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Contents

Introduction

Cotton is picked either by hand or machine. It is estimated that six million tons, or 30% of world production, was picked mechanically in 2003/04. All cotton is machine picked only in Australia, Israel and the USA. Over 90% of production is machine picked in Greece, Mexico and Spain. Almost three-fourths of total production is picked by machines in Brazil. In most other countries, including China (Mainland), India and Pakistan—three of the five largest cotton producing countries in the world—all cotton is picked by hand. Two types of machines, strippers and spindle pickers, are used to pick cotton mechanically. Strippers are used only in the USA. Most strippers have field cleaners, but field cleaners are not installed on all machines.

The cost of picking a ton of seedcotton varies drastically among countries. Costs are lowest in Australia and Pakistan and highest in Egypt. A lack of labor, and the high cost of labor, forces farmers to adopt machine picking. Data on machine picking vs. hand picking are not consistent, but ginning outturn, staple length, strength and micronaire can be slightly lower in machine-picked cotton. A four-row picker can harvest about 20 hectares a day, but cotton must have a uniform maturity and be defoliated before picking. Changes are also required in ginning to eliminate the extra extraneous matter picked by machines along with seedcotton. The first article on picking of cotton covers many more aspects of machine picking.

Cotton is often regarded as a heavy consumer of agrochemicals, particularly pesticides, and more specifically insecticides. The cotton plant's natural vulnerability to a variety of insects requires that proper safeguards be provided to the plant to produce maximum number of flowers and bolls. Any lapses in insect protection can result in direct losses in yield.

The Australian cotton industry decided to assess and improve the environmental impact of cotton production and processing. In 1991, the industry launched an environmental audit of various aspects of cotton production including soil preparation, irrigation, fertilizer use, insecticide use, and ginning. A private company was hired to assess the current status and suggest recommendations for improving cotton as an environmentally safe crop. The ICAC published a summary of decisions and recommendations 'Australian Cotton Industry Environmental Audit' in the March 1992 issue of the *ICAC RECORDER*. The Australian cotton industry decided to revisit the issue in 2003. The objective was to assess progress on various aspects of production and improve them further wherever possible. A summary of the second audit report is published in the second article. The full 180-page report is available at <http://www.crdc.com.au/>. Highlights of the important issues applicable to many countries are given here to encourage countries to consider the issues in the environmental audit to improve the environmental aspects of cotton production.

The success of the Australian cotton industry in meeting the challenges put forward by the first audit of the cotton industry in 1991 is based on implementation of the recommendation in Best Management Practices. The Best Management Practices have proved to be the cornerstone of improving cotton production practices and improve cotton growing as a responsible and sustainable industry in Australia. The program started at the end of 1997, and by 2002/03, 98% of cotton growers had been introduced to Best Management Practices. The third article contains details on the Best Management Practices.

The International Cotton Advisory Committee has published a book *COTTON FACTS* that is available from the ICAC Secretariat at the following address. The price of the 158 page

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Picking of Cotton

Cotton can be picked by hand or machine. It is estimated that 70% of world production is picked by hand and 30% mainly by two types of machines known as pickers and strippers. This article considers the development of mechanical picking, reasons for using machines rather than human labor to harvest cotton, prerequisites for machine picking, types of machines used, the effect of mechanical pickers on quality, and new developments in mechanical picking.

The idea of mechanical picking of cotton started around the 1850s, and slowly developed to the present day machines. Pneumatic harvesting of cotton was one of the first ideas tried where cotton was picked by either suction or a blast of air. Later, electrical cotton harvesters were tried. Electrical harvesters removed seedcotton from the plant using a statically charged belt or mechanical fingers to attract seedcotton. The third option tried was cutting the plant close to the ground and taking the whole into a machine where seedcotton was separated from the plant material in a threshing operation. Suction, statically charged belt/fingers and threshers all had disadvantages, and the prime objective of picking cotton efficiently with minimum damage to the fiber and with the least amount of trash could not be achieved.

Modern pickers are usually spindle pickers, with spindles that rotate vertically and horizontally on doffers grabbing seedcotton when the spindles come in contact with open bolls and releasing them in the back where they make their way into a basket. Stripping is a harsh process where the chances of grabbing trash and other plant parts along with dust are higher. More details on spindle pickers versus strippers will follow, but strippers are used only if spindle pickers are unable to pick the cotton well.

Stripping cotton combs the plant and takes away an undesirably high amount of trash. Pickers, or spindle pickers, seem to be the best choice thus far, as spindles catch only the fluffy cotton in the open bolls. It took almost a century to contrive the mechanical picking of cotton with pickers. The major non-technical issue related to mechanical picking in the U.S. where machines were being researched and developed, was the fear of eliminating the crop-sharing system in the country. The Rust Picker, which was being developed during the 1930s was estimated to do the job of 50-100 hand laborers, and it was feared that if the machine became successful and was adopted, the share-cropping system, popular in the South, would be abandoned and throw people out of work. Such thinking slowed the adoption of mechanical pickers, but could not stop their eventual use.

Mechanical picking of cotton in the US progressed slowly, but by 1974 more than 99% of the total cotton crop in the US was harvested mechanically. Both types of machines are still used and it is estimated that 70% of the harvest from 61% of the cotton-growing area comes from spindle picking. Twenty-nine percent of the harvest from 39% of the cotton-growing area is done by stripper-harvests.

1930	First stripper developed
1942	First spindle picker developed
1954	22% area picked by machines
1964	59% area picked by machines
1974	> 99% area picked by machines

Strippers are not popular in many countries. Argentina has less than 10 strippers while Australia and Israel use only pickers. It is estimated that the US has 500-700 strippers, which are mostly used in Texas. Most machines in the US are six-row while in Brazil most are five-row machines. In South Africa, out of a total of 250 spindle pickers, only six are four-row pickers and two are six-row pickers. No cotton strippers are used in South Africa. Some reports show that 2,000 machines were imported into Greece many years ago, but the actual number of serviceable machines in Greece and Spain is not known. The number of machines actually working in the central Asian countries is also not available. It is estimated that about 5,000 mechanical picking machines are employed in the world to pick about 6 million tons of cotton in nine countries where either all or a large area is picked by machines. Lately, the situation in Argentina has changed drastically with regard to picking of cotton. Most of the cotton area that was picked by machines has been taken out of cotton production, thus reducing the machine picked area to 15-20% of the total area. But, as the situation improves, machine picking will also gain momentum.

Picking of Cotton in the World

Country	Hand Picking (% Area)	Machine Picking (% Area)	No. of Machines
Argentina			
Northeast	65	35	
Northwest	20	80	700
Australia		100	900
Bangladesh	100		
Benin	100		
Brazil	20	80	
Centralwest		100	300
Northeast	70	30	
South	30	70	30
Southeast	50	50	20
Chad	100		
Cameroon	100		
China (Mainland)	99	1	
Colombia	82	18	27
Cordova	100		
Tolima	30	70	
Sucre	100		
Cauca Valley	70	30	
Côte d'Ivoire	100		
Egypt	100		
Ethiopia	100		
Greece	8	92	
India	100		
Iran	100		
Israel		100	300
Kenya	100		
Madagascar	100		
Mali	100		
Mexico	5	95	
Myanmar	100		
Namibia	99	1	
Pakistan	100		
Senegal	100		
South Africa	40	60	250
Spain	7	93	
Sudan	100		
Syria	100		
Tanzania	100		
Thailand	100		
Togo	100		
Turkey	95	5	
Turkmenistan	70-75	25-30	
Uganda	100		
USA		100	1,500-1,700
Uzbekistan	65-70	30-35	
Vietnam	100		
Zambia	100		1
Zimbabwe	100		5

Why Machine-Pick Cotton?

Machine picking is not the preferred choice because of its effects on quality and high costs. Picking machines are expensive and require maintenance and repair. In addition, the need to defoliate cotton prior to machine picking adds to the cost of picking. Nevertheless, machine picking becomes necessary for two main reasons:

- Picking labor is not available on time, and hand picking will considerably delay finishing the job. The labor problem could be related to more production than the available labor can handle or an improvement in the social status of available laborers and their refusal to continue doing that kind of job. Leaving cotton unpicked in the field for a long time brings deterioration in quality, and storms and rains could result in a disaster. It is also important to finish picking as early as possible, or the crop that is to follow cotton will not have enough time for planting, or a delay in planting could result in significant losses in yield. Wheat planting after cotton is a perfect example of such conditions.

Cost of Picking a Ton of Seedcotton

Country	Cost (US$)
Australia	19.8
China (Mainland)	20.5
Egypt	125.0
India	66.0
Mali	49.3
Pakistan	24.2
Sudan	68.1
Syria	72.0
Turkey	94.7
Uganda	11.3
USA	54.0

- Labor is available but it is too expensive to hire for hand picking cotton. Under the circumstances, when daily wages are high, machine picking is an economically attractive option. Argentina is the best example where statistics show that it is less expensive to pick cotton by machines. This is also the reason why Turkey is considering adopting machine picking and Australia, the US, and other countries adopted machine picking.

Some other reasons, one of which would specifically apply to the Central Asian countries prior to the break up of the Soviet Union, could also dictate machine picking of cotton. The Soviet system managed large agricultural farms in the five cotton-producing republics, and all agricultural operations were mechanized. Large agricultural farms required huge numbers of people to pick cotton but this was not possible as alternate jobs were available in abundance. These republics could produce cotton only if it was picked by machines.

The data below indicate that it is most expensive to pick cotton in Egypt. The labor may be inexpensive, but the cost is high due mainly to the high emphasis on quality and the efforts to pick minimum trash along with the cotton. Hand picking costs are low in China (Mainland) and Uganda because wages are low. The cost is lower in Australia due to higher yields.

Prerequisites for Machine Picking of Cotton

It is common to pick the same field two to three times in countries where cotton is hand picked. In some countries, like China (Mainland) farmers can afford to pick by hand more frequently, visiting the field every few days. Picking open bolls more frequently is practiced by most farmers, particularly in the Yellow River and Yangtze River Valleys. Leaving the open bolls in the field, after they are ready for picking, leads to lower quality. Weather effects, in addition to dry leaves sticking to open bolls, adds additional trash and damages quality. Green leaves on the plant also have a negative effect on quality by maintaining high humidity in the open boll area and secreting plant sugars that stick to the cotton. Thus, it is desirable to pick cotton as soon as it is ready.

Cultural Practices

Machines currently available require that cotton must be planted in rows, and the rows should be spaced at a specific distance from each other. It is estimated that more than 20% of machine time is utilized to empty the basket and on turns in the field. How frequently the basket is emptied depends on the yield in the field, but the number of turns can be reduced by planting longer rows. Smaller fields of 100 meters in length are not suitable for machine picking. So machine picking is only suitable for large growers. Small farmers' cooperatives can have machine picking if the cotton is planted in contiguous blocks close to one sowing date, or similar behaving varieties are grown with the least variation in input applications. Proper weeding is a must for machine picking. It is not important if weeds are killed by herbicides, mechanically, or manually, the field should not have green leaf weeds at the time of picking, as they entangle the spindles and hinder picking in additional to affecting cotton quality.

Suitable Varieties

Not all varieties are suitable for machine picking. Extremely tall and extremely short varieties and varieties with cluster fruit bearing (close to the main stem) are not suitable for machine picking. Cotton to be machine picked should not bear fruit close to the ground either. The first productive boll should be at least 15 centimeters from the ground. The number of monopodial branches should be minimum or preferably zero. The sympodial branches should not be too long. The ideal fruiting pattern will be with 80% of the yield coming from the first position bolls while 15-20% come from the second position bolls and very little from the third position bolls. The most appropriate height of the plant for machine picking is 90-100 centimeters so that 18 or 20 vertical spindles are able to reach all open bolls. The varieties must have a fluffy opening so that the spindles can easily remove cotton from the burrs. Shy or closed opening with locks securely held in between the burrs will have a negative effect on the machine's efficiency.

Defoliation

Most of the cotton (70-80%) is picked in the first pick, if cotton is picked by hand. Remaining bolls can be picked in only one or two more rounds. However, machine picking is done only once. Waiting until the last boll is ready for picking on its own could have a significant effect on quality. Chemicals can be sprayed to defoliate the crop for enhancing boll opening and to reduce the open boll stay in the field. Defoliation of the crop is necessary for machine picking so that all the cotton is picked in one trip. Defoliation has its own consequences in addition to adding to the cost of production, but it is a prerequisite for machine picking. Defoliants enhance the formation of an abscission layer between the leaf petiole and the stem/branch. Plants without green leaves open mature bolls faster than plants with leaves. Chemicals are also available and are sometimes used that have a direct effect on the bolls. Too-early defoliation and forced opening of bolls can produce immature fibers. It is usually recommended that defoliants be used only when at least 60-65% of the bolls (that are productive) have already opened.

Uniform Crop Maturity

Bolls on the plant are formed for weeks. The effective fruiting period can extend from 40-80 days depending on the variety, suitable weather conditions, and the physiological ability of the plant to form bolls. Bolls will open when they have received enough heat units, and accordingly bolls will open at different times. Boll formation time also determines the location of bolls on the plant, i.e., first, second, or third position on the branch and also what branch number. Shortening of the boll formation period and improved crop maturity can minimize position effects and the effect of weather on fiber quality. Input applications should be managed so that most bolls open within a specified time.

Ginning Adaptation

The continuous moistening of spindles adds humidity to seedcotton already carrying undesirably high amounts of trash. Ginning must adapt to high humidity and trashy cotton.

Special Requirements

Growing conditions like those in the High Plains of Texas, USA, where on the average cotton is grown on 1.5 million hectares, require that varieties be resistant to storms. If weather conditions at the time of picking change to windy and cold or rainy and snowy, cotton can be blown from the bolls if the varieties are not storm resistant. Storm resistant varieties are shorter in height and are able to hold cotton in burrs for a longer time. But it is difficult to pick such cotton; hence stripper machines are used in these areas. Similarly, Australian growing conditions require that irrigation be properly managed to maintain required plant height and growth.

Diploid species are grown only in a few countries like India, Iran, Myanmar, Pakistan, and Thailand. Diploids are nowhere picked by machines nor are they suitable for machine picking. Most cultivated *G. arboreum* varieties cannot hold cotton in burrs even for a few days after the bolls open. Six to eight hand pickings are common in *G. arboreum* varieties otherwise cotton will fall on the ground, rendering them unsuitable for machine picking. *G. herbaceum* varieties usually have smaller bolls and cotton is so firmly held in the bolls that they are simply not suitable for mechanical picking. Among cultivated species, *G. herbaceum* varieties are the most difficult to pick by hand or machines.

Preparing for Picking

A good healthy laborer can pick 30-45 kg of seedcotton by hand per day, and about 100 people will be able to pick a hectare with an average yield of about 3,000 kg of seedcotton. A two-row picker is equivalent to 1,000 hand pickers per day. A one-hour stop of a two-row picker is equivalent to about 125 manual work hours. Thus, utmost care needs to be taken so that machines do not break down during operations. South Africa has produced training videos on hand and machine picking. Many other countries produce special pamphlets with instructions for proper picking of cotton. Harvesting should be delayed until the dew has dried, and the relative humidity has dropped below 60%. Lint moisture should not be more than 10%. Spindles, moistener pads, doffers, bearings, and bushings should be checked before the picking season starts. All spindles that are worn should be replaced and all spindles should be properly aligned and adjusted to moisture pads and doffers. Picking machines should be lubricated, and contamination of cotton with grease should be avoided.

Mechanical Picking Machines

There are only two kinds of cotton picking machines in commercial use: strippers and pickers. Strippers are usually used under low yield conditions for picking storm resistant varieties. Pickers are available in various designs starting from two-row to six-row pickers. For the sake of maintaining fiber quality, it is desirable to finish picking within a window of 30-40 days. The size of the machine used will determine the time taken to finish picking. Most machines in the US are six-row pickers, but there are lower-productivity machines in use thus resulting in an average of about 5.5 rows. Average speed in the field for a picking machine is 6-7 kilometers per hour, and the average productivity for a two-row picker is about ten hectares per day. Similarly, a four-row picker will be able to pick 20 hectares per day, which equates to about five hectares per day per picking unit on each machine. Speed weather and field conditions have significant effects on the productivity of a picker. Bigger baskets can save on unloading time.

The two major manufacturers of mechanical picking machines in the world are Case IH and John Deere. They are both based in the U.S. with a little production in Argentina and elsewhere, the latest being in Uzbekistan by Case IH. Picking machines used to be manufactured in Uzbekistan during the Soviet era, but these machines were used only in the cotton producing republics. No new machines have been manufactured for many years, and spare parts for the old machines are not available thus increasing the need for hand picking in Azerbaijan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan.

Montenegro et al. (2003), of Argentina presented a paper at the World Cotton Research Conference-3, held March 9-13, 2003, in South Africa, in which he compared a new stripper shaker system with a picker (JD 9900) with regard to their efficiencies and comparative effects on quality. The cotton variety Deltapine 50B was planted and treated the same way then harvested by the two different machines. The trial was replicated three times. The Stripper Shaker is basically a stripper platform header with injectors carrying pressurized air. The vibrating rollers shake the plant to make seedcotton fall into a vacuum hopper. A transporting unit carries cotton to a cleaning drum that blows the cleaned cotton into a basket. After picking, cotton that fell on the ground and was left unpicked was collected and weighed. Seedcotton loss in the Stripper Shaker system was 34.3 kg/ha, compared with 310 kg/ha in the case of the picker. The 9% loss of seedcotton in picker-harvested cotton (as against 1% in case of the Stripper Shake system) is due mainly to leaving cotton un-picked on the plant not to cotton falling on the ground. The Stripper Shaker-picked cotton contained 13.9% foreign matter (which reduced losses) vs. 7.7% from the picker. Similar processing for removal of foreign matter reduced undesirable material to significantly lower levels in both treatments, but minor differences remained even after cleaning. As expected, ginning outturn was lower in the Stripper Shaker System, that is, 29.5% vs. 32.4% for the picker. There was no effect on fiber quality parameters other than micronaire, which was lower in the Stripper Shaker system due to picking all bolls all the way to the top of the plant.

Mechanical picking of cotton can produce two types of losses in yield: cotton left un-picked on the plant and cotton that falls on the ground during picking. No machines are able to pick cotton up from the ground. Losses will vary depending on many factors like machine type, variety, defoliation, weeds, ground speed, condition of spindles, spindle speed and their humidification for removing seedcotton. On average about, 10% of cotton is left un-picked in the field, 3% on the plant and 7% on the ground.

John Deere and two other small companies in the U.S. manufacture strippers. Strippers may be Finger Head or Brush Roll, and it is estimated that 90% of the strippers in the US are Brush Roll type. Brush roll strippers are preferred due to the fact that they are flexible for harvest conditions, have higher harvest efficiency, pick less trash and can pick more rows at a time. Strippers may or may not have field cleaners. Field cleaning of stripped cotton improves ginning output by almost 10% thus reducing the time to empty the basket, improve machine efficiency, and reducing the bulk to be carried to the gin. Field cleaners are not yet standard equipment, but it is estimated that over 90% of the machines already have field cleaners.

Bennett et al. (1995), also concluded that burr and stick percentages can be significantly decreased and lint percentage increased by using field cleaners. Field cleaning showed no effect, either positive or negative, on fiber quality characteristics. But the question remains as to whether it is economical to use field cleaners and get rid of most burrs and sticks in the field or removes them at the gin.

Effect of Machine Picking on Fiber Quality

Hand picking is best as it provides a soft action on the seedcotton to be removed from burrs where it is protected against weather for 7-8 weeks. As bolls burst and expose seedcotton to direct weather, fibers and seed begin to dry and prepare to be removed. Fibers dry earlier than seeds. If the seeds are not properly mature, not only is the germination process affected but also the seed coat can be broken easily during ginning, thus increasing seed coats neps. Defoliation forces some bolls to open before they are ready, and forced opening has consequences on fiber quality. Additional cleaning to remove extra trash also affects fiber quality. The affect could be enormous if the necessary steps are not taken to preserve quality.

Brashears and Baker (2000) compared a finger stripper with a brush roll stripper and a spindle picker. They observed that the spindle picker had lower burrs and sticks compared to strippers. The brush roll stripper was found to have significantly lower sticks and longer fiber length compared to the finger stripper. The picker was significantly better than both types of strippers, which could be due to higher processing in the stripper harvested cotton. However, picker cotton showed significantly higher micronaire values over stripped cotton. Nep counts were significantly higher in finger stripped cotton compared to the brush roll stripper and significantly lower in picker picked cotton. Picker harvested cotton can be compressed to a higher density than to stripper harvested cotton.

Turkey is in the process of adopting machine picking and for many years has researched the suitability of Turkish varieties for machine picking. Turkey also investigated the effect of machine picking on fiber quality and ginning output. Kaynak et al. (2000) undertook a study of four varieties from four cotton-growing regions in Turkey and two varieties of Deltapine origin. Six varieties were planted at the Adnan Menderes University in Aydin, Turkey, on the same date and similar inputs were applied. The only difference was that one plot of each variety was picked by hand and the other with a mechanical picker. A defoliant was applied when 60% of the bolls had opened, and cotton was picked when all leaves had dropped. Hand picking was done twice; first when 60-70% of the bolls had opened and again when all the remaining bolls had opened. Data were recorded for harvest losses, trash content, ginning output, fiber length, strength, and micronaire.

Kaynak et al. (2000), observed that there is no urgent need for developing new varieties for machine picking though the data from the US suggest that some varieties consistently show higher foreign matter compared to others grown and harvested by the same methods (Brashears and Baker, 2000). Brashears and Baker attributed higher trash in a particular variety to taller plant type and longer fruiting branches. Kaynak and his colleagues found that current Turkish varieties and the two Deltapine varieties adopted for commercial production in Turkey are suitable for machine picking. Turkish varieties showed higher pre-harvest and post-harvest losses, but the differences were insignificant and losses are dependent on so many factors are not reported here. The same is true for trash content and it is clear that mechanical picking results in significantly higher trash in seedcotton. The data for four other characters on the basis of the average of six varieties showed that ginning outturn, length, strength, and micronaire were lower in machine picked cotton. All varieties exhibited the same trend for all characters. Lower values are not the direct affect of a picking machine; rather it is the effect of readying the field for machine picking and the extra processing required to get rid of trash.

Hand Picking vs. Machine Picking

Characteristic	Hand Picking	Machine Picking
Ginning outturn (%)	40.7	37.7
Fiber length (mm)	29.2	28.5
Strength (tppsi)	81.0	80.2
Micronaire	4.4	3.6

A lot of data are available from the US on the effects of machine picking on fiber quality. Brashears and Hake (1995) compared stripper picking with and without field cleaners with a picker. Two varieties (Paymaster HS26 and Stoneville 123) were included in the trial, and samples were taken and analyzed for extraneous matter particularly burrs, sticks, fine trash, lint percentage and fiber quality characteristics. Harvesting methods showed a significant effect on lint outturn that was the highest in picker-harvested cotton followed by stripper with field cleaners. Burr contents, sticks, and trash were the highest in stripper-harvested cotton without field cleaners. Burr contents were reduced from 21.7% in strippers without field cleaners to 3.4% in picker-harvested cotton. A similar trend was seen for sticks and fine trash in both varieties. Picking methods did not show any effect on quality characteristics. Data for some characteristics on Paymaster HS26 are given below.

Effect of Picking Methods on Various Characteristics of Cotton

Characteristic	Picking Method		
	Stripper Without Field Cleaner	Stripper With Field Cleaner	Stripper
Lint Turnout (%)	23.2	28.3	34.2
Burs (%)	21.7	10.2	3.4
Sticks (%)	2.3	1.7	0.6
Fine Trash (%)			
Before Cleaning	4.5	3.7	2.9
After Cleaning	2.9	2.6	1.8
Staple Length (mm)	34.8	34.9	35.3
Micronaire	4.4	4.4	4.5
Strength (g/tex)	29.8	28.9	28.1
Length Uniformity (%)	83.1	83.0	82.7

Future Directions

Mechanical picking of cotton is continually improving. Since the initiation of spindle picking in the 1940s, improvements have primarily focused on increasing the number of rows picked in one pass and an increase in travel speed with the ultimate objective of reducing the cost of harvesting. Spindle speeds have increased and diameter and length of spindles have decreased. Thinner spindles result in tighter fiber raps around the spindle, but progress in other aspects still continues.

Lately, a variable-row system has become available that can be used in ultra narrow systems as well as in regular line spacing. The greatest challenge for machine picking of cotton is to keep improving the process of grabbing cotton from the plant. The U.S. experience shows that consolidation within the cotton industry has led to fewer producers managing larger areas. The number of active gins in the US has decreased from over 4,000 in the late 1960s to only about 1,000 now. Similarly, US growers are looking for cotton pickers that will harvest a greater area and do it faster. One such approach is to pick more rows in a run. Reducing or eliminating the time to off load the basket can significantly improve the efficiency of a machine. Six-row machines with a collection basket capacity of close to five tons of seedcotton have already been developed. It would be more desirable to eliminate the need for stopping by developing a mechanism whereby the basket can be emptied while the picker is moving in the field.

Mechanical pickers require regular maintenance that consumes time and resources. The operator has to make sure that pressure door settings are properly positioned for assuring best push of cotton against spindles, that the moisture column is properly adjusted, that all doffers are uniformly positioned, gears and spindles are properly lubricated, wetting drums are normal, etc. But all these chores mean not only additional hours of work but also a delay in finishing the picking. Future machines should require a minimum of daily maintenance and less frequent replacement of parts, such as spindles.

It is desirable to eliminate the additional trash in cotton picked by machine. If it is not eliminated, the cotton is unfit for spinning. Future machines should have the ability to pick with a minimum amount of trash. Also, green bolls should not be picked along with cotton.

The ground speed of the tractor cannot be increased with the current generation of machines because higher machine speed in the field means a higher speed for the spindles. Higher spindle RPMs throw more cotton away rather than grabbing and carrying it to the collection basket. Future machines should be able to pick with the least amount of loss at higher speeds.

All leaves are shed as they mature but varieties differ in their ability to shed leaves without the use of chemicals. Varieties can be developed that are able to shed leaves faster and automatically once they reach the 60% boll-opening stage. Varieties can also be developed that have minimum re-growth.

Better machines and perhaps varieties of cotton specifically developed to meet the needs of those machines will be the answer to cost-effective and efficient harvesting of cotton.

References

Bennett, Blake K., Sukant K. Misra, Alan Brashears and Tracy L. Dowty. Effect of burr extraction on trash in seedcotton and fiber quality for different harvesting dates. 1995. *Proceedings of the 1995 Beltwide Cotton Conferences*, Volume 1, 649-52, National Cotton Council of America, Memphis, TN 38182, USA.

Brashears, A. D. and K. D. Hake. 1995. Comparing picking and stripping on the Texas High Plains. *Proceedings of the 1995 Beltwide Cotton Conferences*, Volume 1, 652-54, National Cotton Council of America, Memphis, TN 38182, USA.

Brashears, A. D. and R. V. Baker. 2000. Comparison of finger strippers, brush roll strippers and spindle pickers on the Texas High Plains. *Proceedings of the 2000 Beltwide Cotton Conferences*, Volume 1, 452-453, National Cotton Council of America, Memphis, TN 38182, USA.

Kaynak, M. A., A. Ünay, I. Özkan, H. Basal and E. Bayindir. 2000. *Proceedings of the Joint Workshop and Meeting of the Interregional Cooperative Research Network on Cotton for the Mediterranean and Middle East Regions*, September 20-24, 2000, Adana, Turkey.

Kevin D. Baker, S. Ed Hughs and James Mackey. 2003. Quality of spindle picked cotton. *Proceedings of the 2003 Beltwide Cotton Conferences*, Volume 1, 2523-27, National Cotton Council of America, Memphis, TN 38182, USA.

Montenegro, A., O. M. Royo and A. P. Fernandez. 2003. Fiber quality, gin and harvest efficiency evaluation of a new stripper shaker system compared to the picker system. *Proceedings of the World Cotton Research Conference-3*, Cape Town, South Africa, March 9-13, 2003 (In press).

Second Environmental Audit of the Australian Cotton Industry

The cotton plant's natural vulnerability to a variety of insects requires that proper safeguards be provided to produce maximum yields, within the constraints of physiology and growing conditions. Because cotton needs to be protected at both, the vegetative and reproductive stages, it is a heavy consumer of agrochemicals, particularly pesticides, and more specifically, insecticides. The use of chemicals on cotton results in high environmental costs.

In 1991, the Australian cotton industry decided to assess and improve the environmental impact of cotton production and processing. The industry undertook an environmental audit of various aspects of cotton production, including soil preparation, irrigation, fertilizer, insecticide use, and ginning. A private company was hired to assess the then current status and suggest recommendations for improving cotton as an environmentally safe crop. The ICAC published a summary of conclusions and recommendations entitled "Australia Cotton Industry Environmental Audit" in the March 1992 issue of the *ICAC RECORDER*. Last year, the Australian cotton industry decided to assess progress in various areas and to seek improvements wherever possible. The full 180-page report on the second Australian cotton industry environmental audit is available at <http://www.crdc.com.au/>. In this article, highlights of the important issues applicable to many countries are discussed, with the objective of encouraging more countries to follow the example of the Australian cotton industry and contribute toward improving the environmental impact of cotton production in the world.

The Second Australian Cotton Industry Environmental Audit rated the compliance with 1991 audit recommendations and also made new recommendations on the management of water use, pests, pesticides and other chemicals, land, waste, air emissions and many other aspects of ginning. The audit was undertaken by GHD, a private company. Information sources included meetings with concerned authorities, review of literature, surveys of and interviews with stakeholders, workshops, and inspection of selected farms, gins and other facilities connected to the cotton industry. The audit team visited 32 farms in two cotton producing states. These farms accounted for about 3% of all cotton farms in Australia. There are 40 gins in Australia; the team visited seven gins across New South Wales and Queensland.

Cotton Production System in Australia

Cotton is grown in the State of New South Wales and Queensland. The Australian cotton production system is different from those of other countries. About 90% of the total cotton area is irrigated, and only 10% is rainfed, located about equally in both states. Only 1% of cotton farmers own less than 100 hectares. Eighteen percent of farmers own 100 to 400 hectares, while 63% of Australian cotton growers own more than 400 hectares. Cotton production is highly mechanized, with all cotton harvested by machines. The national average yield, including rainfed areas, is either the highest in the world each year, or the second highest after Israel. New South Wales contributes about two-thirds of the total production in the country. Irrigated yields are almost three times higher than rainfed yields. The numbers of sprays on non-transgenic varieties averages about 10 per season and are mainly used to control *Helicoverpa armigera* and *Heliothis punctigera*. Transgenic cotton was adopted in 1996/97, and as of the 2003/04 season, 30% of available cotton growing area was planted to transgenic varieties. Varieties developed by Australian breeders and of Deltapine origin are grown on a commercial scale. Fusarium wilt is a major concern.

Compliance with 1991 Recommendations

The first audit made 69 recommendations, of which 49 were related to cotton farms. Some recommendations are no longer valid, due to changes in production technology or operating procedures. However, the audit team observed that all recommendations were implemented to some degree. Seventy-five percent of the farm-level recommendations showed high compliance, 20% partial compliance and 5% low compliance. Five out of 49 recommendations that were regarded as not directly applicable to farms related to changes in legislation.

Irrigation Water Use and Management

Cotton consumes 16% of all irrigation water used in Australia. It is estimated that seven megaliters-ML (one million liters) of water are used to grow one hectare of cotton. This is comparable to other crops in Australia. Rice requires more water, but in Australia, sugarcane and cotton consume the same quantity of water. In most countries water uses in sugarcane is higher than for cotton. However, the audit reported that cotton has a higher water use efficiency of A$452/ML, compared to A$31/ML in rice and A$21/ML in sugarcane. The surface area for water storage often varied from 50 to 100 hectares, with a national capacity of up to 3,800 megaliters. Many farmers have more than one storage facility.

Evaporation and leakage are natural sources of loss in the open storage of water. Farmers have tried to minimize losses by various means, such as: lining storage facilities with bentonite, clay or other liners; making deep storages for reducing surface-to-volume evaporation; using local dams and reducing on-farm storage. Farmers have also used electromagnetic surveys to detect potential leakage and have conducted geophysical analysis for leakage testing. Smaller growers owning 100-200 hectares were not usually aware of the actual evaporation and leakage losses. Studies have shown that storm water is the main source of pesticide transportation from fields. Farmers recognized the issue, and now most farms have storm water runoff collection facilities.

Water quality is measured for conductivity, nutrients, pH and a range of cations and anions.

The availability of water and the cost of water are driving farmers to enhance water use efficiency. Average irrigation efficiency in cotton is about 57%. Significant efforts are being made to improve water use efficiency by tail water collection and reuse, laser leveling, increasing water flow by increasing the number of siphons, selecting varieties that require less water, skip row ridge planting and participating in research and training courses. Economic analysis shows that farmers who achieve the highest farm operating profits have the highest water use efficiency. These farmers used half a megaliter per hectare less water than others.

Water Management Recommendations

The following recommendations for water management were made by the auditors:

- Wherever possible, deeper water storage facilities should be built to reduce evaporation losses. Storage facilities should be lined.

- Farmers should be encouraged to calculate the volume of water lost and to calculate economic losses through evaporation from storage facilities and distribution channels.
- Growers should assess the sources of water loss and work to improve water use efficiency. Water loss as well as usage should be quantitatively measured.
- Growers should be encouraged to participate in water and irrigation management courses. Irrigation application methods should be improved based on recent research.
- All tail-water should be retained on farms within 10 years.
- Storm water management systems need to be improved on most farms. Rainfed farms should also have such facilities.

Pest Management

The Australian cotton industry has suffered a lot due to heavy insect pressure, particularly from the bollworms *Helicoverpa armigera* and *Heliothis punctigera*. Insecticide use increased to unacceptable levels, but thanks to resistance management strategies, the bollworm complex has been brought under control. The Australian resistance management program is considered one of the most successful in the world, having proved its worth even before the adoption of Bt cotton, called Ingard in Australia, in 1996/97. Lessons learned from the insecticide resistance problem and early understanding of Bt gene resistance to insecticides led Australia to limit the area devoted to Bt varieties to 30% of the total cotton area. Australia is the only country to voluntarily impose a limit on the area planted to Ingard. 2003/04 is the last year of this condition, as the double resistance mechanism (Bollgard II) varieties have already been approved in Australia, and Bollgard II varieties will replace all Ingard varieties by 2005/06.

Transgenic varieties have been used in Australia as an important component of an integrated pest management (IPM) strategy to reduce the use of insecticides. A number of other IPM strategies, such as selective insecticides, rapid decomposition insecticides, trap cropping, higher threshold levels, increased emphasis on beneficial insects, avoidance of pyrethroids as far as possible, area wide management of insects via collaboration with neighboring growers, etc., have been adopted since the first environmental audit of the cotton industry. Farmers acknowledge that the application of IPM recommendations has reduced the number of sprays needed, even on conventional varieties. A report from the Australian Cotton Research and Development Corporation shows that the quantity of pesticides used has been almost halved in the last 10 years, from over six kg a.i./ha to close to three kg a.i./ha in 2001/02. Pesticides were used in much higher quantity in 1998/99 due to severe pest pressure. A significant impact of IPM practices is the reduction in pesticides used on Ingard cotton. For more details on pesticide use in Australia, refer to the article on “Implementation and Impact of Transgenic Bt Cotton in Australia” published in December 2003 issue of the *ICAC Recorder*.

Farmers strictly observe windows for application of specific chemical groups as advised by experts under the Insecticide Resistance Management Strategy. The audit team verified the same through spot checks. The audit noted improvements in the management of spray drift. Weather monitoring during spraying and weather stations on farms have contributed to minimizing spray drifts. A number of research projects have been sponsored by the industry to investigate ways to mitigate the effect of spray drifts. Some of these include optimization of large droplet placement technology for aerial application for insecticides in cotton, potential for long distance endosulfan drift, improved pesticide application performance, development of guidelines for ground-based spray applications, enhancing access to climate and weather data, use of electrostatic nozzles on aircraft and helicopters, etc. A network of weather stations has been established and used by aerial spray operators before spraying in a particular area. Aerial spraying is done on significant areas in Brazil, Mexico, Sudan and the USA, and at least on some area in Colombia, Israel, Madagascar and South Africa. In Australia, all cotton is sprayed from airplanes, and the New South Wales Pesticide Amendment Regulation (2001) requires a record of weather conditions before application of pesticides. The audit observed that almost 90% of farmers keep good records of pesticides used throughout the growing season. Details included chemical name, date, applicator, area treated, quantity used, wind speed and direction. Approximately 75% of farms also maintained maps showing sensitive areas on the farms (to be avoided during spraying) for aerial spray operators. Specific instructions, such as no spraying during northeastern winds and/or school bus hours, were also observed.

A set of recommendation contained in Best Management Practices (BMP) have significantly improved pesticide storage practices on farms since 1991. Pesticides are now stored in designated lockable storage facilities. Farmers have reduced on-farm store of pesticides as much as possible by ordering only as required. Farmers have also improved the disposal of unused chemicals, either by returning them to pesticide companies or disposing of them through ChemCollect and Chemclear programs.

Helix (Chlorfluazuron-CFZ) was sprayed on cotton in 1994, and due to the shortage of cattle feed (due to drought), 30,000 tons of cotton gin trash was fed to cattle. CFZ residues accumulated in the fat, and endosulfan was detected in the meat. Consequently, Australia suffered losses in meat exports to other countries. The cotton industry’s awareness of its impact on the environment convinced farmers to voluntarily stop using Helix. Stricter conditions were applied regarding the use of endosulfan on cotton. The industry also decided not to feed gin trash to cattle. This reflects the high level of awareness the environmental audit has brought to cotton in Australia. The audit recommended that cattle should be prevented from having direct access to cotton fields during or after cotton has been picked.

Pest Management Recommendations

The following recommendations were made regarding management of pests and pesticides:

- The audit team noted that some farmers grow cotton only intermittently and thus do not implement IPM in the same way as regular cotton growers do. The audit recommended that intermittent cotton growers be encouraged to follow the same IPM principles as annual cotton growers.
- The Australian cotton growers are advised by private consultants because there is no regular extension service from the federal or state governments. Consultants do not consistently record beneficial insects. The audit recommended that farmers record beneficial insects.
- Comprehensive checks of spray records should continue to be conducted during audits of Best Management Practices to make sure that farmers comply with the Insecticide Resistance Management Strategy. Education and strategies should target farmers who do not fully comply with the resistance program.
- Not all growers maintain and update annually a pesticides application management plan. The recommendation is that cotton growers should cover all pesticides and inform neighbors about their pesticide application plans.
- Pesticide storage has improved, and any remaining storage on wooden floors or porous material that can absorb pesticides should be stopped. Ventilation of storage facilities should be improved and wherever possible storage should be built in the shade to avoid unwanted increases in temperature. Old or unused chemicals that are not intended to be used should be removed and disposed.
- Incompatible chemicals should be segregated while in storage.
- There is a need to improve emergency plans to deal with spills and contamination. Almost one-third of farms have such plans. Material Safety Data Sheets should be available for individual chemicals and be properly tagged in the folder for quick identification in case of any emergency.
- Australian citizens submit complaints and concerns to the state environmental agencies regarding pesticides uses. The audit recommended that such complaints be compiled and used as an indicator of pesticide use performance. A procedure should be formulated to create consistent data from complaints received.
- The audit also looked at chemicals other than pesticides and made many recommendations regarding storage of diesel, gasoline and other chemicals used in the cotton production chain.

Waste Management

Most farmers prefer to use containers that are returned after use. Australia started a program in 1999 called “DrumMUSTER,” in which farmers are able to return triple rinsed containers to new collection points. This system is a great improvement over burying containers, which was a common practice in 1991.

In most other countries, responsible companies crush the drums at formulation sites and deliver the crushed material to smelters for molding into machinery. Farmers are advised to cut retail plastic (PET or COEX) packaging material into pieces or to bury them underground without cutting. [In countries with small scale farming systems, empty pesticide containers can be seen lying on the ground. No statistics are available, and the percentage is expected to be very low, but it is possible that pesticide containers are used for carrying or storing non-human consumption materials. The rare use of empty pesticide containers to carry human-related goods is not beyond imagination. Most countries have no collection or recycling systems, particularly for insecticides made available in smaller packs for smaller areas.]

Waste Management Recommendations

- The audit recommended that the Australian cotton industry work with the chemical manufacturers and to maximize the use of reusable containers. Efforts to collect and properly recycle containers should be enhanced, and burying underground should be stopped. The disposal of pesticide containers should be made a component of Best Management Practices. The audit recommended that other wastes, such as workshop waste and waste oil, should be recycled wherever possible or otherwise disposed of in an environmentally safe way.
- At present, pesticide containers are washed and then delivered or disposed of. The washout water is used in the tank if washing is done during spraying; if washing is done later, the washout water is directed to secure evaporation pits. The audit recommended that such pits should be lined with thick plastic liners and disposal of washouts, which is already a part of the Best Management Practices manual, be further encouraged.

Land Management

The Australian cotton industry has improved in managing erosion, avoiding soil compaction and salinity, and disposing of cotton stalks. It is estimated that 64% of farmers slash and recycle cotton stalks; 31% pull, mulch and incorporate; and only a small percentage of growers rake and burn stalks. Grazing of cotton fields has stopped since pesticides were detected in meat many years ago. Laser leveling, which has become a common practice, zero or minimum tillage and prevention of storm water run-off onto adjacent fields have all helped control erosion. The audit team observed that erosion seems to be adequately managed at most farms. Stalk incorporation into the field has helped reduce soil compaction, but a number of other measures have also been adopted to minimize compaction. Recent studies show that in certain areas, 12% of growers had a salinity concern, while 6% were concerned about the rising water table on their farms. Farmers conduct soil tests annually, including the salinity status, particularly in irrigated fields. The ground water level is regularly monitored.

Land Management Recommendations

Below are recommendations for improving land management practices:

- Irrigation water should be tested regularly for conductivity (salinity) and sodicity, particularly in areas with a high potential for salinity problems. The Best Management Practices approach should also include assessment and management of vegetation on farms.
- Livestock access to rivers and creeks should be managed to prevent erosion and degradation of stream banks.

Air Emission - Recommendations

The report says that there are no accurate figures on the quantity of greenhouse gases being produced by the Australian cotton industry. Oxidation of nitrogenous fertilizer releases nitrous oxide, and the burning of cotton mulch in fusarium-affected fields adds carbon monoxide to the atmosphere. It is assumed that information on how much greenhouse gases are released into the environment by cotton-related operations is not available from any country. Australia is currently undertaking studies to establish benchmarks for greenhouse gases from cotton farming.

Energy - Recommendations

The audit concluded that energy requirements of producing cotton have not been assessed properly. The audit recommended that the cotton industry assess overall energy use and develop guidelines for cost savings. The audit also recommended that the industry consider a project on life cycle assessment of cotton compared with synthetic fibers.

Health and Safety - Recommendations

After mining, agriculture is the second most dangerous occupation in Australia. Studies undertaken in 1996 found that cotton-related farm injuries were almost three times more common than injuries in some other components of agriculture. The National Farm Injury Data Centre found in 2001 that most farm-related injuries are due to machinery and equipment maintenance. A number of good farm safety recommendations have been made and adopted by the cotton industry. They include maintenance of a farm safety manual, development of emergency plans and procedures, first aid training and the development of safe operating procedures for equipment.

Transfer of Information - Recommendations

Over 90% of cotton industry personnel have access to the internet and are very receptive to new information. A range of newsletters and other publications are available on a regular basis to facilitate transfer of research results to farmers. A number of information packages, such as CottonLOGIC for insect pests and nutrition, Weedpak, SOILpak, MACHINEpak and SPRAYpak, are available to farmers. A one-on-one approach has been found effective, and the audit has recommended enhancing the number of field personnel for introducing the Best Management Practices Land and Water Management model.

Ginning - Recommendations

There are 40 gins in Australia that operate continuously for about 100 days. Air emissions from gins have improved over 1991. Gins that had cyclones plus fabric filters demonstrated dust emission levels below the threshold of 100 mg/m^3. Cyclones alone were not enough to maintain the emission level below 100 mg/m^3. Module storage pads at gins have been improved with a layer of gravel or crushed rock. The audit recommended planting trees around gins and recording dust deposition during the ginning season, particularly if the gin is in the vicinity of a residential area.

The 1991 audit indicated that disturbances from external noise emissions could be possible at one kilometer from the gin. Improvements since 1991 include redirecting noise from residences, sound proofing on walls, provision of silencers on seed blowers and cyclones, sound insulation in the bale pressing area, and quieter equipment. Some gins have installed truck washing facilities, and the audit recommended such facilities at all gins to reduce the chances of spreading diseases or pests to other areas, like the boll weevil in the southeastern USA. Although the boll weevil was eliminated from the Southeast, it reappeared due to mechanical picking machines coming from boll weevil-affected areas and carrying weevil-infested cotton with them.

The audit recommended better water disposal practices to avoid contamination, as the water from the gin yard may be carrying infected cotton. Chemicals like lubricants, oils, paints, welding gases, etc. were stored in an acceptable manner, but inventory and material safety data sheets for these chemicals were needed. Recommendations have been made to improve the handling of such chemicals.

The disposal of gin trash is an issue in every cotton producing country. As mentioned in the first article of this issue, the quantity of trash will vary depending upon picking method, but it could be as high as 20% in the case of stripper harvested cotton. The trash will consist entirely of plant parts, including seeds. Seed-carrying insects like the pink bollworm larvae can escape through ginning and serve as a means of spreading the pest. In Australia, trash accounts for 7 to 10% of the overall weight of cotton picked from the field. The pink bollworm, which has the highest chances of surviving ginning, is not a threat to cotton production in Australia, but Australia has undertaken studies to analyze gin trash for 29 pesticide chemicals used in cotton production. Early results indicated that the residues of 13 chemicals were found in the gin trash. However, the quantity was low, rather just above the detection levels. Chlorpyrifos, bifenthrin, cypermethrin, indoxacarb, profenofos and propargite were found to be above 1 mg/kg in fresh trash. Older trash showed lower quantities, indicating that breakdown of chemicals continues even after ginning. In Australia, gin trash is not sold for livestock feeding in spite of the absence of data that would prohibit the use of gin waste for cattle feeding (other than the incident already mentioned above). Most gin trash in Australia is composted for making organic matter, either at gins or off site. Land-fill use is limited, and growers' use on farms is limited to cotton fields. Ginneries have investigated the possibility of burning or gasification of cotton trash, but no such facility has been installed as yet.

The audit recommended that records be maintained for all trash disposed off-site, and gin trash should be regularly analyzed for chemicals and diseases. On-site decomposing of trash is preferred until conclusive results become available for safe off-site disposal.

With respect to the environmental audit at cotton gins, the audit recommended that the industry should have minimum standard guidelines and a checklist of environmental standards so as to conduct internal environmental audits. An external audit of gins on a routine basis should be considered.

On workers' health and safety issues, most gins were found to be operating safely. Gins have improved safety at plants by covering machinery before moving, installing new machinery, putting windows in lint cleaners to observe fires, improving railings at stairwells, installing guards at bale strap cutters and others. Workers use personal protective equipment such as dust masks and hearing protection. Management rigorously enforces the requirements.

In 1991, only a few gins had records on noise levels and exposure at plants. Noise monitoring has become routine at gins, and the audit team observed that exposure levels exceeded 90dBA for some workers or work places. Some gins have even produced noise maps and displayed them at important points around the gin. Noise has been controlled using a combination of operational and engineering controls.

It has been recommended that gins investigate better dust control systems. Smaller gins that have lagged behind bigger gins in implanting the human safety issues should be provided a checklist for self-audits. Floors and equipment surfaces are routinely cleaned manually and with vacuums and compressed air. Vacuum systems are preferred over compressed air but according to the Australian Cotton Ginners Association, vacuum systems are not successful. The Australian Cotton Ginners Association has developed training programs for cotton ginners, and the training packages had special preference for human safety issues.

Transport Spillage - Recommendations

Traveling through cotton areas during the late picking season and later shows that if seedcotton is not covered when transported from farms to gins there will be cotton spillage. Sometimes gins can be traced from the spillage trail as one moves towards the gin. Australia has introduced the practice of covering modules with tarpaulins and the use of enclosed module trucks since the 1991 survey. However, the audit noted some cotton still alongside roads and recommended that the cotton industry improve transportation of seedcotton to gins. The audit team proposed that gins could consider accepting cotton only if it is properly covered.

Note: The GHD Pty Ltd undertook the Second Australian Cotton Industry Environmental Audit with the help of its 11 experts. GHD is an independent multidisciplinary company of consulting environmental scientists, planners, engineers and project managers. The audit is unique in many respects and readers seeking in-depth information on any particular aspect are referred to the 180-page report available free at <http://www.crdc.com.au/>.

The Australian Best Management Practices Program

Since the adoption of chemical-dominated production technology in cotton, use of fertilizers, herbicides and insecticides has increased so much that they can be regarded as overused. High reliance on chemicals, which has been encouraged through subsidies in many countries, including developed and developing, has turned cotton production technology into chemicals dependent technology. High chemical use has two serious consequences that are acknowledged throughout the industry. These are effects on the environment and increased costs of production. Realizing that the increases in yields brought about by chemicals are temporary, growers and researchers are looking for alternatives to maintain yields with minimum use of chemicals, particularly pesticides. Viable alternatives to chemical fertilizers are not available yet. The Australian Best Management Practices (BMP) approach addresses both environmental and cost concerns by placing a high emphasis on environmental safety and judicious use of natural resources. The Australian program has immediate and long-term benefits:

- Enhanced awareness about the impacts on the environment of growing cotton
- Improved production practices on farms so that cotton is an environmentally sustainable crop
- Safer, more effective and more economical use of agrochemicals
- Reduced costs of production through saving on inputs and utilization of non-chemical approaches
- Mobilization of cotton growers to follow consistent, uniform and recommended production practices.

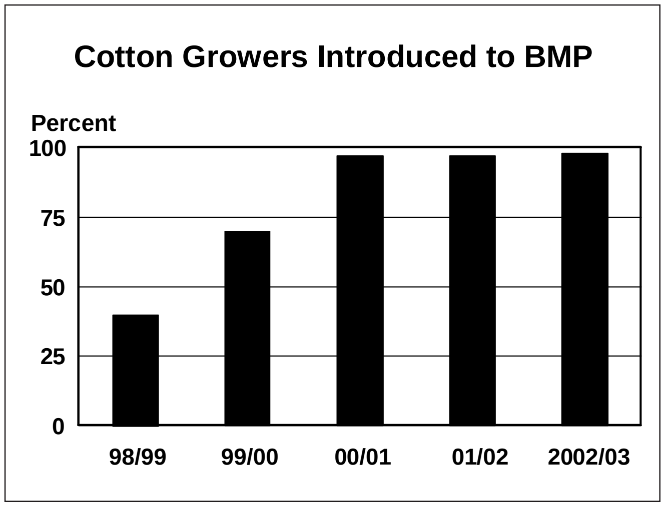
The first environmental audit of the Australian cotton industry, undertaken in 1991, prompted a decade of inquiry, research, development and finally implementation of a BMP program in Australia. This article provides background on BMP, as well as highlights from the BMP Manual.

Background

Herbicide use was common in Australia in 1991. Insecticides were applied more than 10 times on average per season in addition to the use of defoliants. One of the primary recommendations of the 1991 Australian environmental audit was to improve the management of irrigation water and storm water runoff from cotton fields to riverine systems. High chemical use can contaminate irrigation water that finds its way into river systems. In July 1991, the Australian cotton industry organized a workshop, "Environmental considerations of surface runoff from cotton farms," which recommended reviewing research in this field and holding a further workshop to develop a research program to address the gaps identified. The Cotton Research and Development Corporation (CRDC) and Land and Water Resources Research and Development Corporation (LWRRDC) of Australia commissioned a report on "The impact of pesticides on the riverine environment with specific reference to cotton growing." This led to a major joint research program over the next three years, funded by CRDC, LWRRDC and the Murray Darling Basin Commission. Projects were undertaken to understand the transport mechanisms and identify management practices to minimize riverine contamination from cotton fields. By 1995, these management practices had been consolidated in the form of a rudimentary BMP concept, and a pilot project to develop this idea further was started in 1996. In 1997, a draft BMP manual was prepared for comment from cotton growers and other stakeholders. Finally, the first BMP manual was released to cotton growers in December 1997.

BMP is a voluntary program, but from the outset, it was a goal to have all cotton growers in Australia adopt BMP practices. In 1998, the industry set the ambitious target of having all cotton growers involved in the BMP program by 30 June 2001. The BMP manual and components of the audit program (introduced in 2000) were developed through the CRDC. Cotton Australia, which is the largest Australian cotton grower organization and is supported by farmers via a levy of A$2/bale of cotton, was given the role of encouraging all cotton growers to implement BMP on their farms. Cotton Australia has a special interest in environmental management, occupational health and safety, and its field staff located throughout cotton growing areas assisted farmers to adopt BMP practices.

The data from Bruce Pike of the Australian Cotton Research and Development Corporation show that by June 2001, 97% of cotton growers had been introduced to the first manual on BMP.



Highlights of BMP Program

The BMP program manual has six modules: 1) application of pesticides, 2) storage and handling of pesticides, 3) integrated pest management, 4) farm design, 5) management and farm hygiene and 6) storage and handling of petrochemicals. A new land and water module is available in draft form and is scheduled for general release late in 2004 following an extensive trial program. Only the IPM module is discussed in this article because it has the modest application in many countries and produces the most identifiable benefits. According to Williams et al. (2004), the BMP Program consists of three components.

- Best Management Practices booklets explain the practices for the topic and why they are important. They outline legal obligations and recommend practices to help meet these responsibilities.
- Self-assessment worksheets help cotton growers assess their own operations against recommended best practices. These include lists of resources to help plan and implement best management practices.
- Blank templates help growers make action plans to address areas identified during the self-assessment process.

The BMP Manual provides both a risk-assessment process and suggested best practice solutions. Many documents, strategies, action plans and publications raising awareness of issues that need to be addressed highlight the risks that may arise from carrying out an activity, but it is fundamentally important that the solutions are also explicitly identified and provided (and not simply referenced in another document or location).

The following descriptions come from just one module of the Australian BMP Manual – the IPM Module. The headings used are those found in this module.

Manage the Crop for Early Maturity

Depending upon growing conditions, the variety best suited for an area should be selected. Cotton should be planted as early as possible within the optimal planting window. Excessive doses of nitrogen can delay maturity, while under-dosing can have a negative impact on yield. Nitrogen should be applied, depending on soil tests, such that neither yield nor early maturity is sacrificed. The decision to use growth regulators should be based on early season crop growth. If the rate of increase in the internodal length is more than 6.5 cm/node, growth regulators should be used to avoid excessive growth. When to apply the last irrigation is another important consideration that can have a significant impact on crop maturity. In Australia, the nodes-above-white-flower technique is used to determine the cutout time. This technique is based on the assumption that the top-most white flower will take 40 days to mature and contribute toward productivity. When the number of nodes above the top-most white flower decreases to four, the cutout stage has been reached, and the date of last irrigation can be determined.

Monitor Insects and Damage

The crop should be regularly monitored for insects and the damage caused by them. Fields should be visited two to three times a week, and the instructions given in various publications related to IPM and insects should be followed. Field visits become extremely important when the insect pressure/damage is close to the threshold level. BMP emphasizes the ability of a plant to compensate for losses. A plant has the highest compensation ability during early growth stages, but this ability decreases with time and cotton plants ultimately reach a stage when they are unable to compensate for losses in fruiting parts. Under Australian conditions, about 60% fruit retention on the first position bolls means that plant growth is likely to achieve the desired yield target. Insecticide application decisions should be based on the economic threshold levels for various pests. The threshold should be based on the target yield (slightly higher for low yielding areas) as well as crop stage. The number of larvae can be increased from two to three per meter at different stages of crop growth. For example, the number of larvae can be increased to as much as five larvae per meter if 15% of bolls have already opened. The other important consideration is the proportions of *H. armigera* and *H. punctigera* in the bollworm population. This proportion is used to decide which insecticide should be applied. Lower-cost products can be used against *H. punctigera*, which is more insecticide-susceptible than *H. armigera.*

Preserve Beneficial Insects

Not only should beneficials be encouraged in cotton fields, but efforts should be made to attract new beneficials into cotton fields by using special formulations. Information on the ratio of beneficials to harmful insects should be considered in the decision to spray.

Prevent Development of Resistance

Growers must adhere to an insecticide resistance management strategy. This is different for transgenic (Ingard) and conventional varieties. Over-wintering populations should be minimal. Cotton fields should be plowed before August 31 (cotton is planted in October in Australia.). Over 90% of the total area is planted at one meter (40 inches) row spacing and around 5% at skip row planting. While cultivating the field for killing pupae, the whole soil surface should be cultivated to a depth of 10 centimeters. Early cultivation is encouraged for conserving moisture and eliminating weeds.

Host and Trap Crops

Cotton insects survive on weeds and other hosts during the winter; this necessitates elimination of weeds in and around cotton fields. Farmers are provided with information on insects and their alternate hosts. The largest single alternate host can be a commercial crop grown during the winter in a cotton area. Host crops can be very dangerous in the case of major pests. Trap cropping is not common in Australia.

Area-Wide Management

Guidelines are available on various aspects of IPM, including area-wide management of pests. Insects and weeds should be controlled over large area so that neighbors are not harmed. In most small-scale farming systems in the world, it is a common complaint that one farmer will adopt proper insect control measures, but his crop is still affected by neighbors, who do not spray or who adopt poor insect control methods. Insects multiply in the neighbor’s field and move to other farmers’ fields nearby.

The endosulfan issue is important in Australia due to its detection in meat from cattle fed on cotton gin trash from crops sprayed with endosulfan in 1994. Under the BMP program, cotton growers should inform their neighbors in writing about the date and time of spraying endosulfan. The formulation of the endosulfan to be sprayed and the method of application should be included in each letter, along with a map of the farm and specific areas to be sprayed.

A variety of systems are working in the world regarding application of pesticides. In most West African countries and countries like Sudan, where cotton companies provide chemicals, the insecticides to be applied on cotton are determined prior to the start of each crop season. The products to be used are based on the previous year’s insect patterns. In other countries, particularly in Asia, many products are available on the open market, and farmers choose products based on the recommendation of experts or extension workers who will base their recommendations on the pest complex. In these areas, pesticides are not stored for a long time. In Australia, the BMP pesticide application management plan has specific requirements other than the product to be used. Requirements include a detailed map of the farm, information about the consultant, equipment to be used, the pesticide supplier and weather data.

Implementation

The modern farmer faces an ever-increasing list of management issues. The conjunction of generally declining terms of trade for agricultural commodities with greater community expectation about natural resources management has placed additional burdens on all farmers. Unfortunately, this conjunction also coincides with a greatly reduced presence "in the field" by those traditionally providing advice to farmers, the extension agents of a relevant jurisdiction's department of agriculture. Furthermore, the move towards (and need for) more formal management systems for farmers is colliding head-on with a traditional and still very strong "informal" management style. Even in the Australian cotton industry, generally viewed as a progressive and leading industry, the majority of cotton growers do not have a dedicated office or secretarial support.

These factors make it essential that the BMP manual be delivered with direct support. All surveys conducted of participants in the BMP Program have indicated that this has been critical to its success. Success of the BMP program lies in the preparation of the manual, its distribution and explanation to cotton growers about why and how to implement recommendations. Cotton growers were informed about the manual through publications and other communications. Once the manual was distributed to farmers, an introductory meeting on how to use the manual was organized and training days, at which farmers were taught to utilize the manual, were conducted. Field staff of Cotton Australia played a key role in explaining the manual to farmers. A subsequent meeting with each farmer followed training days. Implementation of the manual was organized through local cotton growers, together with field staff of Cotton Australia.

Audit Program

Another factor in the success of the BMP program has to do with the audit program. A recent review of the BMP Program highlighted the importance of the audit program to its external stakeholders. Over 90% of external stakeholders surveyed indicated that they agreed (and over 80% strongly agreed) that the audit program was "critical" to its success. A voluntary audit program based on the BMP Manual exists to verify compliance with the BMP Manual, providing an objective assessment for growers and recommendations for improvement, as well as information on the adoption of best management practices across the industry. Industry auditors must complete an environmental systems auditor's course tailored to the BMP program. The course is recognized by both the Australian Auditors' Association and the international Environmental Auditors Association. The CRDC has provided specialist environmental auditing training to 18 people with expertise in cotton production. Auditors are well trained in environmental management and they are familiar with cotton farming activities. The auditors' practical experience has been greatly beneficial to the efficacy and credibility of the program, and greatly appreciated by the audited cotton growers. A dedicated "audit office" has been established to oversee the administration of the audit program. As of December 2003, approximately 330 cotton growers had undertaken, at their own expense, an audit of their compliance with the BMP Manual. This represents approximately 30% of Australian cotton farmers, and approximately 50% of cotton area.

The most critical step in assessing the success of the program has been the audit of individual farmers against recommendations in the BMP manual. The first audit was done in January 2000, three years after the issuance of the first version of the BMP manual. The audit program covered three levels of compliance: initial compliance audit, industry certification audit and surveillance audit. The initial compliance audit is more or less the initial farm conditions with respect to compliance of BMP manual recommendations. The industry certification audit is the verification of improvements on the initial compliance audit. The surveillance audit is conducted after the certification audit and verifies that there is a continued improvement on the previous two audits. The audit is not intended to compare practices followed by one farmer with the practices followed by his/her neighbor or elsewhere. Rather, the audit was meant to assist farmers in determining the extent to which they have achieved BMP recommendations and how far they still have to go to reach full compliance with the BMP manual. The audit has also been used as a source of feedback to people involved in the preparation of the BMP recommendations. The data show that in 2002, about 100 initial audits, 175 certification audits and close to 200 surveillance audits had been undertaken.

(Help from Mr. Bruce Pyke, Research & Extension Manager of the Cotton Research and Development Corporation, Australia in preparation of this article is appreciated.)

References

On-line information is available at <http://www.cottonaustralia.com.au/bmpindex.html> and <http://www.crdc.com.au/>.

Slack-Smith, Peta. 2000. Managing environmental issues in cotton production: Australian Best Management Practices (BMP). In *Cotton-Global Challenges and the Future*. Washington, DC, USA: ICAC.

Williams, Allan. 1998. Best Management Practices – Where have we been and where are we going? *Proceedings of the Ninth Australian Cotton Conferences*, August 12-14, 1998.

Williams, Allan; Leutton, Ralph; Rouse, Andrew and Cairns, Rob. 2004.The Australian cotton industry: Turning natural resource management policy into on-ground action. Presented at the OECD Expert Meeting on Farm Management Indicators for Agriculture and the Environment held on 8-12 March, 2004 at Palmerston North, New Zeland.

Short Notes

• Cotton Production in Senegal

Cotton area and production in Senegal has seen highs and lows. In 1999/00, cotton area scaled down to 18,000 ha from 48,000 ha in the previous season. The main reason for the decline was a 69% reduction in yield in 1998/99 owing to whitefly attack and drought.

In Senegal, cotton is grown under rainfed conditions in the center (Tambacounda, dry region) and south (Kolda, wet region). The Tambacounda region usually receives 500 to 700 mm of rainfall from June to October, and cotton grows on sandy loam and on black, red and brown vertisol soils with less than 1% organic matter. In comparison, the Kolda region receives 1,000 to 1,400 mm of rainfall, and cotton grows on hydromorphic soils. The two varieties grown are STAM-42 and IRMA-772. Plant-to-plant spacing is 25 to 30 cm; row-to-row spacing is 80 cm. Sixteen kg/ha of delinted and 40 kg/ha of fuzzy seed are used for planting. The major pests are *Helicoverpa armigera* and *Bemisia tabaci*, and the crop is sprayed 4 to 5 times a season. Only 5% of farmers use herbicides, and most operations are done manually.

The Society for Development of Textile Fibers (SODEFITEX) provides seeds, fertilizers, pesticides, and implements and also is responsible for disseminating technology and purchasing seedcotton from farmers. The Institute of Senegal for Research on Agriculture (ISRA) within the Ministry of Agriculture undertakes research on cotton.

The Government of Senegal started the Agriculture Development Project (ADP) in 1999 for two years with assistance from the Government of India. The project was located in the Saint-Louis and Tambacounda regions; these account for 52% of the geographical area of Senegal. The Indian experts deputed to study and suggest recommendations were from the fields of agronomy, seed production and agricultural engineering. The mission produced a report and made a number of recommendations to the Government of Senegal for increasing yields and stabilizing cotton production. Some important recommendations are as follows:

- The soil structure and texture should be improved with green manures and farmyard manure. *Sesbania egyptica* should be grown for this purpose on a large scale in the country.
- Variety STAM-42, which has broad leaves, should be replaced by small, thick-leaved variety(ies). Each region should have a different variety according to its growing characteristics.
- Seed production systems must be improved in order to provide quality planting seed. Farmers should be able to choose the variety they prefer. There should be more than one planting seed distributor offering seed at competitive prices.
- On-farm (farmer field) demonstrations of high-yielding varieties and technology should be organized. Farmers' fairs should be arranged periodically.
- Currently, all fertilizer is applied at the time of sowing. The mission recommended that fertilizers should be used in 2 to 3 stages according to plant needs: preferably 50% of fertilizer (NPK) at the time of sowing, 25% at the time of squaring and 25% at the time of flowering.
- Heavy reliance on pesticides should be reduced to avoid the problem of resistance development. IPM including varietal resistance should be utilized.

Some recommendations have been implemented. Cotton area has recovered from 18,000 hectares in 1999/00 to 22,000, 32,000, 35,000 and 45,000 hectares in 2000/01, 2001/02, 2002/03 and 2003/04, respectively. Average yields for the last three years were more than 450 kg/ha; this has never happened before. The current yield of 533 kg/ha in 2003/04 is a new record in Senegal.

(Contributed by Dr. S. L. Ahuja, a member of the expert team, Central Institute for Cotton Research, Regional Station, Sirsa, Haryana, India-125055).

• WideStrike Cotton from Dow AgroSciences

Dow AgroSciences has developed a transgenic cotton called WildStrike that is resistant to insects. The company announced at the 2004 Beltwide Cotton Conferences of the National Cotton Council of America held in San Antonio, TX from January 5-9, 2004 that they had applied to the US Environmental Protection Agency for necessary approval and that WideStrike could be available for commercial planting beginning in 2004/05. WideStrike will be introduced in elite varieties of the Phytogen Seed Company in 2004 and it is also expected to be available in varieties from other cottonseed companies by 2005.

WideStrike is a stacked-gene variety. The insect protection trait, a combination of the Cry1F and Cry1Ac *Bacillus thuringiensis* (Bt) proteins, has been in development and field-testing for several years. According to Dow AgroSciences, the WideStrike insect protection trait has been extensively tested for its agronomic, efficacy and resistance management performance at many locations across the U.S. cotton belt between 2001/02 and 2003/04.

The WideStrike provided season-long control of a broad spectrum of lepidopterans, such as cotton bollworm, tobacco budworm, pink bollworm, beet armyworm, fall armyworm, yellow striped armyworm, cabbage looper and soybean looper.

- **Economic Impact of Bt Cotton**

Dr. George Frisvold of the University of Arizona, USA presented a paper analyzing the impact of growing Bt cotton at the 2004 Beltwide Cotton Conferences. His paper, "Impact of Bt cotton adoption in the United States and China (Mainland)" showed how Bt cotton adoption in the two countries has affected world cotton production, consumption, prices and imports/exports in China (Mainland), USA and rest of the world. Using data for 2001/02, when China (Mainland) and USA together shared over 95% of Bt cotton area in the world, Dr. Frisvold ran three scenarios: global impact of Bt cotton adoption in China (Mainland), adoption in the USA only and combined effect of adoption in both countries.

Dr. Frisvold and his colleagues concluded that adoption of Bt cotton in the USA alone lowered world cotton prices by 1.6 cents per kilogram of lint. Adoption of Bt cotton production in China (Mainland) resulted in a similar reduction in world cotton prices. The combined effect of adoption of Bt cotton in both countries lowered the world average price by 3.1 cents per kilogram of cotton in 2001/02. The US Loan Deficiency Payment rate increased by the same margin in each case. The impact on farm prices in the USA was a decrease of 2.7 cents per kilogram due to adoption of Bt cotton in China (Mainland) and the USA. Adoption in each country had a similar depressing effect on farm prices received in the USA. Consumption in China (Mainland) and the USA increased due to adoption of Bt cotton in either country. Adoption of Bt cotton in China (Mainland) increased consumption by 0.4% in the rest of the world. However, higher production in China (Mainland) and the USA due to Bt cotton negatively affected production in other countries, thereby increasing imports into these countries. The full paper will be published in the *Proceedings of the 2004 Beltwide Cotton Conferences*.

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