fe	Fe ⁺⁺ , Fe ⁺⁺⁺
Manganese	Mn	Mn ⁺⁺
Molybdenum	Mo	MoO ₄ ⁼
Zinc	Zn	Zn ⁺⁺

sufficiently available in the soil, their deficiency may go unnoticed particularly under low yielding conditions.

Calcium

Calcium functions include the strengthening of cell walls to prevent their collapse, enhancing cell division and plant growth, protein synthesis, carbohydrate movement and balancing cell acidity. Calcium deficiency in the soil affects the ability of the plant to resist seedling diseases. A crop grown on calcium-de-

Secondary nutrients include calcium (Ca), magnesium (Mg) and sulfur (S). This trio of nutrients, which may be identified as “the synthesizers,” play a key role essential for plant growth and health. The cotton plant takes up magnesium and sulfur in about the same quantities as phosphorus, a major nutrient. Calcium is required in even greater amounts. Because micronutrients—an integral part of the plant growth system—are required in small quantities usually

ficient soil has a short internode length, especially at shoot terminals, and weak stalks. Also, stems may be rough and cracked. Weak stems may give rise to slow growth and poor fruit set.

Magnesium

On average, magnesium is removed by the plant at a rate of 8.3 kg/ton of lint but it also leaches into the soil. Magnesium is essential for the production of green pigments in chlorophyll. Chlorophyll is essential for photosynthesis, the conversion of sunlight into plant food (carbohydrate synthesis). Early symptoms of magnesium deficiency resemble nitrogen deficiency symptoms: dark green plants often developing red and purple colors, with stalks shorter and thinner if the deficiency takes place in the late stages of growth. Magnesium deficiency symptoms can be easily confused with maturing leaf symptoms. Magnesium deficiency symptoms show interveinal chlorosis, chlorotic older leaves with veins remaining pale green. Leaf margins become necrotic and may roll or curl. Symptoms may also appear on younger leaves as deficiency progresses.

Sulfur

Sulfur is essential for the production of three amino acids that are the building blocks in the synthesis of proteins. Soil organic matter is the primary storehouse of sulfur in the soil. Thus, soils low in organic matter would suggest a possible need for added sulfur. Sulfur is used by plants in the form of a sulfate that is highly mobile in the soil even with percolating water. The mobile nature of the sulfate ion precludes maintenance of optimum sulfate levels in coarse textured soils with a low cation exchange capacity (CEC). In cotton, common sulfur-bearing fertilizers are ammonium sulfate, gypsum, potassium sulfate and ammonium thiosulfate. All are sulfate forms and equally available to the plant. Sulfur deficiency looks much like nitrogen deficiency: pale-green leaves on the upper part of the plant, the only difference being that sulfur deficiency appears on new growth first, while nitrogen deficiency appears on older leaves first.

Molybdenum

Plants grown on soils deficient in molybdenum rarely show any symptoms at an early stage. Recently matured leaves are affected first with mild symptoms. As the plant grows, older leaves show a pronounced effect. First, symptoms appear in the form of small spots of dead tissue usually at tips and between veins, more marked at margins of leaves. Symptoms are more common late in the growing season.

Zinc

Zinc deficiency symptoms are very specific but sometimes resemble those of calcium and boron. At the stage when the soil becomes deficient in zinc, symptoms on new buds or new bud leaves are more localized. In the case of an acute shortage, terminal buds start dying following the appearance of distortions at tips or bases of young leaves. Later growth is characterized by a cutout appearance in affected plants.

Boron

Plants deficient in boron show a wide variety of symptoms, depending upon the plant's age, but the earliest symptom is

failure of root tips to elongate normally accompanied by inhibited synthesis of DNA and RNA. Such symptoms may not be visible until cell division in the shoot apex and in young leaves is inhibited. The growing bud may remain alive but it shows wilting or chlorosis of younger or bud leaves, with or without spots of dead tissue becoming apparent. An acute shortage of boron may even result in the death of terminal growth and, consequently, the lateral buds may develop chlorotic leaves.

Copper

One of the peculiar symptoms of copper deficiency is chlorosis, with or without spots of dead tissue scattered all over the leaf. Chlorosis is less marked near veins, but affected areas eventually become brown. Soils where copper deficiency may be a problem are high organic-matter soils (more than 10%) or sandy soils with a high pH value.

Manganese

Symptoms are similar to those in nitrogen deficiency. Leaves become uniformly light green, followed by yellowing and poor growth.

Role of Boron

Although some of the sixteen essential nutrient elements given in the table on the previous page can be supplied through foliar application, the soil is the main source of supply of thirteen essential elements required by the cotton plant. The supply from soil reserves is limited. The plant takes up all nutrients, which must be supplemented in appropriate doses. In addition to the boron effect on root-tip growth and synthesis of DNA and RNA, boron also plays an important role in the elongation of pollen tubes.

At white-flower day and even just before the flower opens, anthers shed pollen grains. Pollen grains must germinate on the stigma and form a tube of desired length to reach the ovules. Generative cells travel through the tube and are dispersed in the vicinity of the ovules for their fertilization. Specificities of the boron role in the formation of a longer pollen tube have not been determined, but it is certain that if the pollen grain tube fails to attain proper length, the flower remains unfertilized and is ultimately shed. As a reproductive cell from a separate pollen tube fertilizes each ovule, tubes equivalent to the number of ovules must reach the ovary. The number of pollen grains is many times greater than that of the ovules, hence even if some pollen tubes fail to form sufficient length, many others will be able to reach the ovules to fertilize all. But if the plant seriously lacks in boron supply, that can affect pollen growth, some ovules may not be fertilized and thus result in lower yields and increased moles. Sometimes symptoms may not be seen but, due to less boll fill, boron deficiency may result in lower yields.

Boron influences the conversion of nitrogen and carbohydrates into more complex substances such as proteins. Boron also plays a role in the transfer of sugars within the plant and exerts a marked influence on cell division, and helps in the formation of certain membranes.

Boron Application

Boron deficiency is usually found in sandy soils with organic matter less than 1.5%. Common forms of boron fertilizer include granulated fertilizer containing boron, borax (11 percent boron), sodium tetraborate (14-20 percent boron), and solubor (20 percent boron). It is recommended to apply one-third to one-half of a pound of boron annually, particularly 1-2 years after liming.

Solubor is the preferred source for foliar applications of boron. One method that has worked well is the application of 110 grams actual boron per hectare (680 grams solubor) applied four times at weekly intervals beginning at pinhead square.

For cotton, apply 450 grams of boron per hectare in fertilizer or insecticide spray in either one or several applications as long as the total amount applied does not exceed 450 grams per hectare. Since boron is mobile in the soil, like nitrate, a blanket recommendation is given with the assumption that at the beginning of the cropping season most of the residual boron from the previous year's crop will have leached through the soil past the root zone. As with copper, a tissue test will give the best assessment of available boron.

Boron is almost entirely absorbed as boric acid. It functions in plants in the differentiation of meristem cells. With boron deficiency, cells may continue to divide, but structural components are not differentiated. Boron also regulates the metabolism of carbohydrates in plants. Boron is non-mobile in plants and a continuous supply is necessary at all growing points. A deficiency is first found in the youngest tissues of the plant.

Boron can be toxic and can result in as many problems as if it were deficient. Toxic levels of boron are associated with high-boron waters. This is true in many countries where instead of adding boron there is a need to monitor its level so that it does not exceed the tolerance limit. For example, in Israel, if there is any concern with regard to boron it is not the deficiency but the toxic effect of excess levels. In Israel, soils are naturally rich in boron and, as cotton is irrigated from recycled sewage water that contains 0.2 to 0.6 ppm of boron, a deficiency is not expected.

In Pakistan, trials on boron application have been conducted for years with no effects on yields. Boron in the form of boric acid was applied at the rate of 1.0, 2.0 and 3.0 kg/B/ha⁻¹ at a number of locations in the main cotton growing area. Boric acid was broadcast and incorporated into the soil at the time of preparing it for planting. The addition of boric acid increased the soil boron level from 0.38 to 0.74 ppm. The boron level in mature leaf tissues increased with its increase in the soil. Control plots indicated a level of 66 ppm of boron in mature leaves, enough for normal growth and seedcotton yields. The addition of boron did not affect yields, as soil availability was enough for target yields. Detailed studies have also been conducted on the number of bolls, number of seeds/boll, lint/boll and lint percentage but no effects were found between control and treated plots.

In the USA, buffered foliar-applied boron and potassium were evaluated under no-tillage conditions. Boron and potassium were sprayed four times as unbuffered at the rate of 0.1 kg/ha and 5 kg/ha respectively, alone and in combination. Same treatments were repeated as solution buffered to pH 6.0 and 4.0. Full foliar dose of potassium and boron was completed in four applications in 10-gallons of water starting from bloom period. Twelve treatments were repeated for three years from 1995 through 1997 in addition to normal fertilizer application of 90 kg/ha N and 33 kg/ha of phosphorous and potassium. According to Howard and Gwathmey (1998), no-tillage yields increased by about 110 kg/ha in foliar treatments when compared with the check. It was also found that buffered to pH 6.0 did not increase yields compared to unbuffered, but buffered solution to 4.0 pH-increased yields over buffered to pH 6.0.

Abaye et al (1998) studied the interaction of boron with various nitrogen doses. Nitrogen was applied at the rate of 0, 33, 66, 100 kg/ha while boron was applied in nitrogen sub plots at the rate of 0, 0.56, 1.12 and 2.24 kg/ha in foliar form. On the bases of two-year data, it was concluded that N x B interaction did not affect yields. As expected, nitrogen applications increased lint yield but boron did not. On the contrary, while the addition of lower doses of boron increased yield insignificantly, there was a significant drop in yields with the addition of 2.24 kg/ha boron during both years (1996/97 and 1997/98). However, boron application increased leaf tissue level over the control and initial boron level during both years. On the average of two years, the addition of boron at the rate of 0.56 kg/ha, 1.12 kg/ha and 2.24 kg/ha increased leaf tissue levels to 51.3, 67.1 and 91.8 ppm respectively compared to 39.2 ppm at no application of boron.

Some of the old work on boron in the USA showed that cotton did respond to boron when gravel was supplied with the nutrient. A nutrient solution having traces (<0.5ppm) to 25 ppm was applied to cotton plants grown on gravel. Results indicated (Howard 1986) that yield increased with the increase in boron to 10 ppm, then decreased as boron was raised to 25 ppm. Anderson and Boswell (1968) applied boron at the rate of 0.45 kg/ha and 0.89 kg/ha for three years as against no boron. The 0.45 kg/ha application increased the amount of seedcotton in the first pick, thus showing a relationship between boron and earliness in cotton.

Oosterhuis and Steger (1998) also studied nitrogen and boron interaction and came to the conclusions drawn by other researchers. They applied nitrogen at the rate of 56 kg/ha and 112 kg/ha while boron was applied as follows: (1) 0.56 kg/ha boron applied to the soil (2) 1.12 kg/ha boron applied to the soil followed by three foliar applications at the rate of 0.45 kg/ha; (3) 2.24 kg/ha boron applied through foliar at different stages of plant development as against no application of boron. The results indicated that three weeks after the first flower, soil+foliar application treatments showed higher B in the plant. Due to higher plant volume in the case of higher N doses, total B was higher in high N treatment plots. Leaf tissue analysis showed lower B in lower N doses compared to higher doses. Analysis

of fruiting parts (squares and bolls) indicated lower B concentration in lower N doses.

Guertal et al (1998) tried various sources of boron fertilizers and did not find any differences among them. Work is continuing, although not much. New sources of boron fertilizers are also coming up. In the USA, some states like Alabama, Georgia, North Carolina and Virginia include boron in their standard recommendations.

Conclusion

The exact role of boron in plant nutrition is not fully understood. It seems that boron is an essential trace element and plays an important role in many operations within the plant. It is difficult to highlight the specific role of boron under a variety of soil types. However, under most common conditions, a boron deficiency is generally related to high rainfall areas as well as areas irrigated for a considerable time with low boron surface waters in light sandy soils. A separate boron analysis is needed for certain suspect fields (low organic matter, excess lime, sandy texture, partially filled bolls, severe fruit drop and/or delayed maturity). Mid-bloom to heavy bloom is the time when lower bolls are developing and the demand for boron is the highest. Soil boron is 90 percent unavailable at this time because root growth has all but stopped but, in case of a severe deficiency, foliar applications can make up the difference. Boron is compatible and can be supplied with foliar applications of growth regulators and/or insecticides.

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Genetic Engineering in Cotton

Genetic engineering of cotton is less than two decades old and is talked about in every cotton-producing country of the world. The need to induce non-cotton genes into the cotton genome came as a result of the desire to find less expensive and environmentally safe methods to control insects. When insecticides came to be known and developed, they were quickly adopted in many countries. Many producing countries started subsidy programs to promote insecticide use at a faster rate. The two main reasons for the fast adoption of insecticides and the involvement of governments are effectiveness and cost. Insecticides were more effective than other means to control insects and the benefit-cost ratio is exceptionally high. In an effort to control insects effectively and economically, the aftereffects of injurious chemicals were forgotten. But soon many countries started realizing the consequences in damage to the environment, resistance development, change in the pest complex and a continuous increase in the number of sprays. Thus, researchers started exploring the means to get away from insecticides without sacrificing effectiveness and low cost. Transgenic cotton was found to be one such option.

Development of Genetically Engineered Plants

Chromosomes carry desirable as well as undesirable genes, and conventional breeding has the limitation of transferring the whole set of chromosomes at the same time. When two parents are crossed, depending upon the mode of inheritance, transfer of a particular character to the F_1 generation can be determined. If the character is controlled by a single dominant gene, it is certain that the character will be expressed to the F_1 generation and the F_2 generation will segregate into 3:1; 1 homozygous for the character, 2 heterozygous for the character and 1 homozygous for non-existence of the character. Though the objective for the target gene has been achieved in the first case, there is no mechanism to recover all other genes of the recipient parent. Genetic engineering provides a mechanism to add or delete a single gene to and from a genotype.

Biotechnology can be defined as the use of biological organisms or processes in any technological application. Genetic engineering is a division of biotechnology related to altering the properties of biological organisms. Genetic engineering alterations can be made at a single gene level. However, development of a transgenic genotype involves identification of a suitable gene capable of producing a particular characteristic in the plant, isolation of such a gene and induction into the target species. The three-stage developments have moved very fast during the 1980s. According to Jenkins (1990), Agracetus developed the first transgenic cotton plants reaching the field testing stage. However, the transgenic plants that effectively killed the bollworm in the laboratory failed to exhibit its effectiveness under field conditions (Jividen 1996). Just a year later

Monsanto came up with another Bt gene that was capable of controlling bollworms under field conditions. Now Monsanto, the largest biotech company in the world, also owns Agracetus. Recently, the company entered the cotton seed business, particularly with the purchase of Stoneville Pedigree Company. Currently, Monsanto is offering Stoneville Pedigree Company for sale and is in the process of acquiring Delta and Pine Land Company based in Mississippi. Delta and Pine Land Company is the largest cotton seed company in the world.

Following are important stages in the development of transgenic cotton in the world:

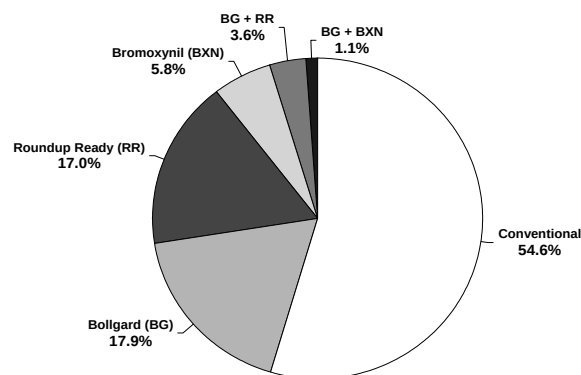
- 1980 Work on transgenic cotton started
- 1983 First transgenic cotton plant was developed
- 1985 First transgenic plant was transferred to the commercial side
- 1986 First field testing of Bt cotton
- 1993 First commercial demonstration trials (BXN)
- 1993 First regulatory approval for commercial production
- 1995 First commercial cultivation of herbicide tolerant transgenic cotton
- 1995 Seed production for commercial adoption of Bt cotton
- 1996 First commercial cultivation of Bt cotton
- 1997 First commercial cultivation of stacked gene varieties, insect plus herbicide resistant varieties

Area under Transgenic Cotton

In the early 1990s, the ill effects of insecticide use became more evident. Farmers who for many years had been hearing about Bt cotton became impatient and wanted to have the technology available as early as possible. In this effort, some of the regulatory processing and field-testing were hastily completed. However, 1996/97 was the first time in history when Bt cotton was cultivated on a commercial scale in the USA and Australia. Bt cotton has been adopted faster than expected. It is estimated that in 1998/99, 45% of the total cotton area in the USA was planted to transgenic varieties.

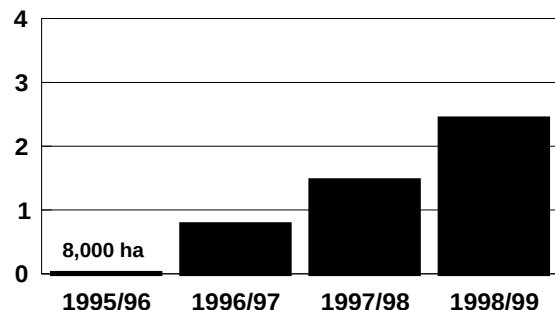
The Bt gene derived from the soil bacterium *Bacillus thuringiensis* is not equally effective against all bollworms. The toxin produced by the gene Cry1A is most effective against the tobacco budworm *Heliothis virescens*. However, the gene is also quite effective against the cotton bollworm *Helicoverpa armigera* and other bollworms, but is almost non-effective against sucking insects. Thus, Bt cotton is not suitable for cultivation in all countries and in all areas. In the USA, Bt cotton is most successful in the Southeast, particularly Alabama and the Delta region, where the cotton bollworm is a major pest.

Outside the U.S., Bt cotton was commercially cultivated in Australia in 1997/98. During 1998/99, Bt cotton was commer-

Cotton Varieties (by Gene Type) in the USA - 1998/99

TRANSGENIC COTTON AREA IN THE USA

Million Ha



Transgenic Cotton Area 1998/99

Country	Hectares
Argentina	8,000
Australia	80,000
China (Mainland)	52,000
Mexico	40,000
South Africa	12,000

cially grown in Argentina, Australia, China (Mainland), Mexico and South Africa. These countries have not yet developed their own commercial varieties carrying Bt genes and they have to rely on either

Monsanto or Delta and Pine Land Company to provide transgenic varieties.

It has been confirmed in the USA, after many years of research, that the Bt gene in cotton has no deleterious effects on the plant. It does not have any adaptability problems either. But, before a variety is brought into commercial production in any country, it requires experimentation of that variety under local conditions. Trials on transgenic varieties have been completed in Spain, which are ready to go for commercial production. If a transgenic variety is cultivated in Spain, the variety approval procedure permits it to be cultivated

in Greece also. Thus Spain and Greece may be the next countries adopting Bt cotton. Trials are almost near completion in Zimbabwe, which may also be planting Bt cotton in 1999/00. Trials are proceeding in Colombia, Bolivia, Brazil, El Salvador, Greece, India, Israel, Paraguay and Thailand.

Technology Fee

Transgenic cotton is not available for free. Commercial production of Bt and herbicide tolerant varieties is conditional on a fee to be paid to owners of these genes. The ability of the cotton plant to tolerate herbicides over the top of the plant and the plant's ability to produce a specific toxin are heritable characters. Once such resistant genes are induced into the cotton plant they are automatically transmitted to the next generation. Farmers can keep the seeds and use them year after year. In the USA and Australia, this has been avoided through agreements signed with farmers that prohibit the storing of seeds for next year and also the transfer of seeds to other growers.

Agreements with biotech companies may or may not have been abused and illegal transfer of seed may or may not have taken place but there is a potential threat that it might happen, which could affect the recuperation of research and development costs by biotech companies. Chances are that the technology could be leaked to other farmers and countries without payments by growers receiving the advantages of these traits. After almost five years of research, the USDA and Delta and Pine Land Company have developed a technology called "Technology Protection System (TPS) which produces infertile seeds." TPS is a clever three-gene system that forces plants to produce a toxin that is fatal to their own seeds, compelling farmers to buy new seeds every year. A detailed note on the system was published in the March 1999 issue of *THE ICAC RECORDER*.

The TPS varieties are still a few years away but there has been a lot of criticism about the impact of the self-seed sterility system. It is perceived as exploitation of poor farmers, particularly in small farming communities. Monsanto is inclined to revisit the issue before the commercial release of TPS varieties.

The technology fee is higher in Australia because farmers will save more on insecticides. In 1997/98 a Value Guarantee Program was introduced, whereby farmers would be compensated if they spent more on Bt cotton compared to conventional insecticide spraying. The Value Guarantee Program ensured that if the cost of the technology fee minus thirty Australian dollars

Technology Fee for Transgenic Cotton in the USA

Transgenic Cotton	1996 US\$/ha	1997 US\$/ha	1998 US\$/ha
Bt cotton	80	80	80
BXN cotton	-	15	Free
Roundup Ready	-	12 = Stripper varieties 20 = Picker varieties	17 = Stripper varieties 22 = Picker varieties
Bt + Roundup Ready	-	101	101

**Bt Cotton Area and Technology Fee
in Australia**

Year	Area Limit (%)	Technology Fee US\$/ha	Area Hectare
1996/97	10	147	38,000
1997/98	15	131	64,000
1998/99	20	112	80,000

were more than the cost of conventional spraying, Monsanto would compensate for the additional expenditure.

Concerns to the Industry

In the last three years some issues related to the effectiveness, impact of non-cotton genes, etc., have come up for the consideration of owners of the technology and of public researchers. Two of these issues which have become most important—malformation/shedding of fruit in Roundup Ready cotton and development of resistance to Bt toxin—are discussed here.

Since the cultivation of herbicide tolerant transgenic cotton started in 1995, a number of farmers in the USA reported problems with the Roundup Ready varieties in 1997/98. The complaint was localized to Mississippi and so far restricted to only one season. The common observation was that the Roundup Ready transgenic cotton showed abnormal boll shedding and in some cases bolls were deformed or partially filled. Monsanto critically analyzed the issue and concluded that there is no problem with the technology and the ability of the non-cotton gene to produce a specific enzyme for interference in the pathway of amino acid production. Extremely abnormal low temperatures during May and June and spraying of herbicide even after the four leaf stage were determined to be responsible for the excessive shedding. Since then, the company has advised farmers not to spray Roundup Ready on the cotton plant after the four-leaf stage. The company's conclusions have been supported by no abnormal effects during 1998/99.

Along with the introduction of Bt cotton for commercial scale production, fears spread that insects could soon develop resistance to the Bt toxin. Such observations have sound technical reasons. Once a Bt gene is inducted into the cotton plant, the toxin is produced throughout the plant's life regardless of whether bollworms attack. All generations of a particular bollworm will feed on the plant and could quickly become immune to the toxin, just as insecticides that are sprayed only a few times during the fruiting period. And if the toxin is present in the plant all the time, insects have a higher chance of developing resistance quickly. Developers of the insect resistant transgenic cottons admitted the fact and recommended planting of refuges. Farmers were given two options:

- For every 100 hectares of Bt cotton, 25 hectares of conventional varieties (not containing the Bollgard gene) should be planted. The non-Bt variety area would be treated with any insecticide except foliar Bt products.

- Planting of 4% of the total Bt area to non-Bt varieties. No bollworm control insecticides should be used on this area. Monsanto would provide a list of prohibited insecticides but sucking insects could be controlled with any insecticide.

Either recommendation could be adopted, which would help to delay the development of resistance. Growers could use both options to allow maximum flexibility. The objective was that the susceptible population would cross with the population feeding on varieties having the Bollgard gene and consequently a hybrid population would be produced, prolonging the development of a pure resistant population. The approach seems to be working as there are no reports of resistance development yet.

Bt Cotton and Organic Production

Organic production requires the elimination of conventional synthetic pesticides and fertilizers. Under high insect pressure, the elimination of insecticides results in extremely low yields. Thus, some areas having high insect pressure, particularly bollworms, may be unfit for organic production. It was hoped that Bt cotton varieties would become an integral component of organic production and help to promote organic production. But environmentalists have been able to convince authorities in Europe and the USA that it is not environmentally safe to grow genetically engineered varieties. Consequently, organic cotton is not considered environment friendly. According to the U.S. Environmental Protection Agency, it has been officially decided that Bt cotton cannot be certified as an organic cotton even if it were grown under organic conditions.

As the system works, the currently available Bt gene, called Bollgard in the USA and Ingard in Australia, produces a specific toxin injurious to lepidopteran insects. But the mechanism of herbicide tolerance is different from toxin production. The mode of action of glyphosate lies in the inhibition of a particular enzyme synthase, which is a key catalyst in the production of aromatic amino acids. Animals do not produce aromatic amino acids and are not affected by glyphosate. According to Stewart (1991), resistance to glyphosate has been achieved by two pathways, over production of an enzyme and enhanced insensitivity of the enzyme to the herbicide. Calgene, Inc. has developed lines of cotton resistant to glyphosate from a gene extracted from the soil bacteria *Klebsiella ozeanae*. The gene codes for the enzyme, which removes the nitrile atom from the compound and thereby detoxifies it. The mechanism of resistance to Roundup Ready does not involve production of any toxin either.

Resistance to insects through production of toxin within the plant body is one aspect of genetic engineering. There could be many more applications of genetic engineering that may not require toxin production and may be even simpler than herbicide resistance. Such genotypes may include colored cotton or the improvement of a specific fiber character. These transgenic genotypes could be perfectly fit for organic production but now

they will also be prohibited in organic production. Bt cotton has been debarred from organic production but still would be an important component of integrated pest management programs.

Yield Improvement

Considerable work is proceeding on various aspects of the cotton plant but none is continuing on the improvement of yield, though yield improvement has been and still is the primary plant character to be improved. The need to improve the genetic ability of the plant to give higher harvestable yield increases with the current stagnation in yields. In most countries, the agronomic management of the plant, including pest control and optimum utilization of other inputs, irrigation water and fertilizers has reached near optimization. On the other hand, cotton genetics has reached a plateau in terms of producing new varieties with higher yield potential. Breeders have made substantial contributions in order to devise a plant most suitable to growing conditions and thus avail the maximum genetic ability of the plant. There are limitations to realizing the maximum ability of the plant and those limitations vary in nature according to growing conditions. Given the limitations in various countries, high yielding as well as low yielding, a significant improvement in yield seen in the last 4-5 decades is not expected. Though expensive but alternate methods of pest control are available in the form of insecticides, these are also being researched further with heavy investments to make them more target specific, less damaging to the environment, etc. Yet, most of the genetic engineering at this time is focused on improving agronomic characteristics of plants. End-use level products are not yet available but are expected to be available soon. There is no work on yield improvement even in the offing.

Why is no work being done on yield improvement? Tomorrow's plan may include boosting the genetic ability for bearing higher number of bolls but there is no such indication at this stage. The following factors may be responsible for the lack of any work on yield improvement.

1. Yield is a quantitatively controlled multigenic character and it is difficult to work with such a complex character.
2. The three most important components of yield are boll number, boll weight and ginning outturn. The number of bolls and boll weight, the primary characters to measure the genetic ability for yield, are influenced so much by growing conditions that genetics seems to be playing a secondary role. Even if the means are developed to boost productivity, the influence of growing conditions cannot be eliminated and certainty cannot be achieved, unlike toxin production in the plant.
3. The inheritance of yield is not properly understood, which handicaps biotechnologists to initiate work on yield improvement.
4. The morphological behavior of the cotton plant results in the production of many flower buds of which only a small

part is realized as productive yield. The potential for higher yields exists. Although there may be no need for increasing the upper limit, there is a need to increase the lower limit.

What is Next?

Currently, only three types of transgenic cottons are available for commercial production: Bt resistant to lepidopteran insects, cotton resistant to glyphosate (BXN) herbicide and cotton resistant to Roundup Ready (RR) herbicide. Combinations of these became available for commercial production in 1998/99. Genetic engineering has provided an opportunity to move toward directed breeding. What genetic engineering can contribute to the development of cotton in the world is probably beyond imagination at this stage. In the future, breeders and biotechnologists might be able to construct genotypes of their own choice. There will be a choice to pick and choose genes for meeting specific needs. Conventional breeding will not be eliminated but its role will change.

Not only are insecticide costs high but the availability of the appropriate gene and its expression was also a reason that insect-resistant transgenic cotton was developed first. But now, work is going on in various aspects of the cotton plant for very specific objectives. The process of inducing foreign DNA into the cotton plant has become more successful. Though there are many ways to induct a new gene into cotton, agrobacterium-mediated transformation and direct delivery of DNA with a gene gun have been commonly used in various countries. Some varieties like Coker 312 from the U.S. and Siokra from Australia can be easily regenerated by agrobacterium mediated transformation compared to others. Researchers have to transfer genes via these two varieties. But recent developments in the gene gun method have made it more popular and successful. Now hand-held gene guns are also available, which can be carried to the field to shoot grown up plants with new DNA material.

According to Monsanto, three development stages in cotton are

Agronomic stage – Like insect resistance and herbicide tolerance, other agronomic features of the plant could be improved to include resistance to a variety of other insects and pyramid resistance to any one insect.

End-use product stage – The plant system will be manipulated to produce a specific product with a higher value like very strong or long fibers, etc. Cotton in natural blue and other colors may be available soon. Reports also indicate that it is possible to produce cotton with polyester characteristics.

Biofactory stage – Cotton is grown now only for fiber production, and the bulk of the material in cotton does not have an economical use. Cotton sticks are incorporated back into the soil or used as a fuel. Some other non-traditional uses have been explored but are still not used on a commercial scale. Farmers are not paid for 60-80% of their harvest from a cotton field but only for lint. The cotton plant can be manipulated to pro-

duce specific chemicals for medicinal purposes and the crop value can be enhanced. No reports are available on the biofactory nature of the plant utility but some work is going on in this direction.

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Ultra Narrow Planting in the USA

Cotton can be planted by broadcasting seed or planting in rows. Brazil, China (Mainland), India, Iran, Pakistan and Syria are among the few countries in the world where cotton is still planted by broadcasting seed, though only in a small percentage. Broadcasting requires a high seed rate and results in an uneven plant stand in the field; it is not possible to carryout intercultural operations by mechanical means. If seed is not planted in rows, a field can only be sprayed with small manual sprayers or by aerial applications, not by using tractor sprayers that are one of the most common methods of applying insecticides in many countries of the world.

Most of the cotton in the world is planted in rows distanced at 76 centimeters (30 inches) or 102 centimeters (40 inches). The approximate area planted in 76 cm and 102-cm row-to-row distances is given below.

Row to Row Spacing in Some Countries		
Country	Approximate Area in Percent	
	76 cm (30 inch)	102 cm (40 inch)
Bolivia	-	100
Brazil	20	80
Greece	100	-
India	50	35
Iran	49	12
Israel	-	93
Pakistan	100	-
Paraguay	-	95
Spain	12	88
Turkey	100	-
USA	36	64
Uganda	30	50
Vietnam	90	-
Zimbabwe	5	85

In this table, if the planted area under 76 cm plus 102 cm rows does not add to 100%, in most cases it means that the remaining rest area is not planted in rows. However, irrespective of row spacing, cotton may be planted on flat land or ridges. The width of the bed in ridge planting may also be different in different countries. In Uzbekistan, the fifth largest cotton producing country of the world, cotton is not planted either at 76 cm or at 102-cm row spacing. About 40% of total area is planted in rows distanced 61 cm (24 inches), while 60% of the area is planted at a row-to-row spacing of 91 cm (36 inches). In Uzbekistan, 100% of cotton area is furrow irrigated. In the USA, some cotton is planted at 81 cm (32 inches) and 96.5-cm (38 inches) row spacing, but it is considered to be 76 cm and 102 cm respectively.

Ultra Narrow Row System

In countries where all cotton or most of the area is planted at 76 cm, normal planting will be 76 cm. But, in the USA normal planting is commonly done at 102-cm row-to-row spacing. Row spacing ranging from 76 cm to 91 cm is called narrow row spacing. Ultra Narrow Row (UNR) spacing refers to row-to-row spacing of 25.4 cm (10 inches) or narrower, no matter what the plant-to-plant distance is. In 1995/96, UNR cotton was grown on only about 1,200 hectares. It is estimated that about 40,000 hectares of cotton were planted under UNR in the USA during 1998/99, almost double the 1997/98 level. About half of UNR cotton in the USA during 1998/99 was in the Southeast Region. The main objective of UNR planting is to increase plant density so that the plant does not grow to form many long sympodial and monopodial branches. In the absence of long branches, the cotton plant will tend to grow taller. Under 76 cm or 102 cm planting, it is difficult to check the vertical growth of branches. But under the UNR system, excessive growth can be

checked by spraying growth regulators to force the plant into reproductive growth. It is estimated that under UNR planting, plant height will be about 60 to 75 cm approximately, 25.4 cm lower than normal planting. It has been observed that it is very important to apply growth regulators under UNR sowing. Although experiments have shown that it is not economical to apply growth regulators in every country, in the absence of a check on growth under the UNR system, plants not only become too vegetative but also the yield advantage is reduced and the lint grade affected due to higher trash content.

Objectives of the Ultra Narrow Row System

UNR planting does have a number of advantages; three main objectives of growing cotton in ultra narrow spacing are as follows:

Shorter growing season

Cotton production in the world may occur during either long or short growing seasons. A long growing season allows the plant to form bolls at a slower rate and the plant will be in the field for a long period of time. However, when the plant is in the field and forming bolls, it requires monitoring, protection from pests, and other inputs like fertilizers and irrigation. Under shorter growing conditions, yields are limited due to the early onset of cutout. Low temperatures terminate growth before the plant is physiologically exhausted on its own. The plant may still be able to form bolls without additional inputs, but it is forced to go into a cutout phase as conditions suitable for normal growth cease to exist. Under both situations, it is desirable to shorten the growing period.

Lower cost of production

If a plant is large, it requires more inputs to grow and maintain its volume. A low harvest index means less profitable production. It is one of the main objectives of UNR production to reduce production costs. If the production period is reduced by 10-12 days and yet the plant matures at a physiological cutout without losing any productive bolls, savings can be made in insecticide, fertilizer and irrigation applications.

Higher yields and better quality

In 76 cm and 102 cm spacing, the plant is made to attain some volume so that there are positions for bud, flower and boll formation. If the plant is artificially forced into the flowering stage, chances are that it may form bolls under pressure but limit its growth. A sub-standard plant under normal planting may result in lower yields. Under UNR planting, the plant will grow in an environment to remain short and form only 3-4 bolls. Fewer bolls mean a higher number of bolls on first positions, which produce better quality cotton. A shorter growing season also means that more bolls are formed under more uniform conditions compared to a longer season under conventional spacing.

Precautions of Ultra Narrow Row

Though farmers in every country are interested in reducing costs and increasing productivity, UNR cotton is not suitable for all kinds of soils and production practices. UNR may result in lower yield and, consequently, lower net income per unit area if growing conditions are not taken into consideration at the time of making a decision to go for UNR. According to Smith (1998), farmers should not plant UNR cotton under the following conditions:

- Poorly drained and cold natured soils
It is not advisable to plant UNR cotton on fields where it is not possible to efficiently drain water. Continuous standing water in fields may result in high humidity in the boll area and aggravate boll rot. Cold natured soils are prone to excessive vegetative growth.
- Fields usually heavily infested with weeds
Under the UNR system, it is difficult to control weeds, particularly under conditions where herbicide use is not common.
- Highly fertile soils
The rate of growth under fertile soils is faster than under less fertile soils. If cotton is planted in close spacing in fertile soils, the plant gains height quickly without forming flowers and bolls. By the time the plant is able to form bolls, it has already gained a height not proportional to the expected number of bolls on each plant. Greater vegetative plant volume, compared to fruiting parts, is a waste of inputs. According to Kerby (1998), UNR has proved most successful on soils where plant growth is severely limited.

Under mechanical production practices, UNR requires changes in implements. Smith (1998) indicates that management of UNR cotton production is difficult compared to conventional production at 76 cm or 102 cm. It requires a closer watch of growth behavior. It may not be possible to fix some of the changes that may have occurred and bring the plant back under control as desired. Under conditions where farmers sell lint, the advice is to consult ginners.

The application of growth regulators is almost a must under the UNR system. If the use of growth regulators has not been planned, cotton should not be planted under the UNR system.

Changes Over Time

UNR production is not a new and innovative technology. Though commercial planting may be at 76 cm or 102 cm row-to-row spacing, different plant population trials are conducted in various countries. But as planting equipment is designed for cotton at 76 cm or 102 cm, a higher population in the form of a narrower row distance is not feasible. In the USA, experiments on UNR have continued for many decades. Mayfield (1999) in his work published in 1978 indicated that the two factors limiting production of UNR cotton are (1) a reliable weed control

strategy and (2) the technology to control plant size. In the USA, there has been a significant change in methods to control weeds and also control on plant growth has increased. This is what justifies a fresh, thorough and economic look at cultivation of UNR cotton. Gholston (1998) has reported on the change in adopting the UNR production system. He compared ginner acceptance, varieties, harvesters, precision planters, desiccants, defoliant, rank growth and weed control, which were among the constraints in adopting the UNR production system in the USA. The data for 1970 versus 1998 clearly shows a significant improvement in the feasibility of UNR production in areas suitable for close spacing. In 1970, nine out of ten ginner did not like closely spaced row cotton cultivation. Though 50% still do not accept it as a good system, there has been an improvement. There has also been an improvement in varieties suitable for UNR production, as now only 20% of the varieties is not acceptable for the UNR system as against 50% in 1970. In 28 years, there has been a drastic change in the acceptance of growth regulators and in the means to control both broad leaf and narrow leaf weeds. Understanding of the physiology of the plant has also improved greatly, and herbicides have become a popular means of controlling weeds, which has converted UNR production into a feasible proposition.

Effects of Ultra Narrow Row Production System

In the advent of growing cotton at 25.4 cm and lower row-to-row spacing, crop expectations will change entirely. Though the crop will be planted at the same time, crop management practices will require adjustments. A high seed rate will be used to establish a plant population of over 200,000 plants per hectare, depending upon the distance between rows and plants. High quality seed should be used to keep a plant stand closer to the optimum. In the case of poor seeds and resulting gaps, the widely spaced plants will tend to grow bigger in volume and exhibit different fruiting behavior. Not only the number of bolls will be different but also the bolls will be formed over a longer period of time and will mature at different times. Under the UNR system, it is important to avoid gaps or missing plants.

Under the UNR system, a shorter plant height is also certain. It is hard to establish what the appropriate height is under the UNR production system; however, on average, a one-third reduction in height can be expected. Kerby (1998) noted that plant height decreased from 85 cm in 102 cm row spacing to 60 cm in 19 cm (7.5 inches) spacing in the Mid-South Region of the U.S.

Under the closer plant configuration, the fruiting pattern will change. There will be fewer monopodial branches, if any, and the length of the sympodial branches will be shorter. Shorter plants will produce fewer bolls per plant and more bolls will be formed close to the main stem. More plants will compensate the smaller number of bolls per unit area for maintaining optimum yield.

In the UNR system, any field operation destined to delay the formation of bolls is not desirable. Thus, the UNR system would require better weed control, less irrigation and low doses of nitrogen applications. Irrigation may be cut by 1-2 applications per season and nitrogen applications may be reduced by 50%. Most of the cut in nitrogen will come from the N utilized to build vegetative mass before entering into fruit formation, or to maintain a minimum growth rate even during fruit formation in conventional spacing.

If growth regulators do not have an effect on yields in conventional production, this does not mean that the application of growth regulators will not have an effect on yields under UNR spacing. UNR spacing enhances the probability of a positive impact of growth regulator applications. If growth regulators are regularly used in a particular area or soil, chances are that the land may not be suitable for UNR cotton production. If the land is found to be suitable, the use of regulators will decrease in UNR production compared to conventional spacing.

There is no country or region specifically suited for UNR production; it will depend on production practices, farm conditions and skills to manage the crop under a high plant stand. The commercially grown varieties, developed for wider row spacing, may not be suitable for UNR production; it would be quite appropriate to make changes in the varieties grown.

The success of UNR cotton lies in higher yields. According to Krieg (1996), the reason for higher yields is greater light interception and more of the total leaf area being effective leaf area. He compared light interception among UNR, narrow row and normal spacing and concluded that UNR has higher light interception per unit area followed by narrow row and normal planting. Higher yields, consequently, mean lower cost of production.

Harvesting and Ginning of UNR Cotton

One of the limitations of commercial production of UNR cotton is mechanical picking. Under machine harvesting, it is only possible to strip UNR cotton, and stripping consequently means higher trash. Thus, the availability of suitable harvesting equipment for exceptionally close-spaced cotton continues to be a challenge for commercial adoption of the UNR production system. Manual harvesting of cotton will also be harder on labor, as they have to bend lower for shorter plants to pick bolls from the bottom of the plant. No data are available on manual picking of UNR cotton.

Ginning cotton with a high trash content always irritates ginners. It seems that for a long period of time, the UNR system emphasis has been limited to the production side only—how to successfully produce UNR cotton. Ginning and the aftereffects of the UNR system in cotton spinning and weaving have been overlooked. Lately, the issue has been realized and Stanley Anthony (1999) of the U.S. Cotton Ginning Laboratory, Stoneville, MS, presented a paper at the 1999 Beltwide Cotton

**Ginning and Fiber Quality of UNR
vs Conventional Cotton**

	Conventional	Ultra Narrow Row
Foreign Matter (%)		
Initial	7.9	20.9
Feeder	3.4	4.8
Lint	2.1	1.8
Ginning outturn (%)	34.9	29.8
Classification		
Leaf	2.9	2.8
Micronaire	4.5	4.4
Fiber length (mm)	27.4	27.2
Strength (g/tex)	28.9	29.0

Conferences on ginning UNR cotton versus conventional production.

The above data are an average of ten locations in ten states. The ginning process for UNR cotton included separator/dropper, dryer, cylinder cleaner, stick machine, dryer, cylinder cleaner, combination burr and stick machine, cylinder cleaner, extractor/feeder and saw ginning, followed by two times lint cleaning. In the case of conventionally produced cotton, the combination burr and stick machine and one of the stages of lint cleaning were not used.

No data were presented but it is assumed that elimination of two machine operations certainly would have reduced the cost of ginning conventionally produced cotton. As UNR cotton was stripped, one-fifth of the total mass of seedcotton was trash, as against 8% in the case of machine-picked cotton. Even after extensive cleaning, UNR seedcotton had 4.8% trash content as against 3.4% in conventional cotton. Higher trash in UNR resulted in lower ginning outturn by five percentage points. High volume instrument classification of cotton showed no differences in leaf grade, color, micronaire, length and strength of fiber.

According to Mayfield (1999), gins that are not equipped to process UNR cotton or wish to avoid two additional processing machines have an option to process UNR by reducing the processing rate to match the capacity of the system bottlenecks. But, it will increase the hourly cost of running the gin system and lower output means higher cost per unit of lint.

Though the use of two additional machines lowered trash in the lint to less than conventional production, and the quality of cotton was found to be comparable, the effects of additional processing on the spinning, weaving and finishing of fabric need to be studied. Mr. Ken Bragg of the USDA-ARS, Cotton Quality Research Station in Clemson, South Carolina, presented preliminary data at the 1999 Beltwide Cotton Conferences, but there is a need to collect more data for making conclusions. There is a concern that spinning and weaving of UNR cotton may also require some changes.

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A DIALOG Search of the Agricola Database

The keywords used in the search are **Cotton** and **Boron**.

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Subfile: IND; OTHER US (NOT EXP STN, EXT, USDA;
SINCE 12/76)
Document Type: Article
- 3512541 20515301 Holding Library: AGL
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Banuelos, G.S., Mackey, B., Cook, C., Akohoue, S., Zambrzuski, S. and Samra, P.
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DNAL Call Number: 64.8 C883
Language: English
Includes references
Place of Publication: Wisconsin
Subfile: IND; OTHER US (NOT EXP STN, EXT, USDA;
SINCE 12/76); AR-PWA; AR-SPA
Document Type: Article
- 3507839 20512695 Holding Library: AGL
Feasibility of cyclic reuse of saline drainage in a tomato-cotton rotation
Shennan, C., Grattan, S.R., May, D.M., Hillhouse, C.J., Schachtman, D.P., Wander, M. and Roberts, B., Tafoya, S., Burau, R.G., McNeish, C. and Zelinski, L.
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Language: English
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Document Type: Article

3379170 20406337 Holding Library: AGL
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Heitholt, J.J.

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ISSN: 0190-4167 CODEN: JPNUDS

DNAL Call Number: QK867.J67 LNSU Call Number:
QK867.J67

Language: English

Includes references

Place of Publication: New York

Subfile: IND; OTHER US (NOT EXP STN, EXT, USDA;
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Document Type: Article

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Wang, Y.H. and Zhou, X.F.

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DNAL Call Number: 10 EX72

Language: English Summary Language: Spanish

Includes references.

Subfile: OTHER FOREIGN

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McConnell, J.S., Baker, W.H., Frizzell, B.S. and Varvil, J.J.

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Language: English

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3071199 91255802 Holding Library: RQF; AGL

A study of ammonia and nitrate nitrogen for cotton / by K.T.

Holley, T.G. Dulin

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Influence of boron concentration

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Place of Publication: Georgia

Government Source: State/Provincial

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Document Type: Monograph; Bibliographies

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DNAL Call Number: 100 Ar42 no.740

Language: English

Cover title.

Bibliography: p. 17-18.

Place of Publication: Arkansas

Government Source: State/Provincial

Subfile: UIU; EXP STN (STATE EXPER. STN); AR

Document Type: Monograph; Bibliographies

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Language: English

Place of Publication: Mississippi

Government Source: State/Provincial

Subfile: UIU; EXP STN (STATE EXPER. STN); MS

Document Type: Monograph

2902465 89035602 Holding Library: AZUA; AGL

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Constable, G.A. Rochester, I.J.; Cook, J.B.

Department of Agriculture New South Wales, Narrabri, NSW, Australia

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Language: English

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DNAL Call Number: QK867.J67

Language: English

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El-Aggory, E. and Monged, N.O.
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