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- Update on cotton production research
- Nouvelles recherches cotonnières
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Contents

Introduction

This issue of *THE ICAC RECORDER* has three articles and some short notes. The three articles are on the subjects of leaf physiology and defoliation, status of agrochemicals used to grow cotton and an update on High Volume Instrument testing.

Cotyledonary leaves exist even before a cotton seed is planted. But, they are also the first ones to be dropped. Formation of all other leaves on the main stem or primary and secondary branches follows the emergence of a fruiting form or a sub-branch. Thus, the formation of leaves triggers shoot growth in addition to the formation of flower buds. In cotton, leaves are the only part of the plant which is automatically shed at a certain age (60-65 days). If leaves are not shed, they are forced to shed chemically for efficient machine picking. The time when these chemicals should be applied so that there is no loss in yield and the quality of cotton is not affected depends on many factors. How different types of harvest-aid chemicals act on leaves and help in the formation of abscission layers is also discussed in the first article.

The 53rd Plenary Meeting of the International Cotton Advisory Committee noted the current extensive use of chemicals and instructed the Secretariat to undertake a survey of the agrochemicals used to grow cotton in various countries. The Technical Information Section (TIS) of the ICAC completed this study in October 1995 and presented a report to the 54th Plenary Meeting held in Manila, Philippines, from October 23-27, 1995. The report, which is available from the ICAC Secretariat, covers fertilizers, insecticides, herbicides, defoliants and growth regulators. Area treated, quantity applied and expected trend in the use of these chemicals is also reported in the publication. A summary of the report is given in the second article entitled ''Trends in Agrochemicals Used to Grow Cotton.'' In the summary given here, it was not possible to cover all countries and report data on all aspects of these chemicals; thus, for detailed information, please refer to the ICAC publication, *Agrochemicals Used on Cotton*, October 1995.

The third article is on HVI testing of cotton. The use of HVI is continuously increasing. By the end of 1995, there were 940 (partial and complete) systems installed in about 62 countries. The USA is the leading HVI user where all cotton produced in the country is classed on HVI. The spinning industry has almost half of the total HVI systems in the world but there is a need to adopt HVI testing in research, particularly for the development of new varieties. Problems associated with testing short fiber content and strength and latest efforts to develop equipment for integration with HVI systems, calibration of HVIs and conclusions of the HVI Working Group of the ITMF International Committee on Cotton Testing Methods, whose meeting was held in Bremen, Germany, from March 5-6, 1996, are also discussed in this article.

At the 55th Plenary Meeting of the ICAC to be held in Tashkent, Uzbekistan, from October 7-11, 1996, the TIS will organize a one-day Technical Seminar on the topic ''Short Season Cotton: How Far Can It Go?'' In April, the TIS will start sending invitations to leading experts involved in development, production and utilization of short duration cottons to deliver papers at the Technical Seminar. The total number of speakers will be 8-9 and their papers will be published after the meeting.

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The Cotton Leaf and Physiology of Defoliation

Leaves are an important part of the cotton plant but there comes a stage when they are no longer necessary on the plant. As in any deciduous perennial tree, cotton leaves become old and reach their natural shedding stage, although sometimes they are forced to drop through artificial means. Absence of leaves on a plant with a heavy load of green bolls helps the plant to complete boll opening earlier. Early opening is a desirable feature for many reasons, but bolls are forced to open through chemicals mainly to pick as much cotton as possible in one trip. Artificial defoliation is a pre-requisite for machine picking of cotton. Green leaves are also harmful because they harbor sucking insects, particularly aphids and whitefly, at the time of boll opening. Both these insects are notorious for causing stickiness, and their presence at the time of boll opening increases their impact.

Leaf Formation and Ageing

Leaves appear on a plant long before we actually see them. A leaf can be seen with the naked eye when it has already attained its shape and requires only expansion in size to perform its functions, but its actual life starts from the time when cell division differentiates tissues to form leaves. When a leaf is visible, it is already about two weeks old; so, the actual age of a leaf is older than the age of a true leaf.

The cotton leaf performs diversified functions. Leaves are a major site for photosynthetic activities. For about the first 16 days after a newborn leaf has attained the shape of a true leaf, carbohydrates produced by the photosynthetic machinery are directed toward its growth. But, as soon as the leaf is near its full size or at least ¾ of its normal size, it reaches its peak carbohydrate exporting ability, and at about 25 days old the carbohydrate exporting ability is already reduced. The drop is not sudden, but a normal healthy leaf will not be able to continue its transmission process at the same rate. The downhill slide continues up to 60-65 days old, when the cotton leaf is no longer capable of exporting carbohydrates. Physiologists have determined that leaves on the 5th node from the top are the most active on the plant. By the time leaves become too old to exist on the 12th node from the top, they become non-functional.

Harvest-Aid Chemicals

Usually, three types of chemicals are used to perform the same function of enhancing boll opening. There are boll openers, defoliants and desiccants, collectively called harvest-aid chemicals. Like contact insecticides, defoliants do not move within a plant, therefore, for effective defoliation, all leaves should come in contact with the chemical. Comparatively bigger droplet size—an undesirable feature for insecticide application—enhances the chances of contacting all leaves on the plant. The 3-4 times higher volume of water compared with insecticide spraying also helps to good penetration of chemicals into the plant canopy. In the case of ground coverage, greater contact with all leaves can also be obtained by directing the spray to different sections of the canopy with drop nozzles, but how deep spraying into the plant canopy should be depends on the plant's condition. Leaves between the age of 20-40 days usually require a higher amount of chemical to obtain successful defoliation. During the first 20 and last 20 days of the leaves' life, it is easier to kill leaves with chemicals. The use of wetting agents and waxy layers on leaves which hinder penetration of water-based chemicals are undesirable for efficient and effective defoliation of cotton. Once the chemical is sprayed, the faster it is absorbed the greater the potential for desiccation/defoliation.

Apparently, it would seem very simple to apply various chemicals for the sake of defoliation and enhance crop maturity. But, because defoliation has an ultimate effect on quality—and cotton is sold on premiums and discounts based on grades defined by quality—the proper choice of harvest-aid chemicals is very important.

Defoliation

Leaves can be shed by age, injury or any kind of external and internal stress on the plant.

At the base of a leaf there is an area which is structurally different from other tissues. This is the area where the abscission layer is formed. Cotton leaf abscission is a physiological process that involves an active separation of living tissue from the plant. Leaf shedding is preceded by a variety of changes in the leaves which include loss of chlorophyll, increased anthocyanin, reduced levels of proteins, carbohydrates and inorganic ions and changes in hormonal concentrations within the leaf.

Green leaves have almost 50% moisture at the time of picking. If green leaves are not removed and they are picked along with seedcotton, storage in modules becomes dangerous. In a module, average moisture contents should not exceed 12%, otherwise, there is a high risk of heating up cotton.

Trash in lint is undesirable because it has to be removed before cotton is spun into yarn. The earlier it is removed the better. Trash removed in the pre or post cleaning operations always takes a significant quantity of lint with it. This lint ends up in gin trash and is a direct loss to producer or ginner who owns the seedcotton. All trash in seedcotton and lint cannot be removed by cleaning. The leaf particles that remain are in the form of pulverized fine particles which cause problems in later processing of the fiber.

After defoliation, light penetration into the canopy is improved enhancing boll maturation. Moreover, dew evaporation is also faster; thus, there are fewer chances of affecting the color of cotton. One way of avoiding the need to defoliate the crop artificially is to increase water stress at the maturity stage. Although water stress stimulates early drying of leaves, it may be harmful to fiber quality. Low yielding fields due to water stress or nitrogen deficiency usually drop a high percentage of their leaves naturally, thus minimizing the need to defoliate the crop artificially.

Mechanism of Chemical Absorption by Leaves

The main objective of defoliation is to enhance boll opening but the chemicals sprayed are all directed to the leaf surface. Some chemicals require coverage of a large leaf area for a long period of time. Defoliants once sprayed are absorbed by leaves in two ways:

- Leaf stomata open during the process of photosynthesis to grab carbon from the air. During this process, leaves lose water and absorb chemicals found in liquid form on their surface, but it is a minor route. Ample soil moisture has a favorable effect on stomatal absorption.
- The major route for defoliants to travel into plants is a cross cuticle absorption. Warm and humid weather conditions and lack of water stress enhance the rate of absorption through the cuticle.

Appropriate Time for Defoliation

Harvest-aids applied too early (20% open bolls) reduce yield and also affect fiber quality (Snipes and Baskin, 1994). Micronaire is reduced as a result of low maturity and, also, the percentage of neps in fiber increases. On the other hand, it is important to consider defoliation when insects like aphids and whiteflies threaten to contaminate cotton with sugars. Time of defoliation is very important not only to have an effective defoliation but also to save quality. Traditionally, the percentage of open bolls is taken in consideration in deciding the time of application of chemicals. It is assumed that, if 60% of the bolls have opened, the time has come to defoliate the crop. Bolls may be formed in four weeks or it may take eight weeks to set the crop. If the crop has been set in a short period of time, it may be time to defoliate at an even lesser percentage of open bolls (below 50%). But, if bolls have been formed over a longer period of time, more than 60% open bolls may be required to apply defoliants. Physically, the time has come to defoliate the crop if, when the last formed boll is cut with a sharp knife, it is not easy to cut the lint and seeds have folded cotyledons without jelly.

Mode of Action

Magnesium and sodium chlorate are two of the earliest products used to defoliate cotton artificially. They are very effective and still used in many countries including the USA and Uzbekistan. In Uzbekistan, calcium nitrate is also used to some extent, but efforts are underway to find plant extracts which are safer compared with magnesium chlorate, which they report to affect fiber quality.

Most defoliants have a common mode of action—they alter the balance of hormones which results in the formation of an abscission layer between the leaf petiole and the main stem or the branch where the leaf is attached to the plant. In a healthy cotton plant, auxin is produced at a high rate and is responsible for inhibiting the formation of the abscission layer between the leaf petiole and stem or branch. As long as auxin can move readily in the leaf petiole, it can efficiently perform its functions and stop the formation of an abscission layer. Other hormones like absissic acid and ethylene stop the movement of auxin and thus trigger the formation of a separation layer. All defoliants disturb this balance by restricting the movement of auxin in the petiole. There are two ways of how this action may occur. The first category of defoliants stimulates ethylene synthesis and slowly injures or exerts stress on the leaf. This is the way most herbicides work. A similar action is also performed by chlorates and chlorites which are strong oxidizers and injure leaves by converting nitrate in the leaves to nitrite and then into amino acids. Other herbicide-defoliants stimulate ethylene stress response by making leaf cells lose water. Higher doses of herbicide-defoliants usually result in an action which may be called desiccation instead of defoliation. The second category of defoliants works through hormone action. Some of the commonly used defoliants like Dropp and Prep belong to this category. They release ethylene in the plant thus stimulating ethylene synthesis and abscission zone formation in the leaf petiole and bur separating walls. The cytokinin group of defoliants stimulate a massive increase in ethylene production and thus their action is even more toward defoliation rather than desiccation.

Some hormones that are known to have an important role in abscission include indole and naphthalene acetic acid, absissic acid, gibberellic acid, ethylene and cytokinin. Literature also shows that some other substances like amino acids and ascorbic acid may also affect the formation of an abscission layer. Generally, the direction of movement of auxins like indole acetic acid and naphthalene acetic acid to retard abscission is a determining factor in whether a particular auxin will trigger or hinder formation of an abscission layer. If auxins are applied to the leaf blade and they move to the stem, formation of an abscission layer is retarded, but abscission is stimulated when auxins are applied to the stem and they move from the stem to the leaf blade. Any chemical action which reduces the concentration of auxins in the leaf blade promotes defoliation of leaves.

The role of ethylene as an abscission promoting hormone is well understood and potent. Absissic acid also has the same action but the effect could be direct or indirect. The direct effect could be stimulation of the formation of hormones which enhance abscission, and the indirect effect could be increased secretion of enzymes into cell walls that stimulate cell wall digestion and ultimately result in loosening of cell joints. Promotion of abscission by ethylene more predominantly comes from its influence on the level of other hormones. Reduction of auxins in leaf tissues could be the best example. The role of gibberellic acid in abscission is still controversial. At times it can prove to serve as a promotor but its retarding effect is also reported in literature. It is more or less agreed that cytokinin delays formation of an abscission layer. Analysis of naturally abscised leaves showed that they had higher concentration of some amino acids indicating that these acids are important regulators of natural leaf abscission. Artificial application of many amino acids was also found to promote abscission.

Formation of an abscission layer is a slow process compared with desiccation through herbicide-defoliants. The abscission layer, carbohydrate in nature and formed more quickly in leaves than in bolls, permits water and nutrient movements in and out of the leaf. If the abscission layer is formed in a normal process as a consequence of hormone activity, leaves are shed properly which is more desirable for machine picking. In cases when formation of an abscission layer is affected by desiccation due to chemical application or low temperatures, complete defoliation is not achieved and leaves dry up on the plant. Such defoliation results in higher trash content. Desiccants usually remain effective even at low temperatures compared with hormone defoliants. Although the action is mostly the same, comparatively slow synthesis of ethylene can turn chemicals into desiccators or boll openers rather than defoliants. Defoliants and boll openers can also be used together for double action to accelerate boll opening and defoliation at the same time. Application of boll openers prior to defoliation decreases the needed doses of defoliants.

A nonchemical method of defoliation is heated or cold air. Hot or cold air physically injures leaves and also exerts physical stress on leaf tissues causing them to die. While cold air in the form of low night temperatures is a natural phenomenon of leaf defoliation, hot air was tried as an alternative many years ago and it was also found to be effective, almost equivalent to chemical defoliation, but the high cost compared to chemicals still remains one of the limiting factors. Although such trials are not reported to occur anywhere in the world now, today's quality-conscious consumer market may object to the overheating of cotton in open bolls.

Factors Affecting Defoliation

Current weather conditions as well as previous weather effects on the plant affect the absorption of chemicals. Major factors affecting uptake are as follows:

- Lack of adequate irrigation during leaf development increases waxiness and thickness of leaf cuticle. Leaves developed under such growing conditions show reduced uptake by up to 35%.
- Low humidity results in quick evaporation of water thus leaving dry chemicals on leaves surface. In addition, if humidity is low for a long period of time or cotton is grown under low humidity conditions, the uptake of chemicals is significantly reduced.
- Cool temperatures during and after application harden the waxy cuticle and thus affect the diffusion rate of chemicals. If the chemical is absorbed but leaf temperature remains low following the application, the uptake process is again slow. Leaves under shade usually have lower temperatures by 4-5^{o}C compared with leaves directly exposed to sunlight and show a slower diffusion process. It is important that night temperatures remain above 16^{o}C for effective absorption of chemicals and defoliation.
- High temperature, humidity and sunlight for 4-5 days following chemical application have an enhancing effect on defoliation.

Beltwide Defoliation Research in the USA

In the USA, a Cotton Defoliation Work Group Committee was formed in 1992 to conduct beltwide trials on chemical defoliation of cotton and develop recommendations to improve harvest efficiency and improve fiber quality, taking into account biotic and environmental factors. The Group will finalize its recommendations in 1997. A project entitled Uniform Harvest Aid Performance and Fiber Quality Evaluation, in the last three years, tested a variety of harvest aids for efficiency, effect on fiber quality and also investigated standard defoliation treatments on uniform basis. The group concluded that when recommended practices were followed for the application of chemicals, there were no significant differences among harvest aids with respect to their effect on fiber quality. All chemicals reduced trash, lowered micronaire and improved color grade. According to Valco and Bragg (1996), the Group also observed that chemicals had no effect on fiber strength, did not increase white specks or neps and had no effect on length and length uniformity. Small differences among treatments in the efficiency of leaf removal were neutralized during the ginning and cleaning processes. According to Valco and Bragg (1996), differences in fiber quality among untreated check and treatments were very small. Crop maturity increased in all treatments vs. untreated check and there were significant differences among treatments. Some products which were more efficient after seven days of application maintained their superiority even after 14 days of treatment.

Nelson and Hart (1995) have studied the effect of plant water status on defoliation of Pima cotton. Irrigation was terminated at various stages to regulate the crop water stress index and accordingly apply defoliants. They applied defoliants to fields with crop water stress index of 0.54 to 0.99 and concluded that, as water stress increased, the defoliation percentage also increased accordingly. Trials were conducted for two years, concluding that water stress cannot be used as a guide to determine when to defoliate a Pima crop. Other factors like nitrogen status, kind of defoliant and weather at the time of defoliation, have a stronger influence in determining the time of defoliation.

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Trends in Agrochemicals Used to Grow Cotton

Agrochemicals have become an integral part of cotton production practices in the last few decades and knowledge of their use is considered to be a crucial factor in realizing an optimum yield under any set of agroclimatic conditions and production practices. For optimum utilization of production technology and inputs, it is important to avoid misuse of agrochemicals. This paper covers the current status of agrochemicals used to grow cotton and their possible future trends. In most instances, trends in the last ten years have been reviewed. The agrochemicals discussed here are fertilizers, insecticides, herbicides, growth regulators and, to some extent, defoliants. In many countries, insect patterns have slowly been changed by the extensive use of insecticides with serious consequences in some of these countries. Also discussed in this paper are changes in insect patterns.

Fertilizers

Fertilizers represent the bulk of agrochemicals used to grow cotton. As in all other agricultural crops, nitrogen, phosphorous and potassium are the major elements needed to grow cotton. Nitrogen has to be applied under any set of growing conditions because plant needs for nitrogen are drastically different at various stages of development. Nitrogen is still not used on all the cotton area in the world. Nitrogen is not applied in Uganda and it is applied to only about 2% of total area in Argentina. Almost all or more than 90% of the total cotton area is treated with nitrogen in China (Mainland), Colombia, Greece, Israel, Pakistan, Sénégal, Spain, Syria and Togo. In the USA, nitrogen is applied to about 85% of total cotton area. Phosphorous and potassium are used more extensively in Brazil, Colombia, Israel, Sénégal, Spain (100%), Syria, Togo and the USA. Micronutrients are applied in small quantities to some area in Colombia, Greece, Sénégal, South Africa, Spain, Thailand, Togo and the USA. The cost of fertilizers is a major part of production costs, but it is still less than the cost of insecticides. Almost US$200/ha is spent on fertilizers and their application in Turkey, over US$170 in China and close to US$100 in the USA, Pakistan and Sudan.

In China (Mainland), particularly in the Yellow River Valley, and Paraguay, over 90% of total area gets organic fertilizers. In India and Pakistan, 20% and 60% of total area is treated with organic fertilizers before planting cotton. Organic fertilizers are used on about 40% of total area in Mali. In Morocco, organic fertilizers are not used in all production regions but they are used on 50% of total area in the Haouz region. In many other countries, organic fertilizers are used on a small scale, less than 5% of total area, and their use is not expected to increase.

Wide-spread cultivation of short stature and short duration varieties in many countries triggered the utilization of higher doses of nitrogenous fertilizers. It is assumed that these varieties cannot tolerate addition of more nitrogen fertilizers because the balance between the vegetative and reproduction growth would be disturbed. Application of potassium is not expected to change drastically, either. However, changes in fruiting behavior do not keep pace with potassium supply from the soil. Although potassium levels in the soil may not demand application of additional doses of potassium fertilizers, a high need for potassium at the time of boll maturation and when most bolls mature in a short period of time has increased the demand for potassium fertilizers. Aerial application has shown positive results and potassium application may be adopted in more countries. Adoption may be slow because consequences of inadequate availability of K in the soil can only be noticed if maximum yield potential is realized.

Fertilizer Use on Cotton in 1994/95

Country	Kg. Nutrients/Ha. (% Area Treated)			
	N	P	K	Micro-nutrients
Argentina	40 (2)			
Australia, NSW	150	8-10		
Brazil	20-30 (50)	40-60 (50)	20-40 (50)	
Chad	31	14	20	
China (M)	100 (90)	(40)	(50)	
Colombia	110 (100)	17 (65)	28 (65)	0.5 (28)
Côte d'Ivoire	43	36	36	
Greece	155 (98)	70 (98)	90 (25)	2 (25)
India	40 (80)	20	20	
Israel	15 (100)	3 (100)	5 (100)	
Pakistan	112 (100)	45		
Paraguay	40 (2)	40	50	
Philippines	97	28	28	
Sénégal	42 (91)	35 (91)	24 (91)	6 (91)
South Africa	100 (45)	20 (35)	60 (35)	0.1 (5)
Spain	200 (100)	75 (100)	75 (100)	(20)
Syria	170 (100)	60 (100)		
Thailand	60 (50)	30 (10)	30 (10)	7 (10)
Togo	41 (93)	33 (94)	18 (94)	10 (94)
Uganda	No fertilizer is applied			
USA	100 (85)	52 (54)	65 (36)	(18)

Pesticides

Insecticides and herbicides are the main components of pesticides used on cotton. Chad is the only country where all pesticides are imported and used on cotton. Togo presents an almost similar situation. In India and Pakistan, 53% and 70% of total pesticides are consumed by cotton, respectively. In China and the USA, which together produce about 40% of total world cotton production, cotton claims only 10% of total pesticide use. The share of cotton in all crop usage of pesticides in different countries is given in the table below.

Share of Cotton in Pesticide Usage

Country	Share
Chad	100
China (M)	10
Colombia	5
Côte d'Ivoire	53
Egypt	80
Greece	19
India	56
Pakistan	70
Sénégal	40
Spain	10
Syria	10
Togo	95
Uganda	75
USA	10

In Syria, 95% of total chemicals (excluding fertilizers) used to grow cotton are herbicides. In the USA, insecticides and herbicides represent 27% and 45% of total chemicals, respectively. Fungicides are used at the most on 12% of total area in Paraguay, which has the highest application rate in the world. Pheromones—a special group of chemicals used to control insects—are commonly used in Egypt.

Insecticides

In many countries, 100% of planted cotton area is not sprayed, nor is there a need to do so. Currently, 100% of the cotton area is sprayed at least once a season in Argentina, China (Mainland), Colombia, Côte d'Ivoire, Egypt, Iran, Israel, Paraguay, the Philippines and Spain. More than 80 but less than 100% of the total cotton area is sprayed with insecticides in Brazil, Pakistan, Sénégal, Thailand and Togo. In the last ten years, significant changes have occurred in China (Mainland): In 1985, only 70% of the total cotton area was treated with insecticides; insecticide use increased to 100% by 1991. The expansion of insecticide application to a larger area was due to widespread losses caused by bollworms and aphids. Brazil also has significantly increased the area sprayed with insecticides. Syria and South Africa are the only countries where insecticide use in terms of sprayed area has been reduced in the last ten years. In Syria, raising of the economic threshold and IPM have reduced the area sprayed from 25% in 1985 to only 4% during 1994. In Egypt, implementation of plans to spray only infested areas, to discontinue use of insecticides against early season insects, to use pheromones (since 1991) and to practice IPM methods extensively is expected to eliminate the need for spraying some areas. Israel, Pakistan and the USA are also giving high priority to IPM methods and treated area is not expected to increase. In the USA, sprayed area is stagnant at around

Percent Area Sprayed with Insecticides

Country	Year		
	1985	1990	1994
Brazil	69	78	92
Chad	64	75	71
China (M)	70	90	100
Greece	N/A	N/A	41
Pakistan	64	57	84
Sénégal	99	97	95
South Africa	79	100	43
Syria	25	2	4
Thailand	80	90	80
Togo	98	96	96
USA	N/A	66	71

70%, but the USDA target is to raise the total area under IPM to 75% by the year 2000. Australia is also considering plans to implement IPM on 90% of total area and bring a 50% reduction in the use of chemical insecticides by the year 2000.

Organochlorines, organophosphates, pyrethroids and carbamates are major insecticide groups used on cotton to control insects. However, organophosphates and pyrethroids are the only two insecticide groups used in almost all countries. Organophosphates are very popular in China, Colombia and Pakistan in addition to Chad, Côte d'Ivoire, Sénégal and Togo. Pyrethroids form more than 50% of total insecticides in Greece, Paraguay, the Philippines and Syria. Use of pyrethroids, a group of chemicals notorious for resistance, has decreased in Colombia and China, mainly due to resistance problems.

Four main methods to spray insecticides are back-mounted hand operated sprayers, motorized sprayers, tractor-mounted sprays and aerial application. Hand spraying is more popular in Brazil, China, India, Paraguay, Philippines, Syria, Thailand, Uganda and Zimbabwe. In Argentina, Israel and Syria, at least 50% of spraying is done by tractor-mounted sprayers. In Greece, all insecticides are applied with tractor-mounted sprayers. In Australia, 80% of spraying is done with airplanes. In Colombia and the USA, 50% of spraying is done with airplanes.

In Colombia, the need for high quantities of insecticides has rendered cotton production an uneconomical business in some areas. The quantity of insecticides applied per unit area does not differ significantly in Brazil, Pakistan, Paraguay, Philippines and the USA. Comparable data were not available from Australia, China and India, but it has been learned that insecticide use has been reduced in Australia while it has increased in China and India. Chad and Syria use the smallest quantity of insecticides/ha because of limited supply and minimum need, respectively.

Among the ten main cotton producing countries of the world, the highest dollar amount is spent on insecticides and their application in Turkey (US$285/ha). In Pakistan, widespread losses due to leaf curl virus disease since 1992 have increased the cost of insect control significantly, and during 1994/95 about US$200 was spent to grow one hectare of cotton. In Australia, a resistance management program has reduced the average number of sprays from 13 to 9 in the last few years, but still about US$170 was spent to grow one hectare during 1994/95. In China, due to bollworm resistance, the cost of insecticides and their application has increased to US$143 per hectare in the last few years. Damage due to boll weevil may increase the cost of insect control in Argentina in the next few years.

The cost of the two major agrochemicals, i.e. fertilizers and insecticides, for producing one hectare of cotton among the main cotton producing countries is the highest in Turkey (US$478) followed by China (US$315), Pakistan (US$282), Australia (US$241) and the USA (US$217). The cost of fertilizers and insecticides per kilogram of lint was the highest in India due to low lint yield. Among the ten main cotton producing countries, excluding Uzbekistan, the cost of fertilizers and insecticides per kilogram of lint was the lowest in Australia due to high lint yield/ha.

Over 75% or all insecticides used on cotton are imported in Brazil, Chad, Egypt, Greece, Iran, Paraguay, Syria, Togo and Uganda. Similarly, three-quarters or all insecticides used in China, Côte d'Ivoire, Israel, Sénégal, South Africa, Spain, Thailand and the USA are locally produced. However, in all countries, new insecticides are registered only after thorough testing and evaluation of test results by government authorities. In many countries, label language is also approved for safe use of products. Toxic effects, effect on the environment and effect of non-active substances on mammal and non mammal species is rarely given on the labels. Our study has also observed that farmers' understanding of insecticide use has improved significantly and farmers are becoming more conscious of using environmentally-safe products. It has also been observed that spraymen often do not wear proper clothing at the time of spraying or while handling toxic compounds; however, intoxication is very rare. If registered insecticides do not conform to claims made by pesticide companies or cause serious effects on non-target species and the environment, they are deregistered in all countries.

Farmers usually judge products by their field performance which is affected by spray machinery and many other factors. If any of these factors goes wrong and the insecticide does not show the desired effect, the purity of the product is blamed. Adulteration of pesticides is a critical issue often raised by farmers. Quality control is in effect in almost all countries. Resistance to various groups of insecticides is another important issue of concern to many countries and requires long term planning.

Currently, not many choices for non-chemical, safer means of insect control are available to farmers. Among biological control agents, Bt is used in some countries but on a limited area. Cost, comparability with insecticides, and control of more than one species of insects are some of the issues which will determine its future use. On the other hand, genetically engineered Bollgard and BXN cotton, tolerant to lepidopteran insects and broad leaf herbicide, respectively, will be planted on a larger scale in the USA during 1996/97. The impact of genetically engineered Bollgard cotton on reducing the use of insecticides is still to be seen. However, IPM approaches have been designed and implemented in many countries. The Food and Agriculture Organization of the United Nations has organized a number of regional meetings in various countries to promote IPM. To some extent, IPM has already shown an impact on the quantity of insecticides used to control insects.

Major Insects Affecting Cotton

In most countries, major damage to cotton fruit and leaves is caused by bollworms and sucking insects, respectively. Which of these insects is important in any country depends on the losses caused and the difficulties encountered in controlling it. Although species of insects found in one country or region may vary, in general, the same insects are found across regions, with the exception of the boll weevil, Sudan bollworm and red bollworm. Boll weevil, *Anthonomus grandis*, is found only in North, Central and South American countries. Extensive work has been done in the USA to understand the behavior, biology, alternate hosts and elimination methods in the last 100 years since it migrated to the USA from Mexico. Since 1992, it has appeared in Paraguay and more recently in Argentina. Boll weevil is a major threat to cotton production in the region. Many countries in Central America have had to stop growing cotton because of heavy losses due to boll weevil and inability to control this insect. Currently, the ICAC is sponsoring a project on integrated pest management of boll weevil in Argentina, Brazil and Paraguay. The project has been funded by the Common Fund for Commodities. *Diparopsis watersi* and *Diparopsis castanea* are still found only in African cotton growing countries.

It has been observed that if a certain major insect is controlled, chances are that a minor insect(s) may become a major insect. Insect patterns which have occurred in the last ten years have shown that the importance of insects has not changed in Brazil, Chad, Syria and Uganda; the same five most important insects continue to be as important now as in 1985. In all other countries, either a new insect has appeared among the five most important insects or the importance of already existing insects has changed. In Argentina, though the boll weevil appeared as a new pest of cotton, now it has become more important to control aphids than ten years ago. In China (Mainland), bollworm was the third most important pest during 1985, but currently it is the most important pest of cotton. Now, it has also become more important to control aphids and mites.

Significant changes have also occurred in many other countries. The significance of *H. armigera* has increased in Pakistan, Sénégal and Spain, while it has become less important in Greece, Israel, the Philippines and Togo. Whitefly continues to be the most important pest in Israel and Pakistan, but, in the last ten years, whitefly control has become more important in Egypt. *Spodoptera* spp. has emerged as an important pest of cotton in the USA.

Herbicides

Herbicides are used extensively only in Colombia, Greece, Israel, Spain, Syria and the USA. Alternate methods of eliminating weeds in the form of cheap labor and mechanical eradication are available and used in other cotton producing countries. In the last ten years, herbicide use has decreased in Sénégal and South Africa. The general trend, however, is increased use of herbicides because of better awareness of the ill effects of weeds which compete with the cotton plant for water and nutrients, harbor insects, hinder cultivation operations and affect lint quality. In the USA, although it is intended to reduce herbicide applications, the release of genetically engineered BXN cotton tolerant to broad leaf herbicide might encourage the use of post-emergence herbicides. Syria has stabilized herbicide use at 70-80% of total area. Cost of herbicides is the highest in Colombia followed by Spain and Israel because all the cotton area is treated with pre or post emergence herbicides in these countries.

Growth Regulators

Growth regulators are used only on a small scale with the exception of Brazil and China (Mainland), where currently 55% and 60% of total cotton area, respectively, is treated with them. The use of growth regulators is expected to increase in these countries. In Greece and Guatemala, the portion of the area treated with growth regulators fluctuates around 35%, depending on planting conditions. 10-14% of the total cotton area is treated with growth regulators in Argentina, Bulgaria, Ecuador, Israel and South Africa. In the last few years, the use of growth regulators has increased significantly in Spain, and now about 70% of the total area is sprayed with them. In the USA, 35-40% area is treated with growth regulators. Growth regulators have shown no significant effect on yield in many countries like Egypt, Pakistan, Philippines and Turkey. With the continuous selection pressure on the plant for short and early maturing plant types, a stage might come when growth stimulants may have a positive effect on yield.

Defoliants

Chemical defoliation is a prerequisite for machine picking. But, in some countries defoliants are used to enhance crop maturity and also to improve uniformity. Sometimes cold temperatures also serve as a natural defoliant and help in natural shedding of leaves and consequently improve crop maturity. Only in Australia and Israel is 100% of the cotton crop chemically defoliated. In the USA, almost all cotton is defoliated in the West but only 20% of production area is defoliated in the Southeast.

Note: For detailed data and information on any aspect of agrochemicals and insect patterns given in this article, please refer to the ICAC publication *Agrochemicals Used on Cotton*, October 1995.

High Volume Instrument Testing

The use of High Volume Instrument (HVI) testing is expanding at a fast rate for at least two reasons, i.e. high efficiency and better reproducibility of results. HVI can very well be called a composite of machines used to measure individual characters like length, strength, micronaire, etc. It is an expensive machine which is currently preferred by consumers. Spinners use it more frequently because it is efficient and provides reliable testing for economical adjustments in the spinning process. But, HVI is in no way less important for the producing countries. If producers know that users of their cotton are going to test it on HVI, it becomes even more important for them to evaluate fiber characters on HVI so that results are reproduced in the mill. Now, more than before, spinners are interested in confirming that fiber characters producers are reporting are true quality characteristics of the cotton they are buying. Reproducibility of quality parameters in the mill also helps to improve confidence among buyers and sellers. Although it is necessary to use HVI more extensively in developing new varieties, it is still not very popular among breeders. Adoption of HVI testing in breeding new varieties can help to screen a higher number of breeding lines/plants and, on the other hand, get more reliable results.

HVI Systems in the World

Only two types of HVI systems, i.e. Spinlab and Motion Control, produced by Zellweger Uster, Inc. and Motion Control, Inc. (MCI), respectively, are used throughout the world. Motion Control, Inc., pioneer in the introduction of HVI systems, stopped producing new models in 1994; however, technical support and maintenance facilities are said to be still available. Production of HVI systems by both companies is given in the table below.

Models HVI 3000, HVI 3500 and HVI 800 require three operators to run one system. Second generation of Spinlab machines, i.e. HVI 900A and HVI 900B, and HVI 4000 of MCI require only two operators. HVI 5500 and all Spinlab models from 1992 onward require only one operator for all tests done on one machine.

HVIs Produced in the World

Manufacturing Period	Model	Units
MCI		
1969-87	HVI 3000	34
1986-93	HVI 3500	41
1986-93	HVI 4000	59
1993-94	HVI 5500	51
Spinlab		
1980-83	HVI 800	21
1984-89	HVI 900A	193
1989-92	HVI 900B	283
1992-present	HVI Automatic	73
1992-present	HVI 900 Semi-automatic	145
1992-present	HVI USDA	140

Currently, Zellweger Uster, Inc. is the sole HVI supplier. By the end of 1995, there were about 940 HVI systems installed in 62 countries, capable of measuring at least the three most important fiber characters—length, strength and micronaire. According to Hunter (1996), approximately half of the total HVI systems in the world are used in spinning mills, and about a quarter by USDA classing offices. The remaining systems are used by cotton growers, ginners, merchants, textile machine manufacturers, research institutes and universities. Only a small number of systems are used by researchers at institutes and universities. In the USA, all cotton is classed on HVI. Although, there are only two HVI systems in Israel, they are enough to test a total production of 30-40,000 tons of cotton in the country. Similarly, there is not a high number of systems in Australia, but facilities to test the bulk of the country's production on a regular basis are available at Namoi Cotton Cooperative Limited and Queensland Cotton Corporation Limited. All quality testing of South African cotton is by HVI. There has been a high rate of adoption of HVI systems in the world but still it will take many years until such facilities become available to researchers in many countries.

HVI Systems in the World
(Complete and Partial Units)

Year	Number of Systems
1980	24
1981	31
1982	41
1983	69
1984	82
1985	107
1986	164
1987	219
1988	339
1989	430
1990	532
1991	630
1992	780
1993	850
1994	850
1995	940

The earlier models were capable of measuring only length, strength and micronaire at a much slower rate. Latest models are fully automated in terms of sampling and testing and take only 20 seconds on average to test one sample. A complex unit is capable of measuring color, fineness, maturity, trash and sugar content, in addition to length, strength and micronaire. A limited number of HVI systems are integrated with FMT fineness and maturity testers, SDL Micromat Tester and NIR systems (only 50 units) for measuring sugar content and maturity. Integration of short fiber content testing equipment will also be available as soon as reliable and agreed methods become available.

Calibration of HVI Systems

According to Hunter (1996), about 60% of total systems in place in the world use HVI Calibration Cottons and 40% use International Calibration Cotton Standards (ICCS). The HVI Calibration Cottons are used mainly in the USA to calibrate systems for measuring HVI pressley strength and upper half mean length or mean length in inches. The ICCS are mostly used outside the USA to measure Stelometer strength level and 2.5% span length in millimeters. Differences exist among countries and researchers in measuring some quality parameters, particularly short fiber content and strength. Without going into details on whether the number of short fibers or weight of short fiber content—or Stelometer or Pressley—is the right method to measure these parameters, reproducibility remains a high priority in HVI testing. The main causes of variation are machine, operator and laboratory conditions. Repeated interlaboratory tests have shown that it is possible to measure length, micronaire and some other characters with a high degree of certainty while it is difficult to obtain similar levels of confidence for strength measurements. Automation of systems has reduced the role of operators. Currently, laboratory conditions is the most critical factor in determining reproducibility of results, mainly because of sensitivity of the equipment to relative humidity and atmospheric temperature in the laboratory. The following conditions are most commonly recommended to calibrate systems and enhance reproducibility of results.

Laboratory conditions

Temperature	$21^{o}C \pm 1^{o}C$
Relative humidity	65% ± 2% RH

Calibration cottons

Micronaire	Use ICCS
Length	Use HVI Calibrated Cotton for UHM length
Length uniformity index	Use HVI Calibrated Cotton
Strength	Use HVI Calibrated Cotton
Color	Use calibration tiles from the USDA
Trash	Use calibration tiles from the USDA

In order to remain within tolerance limits, calibration tests should be repeated preferably every four hours, though reports from Belgium show that once in the morning and once at the end of the day is more desirable (Langenhove and Louwagie, 1996). Testing a minimum of three specimens for micronaire and twelve specimens from each of two calibration cottons for length, length uniformity index, and strength is also recommended.

It has been difficult to maintain a constant humidity level of 65% in laboratories, which requires not only expensive conditioning equipment but sophisticated monitoring equipment to keep a constant watch on humidity levels. The ITMF International Committee on Cotton Testing Methods in its meeting held in Bremen from March 5-6, 1996, considered changing the recommended relative humidity to 50%±5%. Although it is easier to maintain 50% RH, in the absence of any reliable data, the ITMF committee decided not to change the humidity level at least for the time being. However, the committee unanimously agreed that a ±5% range is too high. It was realized that a lower humidity level may also require a change in temperature. The ITMF committee appointed a sub-committee of specialists to investigate if there are good scientific and economic reasons for changes in textile testing environments and solicit comments from persons in the textile industry. Some committee members were instructed to conduct trials so that the committee could have a position on the issue.

The International Standards Organization is already considering revising the humidity standard to 50%±5% and temperature to 23°C± 2°C and is seeking advice from the ITMF committee.

Maintaining recommended laboratory conditions is a pre-requisite for reliable testing of fiber parameters using HVI. One of the causes of producing non-reliable data is that the HVI operator does not realize that his laboratory conditions have exceeded the desirable limits. Hence, a proposal was made to the ITMF committee to consider including a kind of warning signal in the HVI units if relative humidity and temperature go out of acceptable limits. There was no support for such a facility in machines.

Measurement of Short Fiber Content

In the last issue of *THE ICAC RECORDER*, the article, ‘‘Improved Instrumentation to Measure Cotton Maturity and Fineness,’’ discussed in detail the measurement of cross-sectional perimeter and degree of fiber wall thickness relative to perimeter with the help of NIR HVI. Micronaire and length do not seem to have a problem; however, measurement of short fiber content—fibers usually less than 12.7 mm in length—is a challenge for machine manufacturers. No precise reference method is available to test the validity of the latest work going on to integrate a unit of measurement of short fiber content in HVI systems. The HVI’s Length Module, with the help of the optical system method, is capable of scanning 3,000 fibers in less than ten seconds and generating a length frequency diagram called a fibrogram. The fibrogram analysis provides length analysis of all fibers in the sample but fibers shorter than 3 mm cannot be seen in the scanning. Knowing that fibers shorter than 3 mm form less than 1% of total fibers in a sample, optical scanning of a length module provides a potential methodology to measure short fiber content with HVI in the future (Ghorashi, 1996). Mr. Ghorashi also reported to the ITMF International Committee on Cotton Testing Methods that cottons ranging from 20.5 to 38.5 mm in length were tested on Suter Webb, AFIS and Fibrograph Model 730 devices and results were compared with HVI fibrogram analysis. According to Mr. Ghorashi, the correlation coefficient in all cases was above 0.92 thus showing a high degree of reliability in the latest approach to measure short fiber content.

Measurement of Strength

Measurement of strength and its reproducibility remains a matter of great concern worldwide. It has been observed that one of the important sources of variability is relative humidity. Deviations from mean have a higher impact on strength value compared with other characters. It is assumed that if the standard relative humidity level is decreased, it will have a positive effect on reproducibility of strength data. Differences in methods to measure strength (Pressley in the USA and Stelometer elsewhere) is also one of the reasons for differences in strength values. According to Dr. H. Harig of the Faserinstitut Bremen, Germany, there is still a wide range of variation in zero gauge Pressley and Stelometer readings. The Round trials have shown that there is a good correlation between 1/8" gauge Pressley and Stelometer readings and, using either one of the calibration cottons, the two levels can be related by a constant factor of 1.28 (Pressley to Stelometer). The trials conducted by some other laboratories do not agree with the findings of Dr. Harig, thus emphasizing the need for more harmony in testing bundle strength.

A team of experts under the leadership of Mr. C. K. Bragg of the USDA-ARS Cotton Quality Research Station in Clemson, USA, is already working to devise a standard reference method for HVI strength measurements. The group feels that conditioning or measurement of temperature and humidity levels of lint samples, specimen selection and preparation process, force necessary to break a specimen of fibers, and linear density of a bundle of broken fibers are the most important elements for consistent bundle strength measurement. Linear density is the most critical factor in this regard. Ten laboratories in various countries are participating in the group activities. Recommendations on standard procedures for these four important elements are expected to be available by October 1996, which it is hoped will further improve the reproducibility of the strength data.

ITMF HVI Working Group

The International Textile Manufacturers Federation (ITMF) constituted an International Committee on Cotton Testing Methods in 1980, with the objective of recommending accurate and reliable testing methods and enhancing harmonization of cotton testing results. The Committee which meets in Bremen every other year, before the International Cotton Conference, operates through various working groups. The HVI Working Group was created in 1988, and since then has been headed by Dr. Lawrance Hunter of the CSIR Division of Textile Technology, South Africa. In its meeting held on March 5, 1996, the Group considered the latest developments in HVI testing and emphasized the need for further research in certain areas. The formal conclusions of the HVI Working Group meeting, which were presented to the 23rd International Cotton Conference, Bremen, on March 8, 1996 are as follows:

1. The installation and use of HVI systems continues to increase worldwide, there being 940 systems in place in 62 countries at the end of 1995.

2. The Universal Standards Agreement, embracing 21 signatory associations from eighteen countries, has been expanded to include USDA HVI Calibration Cottons, laboratory atmospheric conditions and sample conditioning practices and procedures.

3. Most of the primary objectives of the Porto Group have been accomplished and further activities of this nature are to be undertaken by a technical advisory committee—to be headed by Dr. Preston Sasser—which will provide inputs and recommendations to the Universal Standards Advisory Committee, as well as by the ITMF HVI Working Group.

4. The USDA has established an international HVI Level Assess-

ment Program, modeled after their program (checklot system), in order to promote universal uniformity in HVI fiber quality measurement and levels, with the idea that the signatories to the Universal Standards Agreement having HVI systems act as regional testing centers.

5. Considerable progress has been made in the development of an HVI Universal Reference Strength Tester based upon the Spinlab 900 system and nine systems have been installed in four countries. Round trials are soon to commence. Much has been learned during the development of this system which can be fruitfully applied to commercial HVI systems. Nevertheless, certain issues still need to be resolved.

6. The ITMF recommended that ‘‘Best Laboratory Practice’’ guidelines for HVI testing should be prepared for use with the detailed instruction manual of HVI instrument manufacturers.

7. Software systems standardizing calibration procedures for different HVI systems to eliminate calibration tests, except when the check test has failed, are being installed more widely, thereby helping to reduce the frequency of unnecessary calibration tests and to improve standardization.

8. The continued use of two different calibration standards (ICCS and HVI-CCS), resulting in different strength levels and length measurements, still represents a problem. It was felt that, in the interim at least, as long as the different strength levels and length parameters are correctly calibrated and always specified (also on the HVI Calibration Cottons), confusion should be minimized. The ultimate goal remains one universal strength level and set of length parameters.

9. The importance of limiting variations in moisture content of the beard cotton sample at the instant of testing, or else the correction of any undue such variation, was again stressed.

10. Following upon a proposal last year to change the CEN standard atmospheric conditions, there were again some discussions concerning whether or not 65% RH was really the best for standard atmospheric conditions. The implications and benefits, if any, of changing the standard laboratory atmospheric conditions are now to be investigated.

11. The manufacture of the MCI HVI systems was discontinued in 1994, but component manufacture and technical back-up for existing MCI systems will continue.

12. A software-based system to derive short fiber content from the HVI determined fibrogram appears to have potential, particularly in view of the fact that the fibrosampler does not prepare a length biased sample. This will become a standard feature on all post 1002 (DOS based) systems, once externally verified.

13. A new calibration technique for elongation reduces interlaboratory variability but appears unlikely to reduce it to the target CV of 5%.

14. It was felt that machine manufacturers could do more, and in fact are doing more, to ensure that their HVI systems are, or should be, operated only under correct conditions and procedures.

15. The effect of a sampling device on the reproducibility of best results was again shown and the benefits of a modified and fairly easily installed pinch sampling device for MCI systems were demonstrated.

16. The need to investigate the potential benefits of introducing the latest technologies into HVI measurement of color and trash was emphasized, such work already being in progress in the USA.

17. The advantages of a smaller range of ‘‘fiber amount,’’ now practically feasible with the automatic HVI systems, were confirmed.

18. The importance of a more precise determination of the optical mass at, and of, the position of the break was again emphasized.

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Short Notes

A Biodegradable Material from Cottonseed

Normally, the cottonseed kernel is comprised of proteins (30-40%), lipids, soluble carbohydrates, cellulose, minerals, phytates and polyphenolic pigments. Utilizing the high proportion of ionizable amino acids of proteins, the Cotton Technology Laboratory of the CIRAD-CA in Montpellier, France, has developed a methodology to make a biodegradable material from cottonseed flour for use in packing, coating and many other purposes. Apparently, there are two important steps involved in the whole process. The first step is dissolution of seed proteins in the so-called film forming material to avoid protein-protein interaction. The dispersion is made homogeneous in a centrifuge in order to eliminate non-soluble substances. The second step involves elimination of solvents. The CIRAD-CA researchers used three types of cotton seeds: Glanded, glandless and dilapidated glandless, and were able to make three different types of films. The one made from dilapidated glandless seed was transparent, while the other two were opaque due to lipids that were spread throughout the protein jell. The presence or absence of glands affected the physical and mechanical properties of films. The presence of gossypols in glanded flours produced films that were less soluble than those made from glandless flours. All types of films degrade in the soil after they have served their initial purpose. While some other properties still remain unexplored, the material also seems to enhance soil fertility. Some important properties of films made from cottonseed flour are as follows:

- For use in packaging, the material is insoluble and has good resistance to gases, volatile substances and water vapors; it also has good flexibility.
- The cottonseed films are water permeable and have high elasticity and flexibility at high relative humidity, to be used in coatings for slow release of active substances.
- In respect of agricultural uses, the films have shown high puncture strength, very low solubility, good water vapor permeability, and after degradation they serve as a source of nitrogen.
- The material is non-toxic and can be sterilized for successful utilization in slow release of biologically active substances.
- Materials made from glanded cottonseed flour and dilapidated glandless flours and cross linked with formaldehyde or glutaraldehyde can also be used in surgical operations.

(Source: Biodegradable material made from cottonseed flour, *Proceedings of the 23rd International Cotton Conference*, March 6-9, 1996, Faserinstitut Bremen e. V., Postfach 106727, D-28067, Bremen, Germany.)

A New Method for Estimating Insecticide Residues in Cotton

Researchers in Germany have found a new method called ‘‘Bioassay Method,’’ to test insecticide residues, if any, in cotton. According to a paper presented at the 23rd International Cotton Conference, Germany, three analytical steps involved in the process are extraction of pesticides through a solvent, removal of solvents from the cotton liquid and determination of toxicity of the extract to algae and daphnids. They tried a number of extraction solvents and their mixtures to find the most suitable solvent. The most important consideration for a good solvent is its ability to extract even minor quantities of insecticide residues and, at the same time, it should not be toxic to target test species (algae and daphnids in this case). Removal of solvents from cotton samples is comparatively an easy process and can be performed efficiently. Toxicity to algae and daphnids was determined by two methods: Modified short term test for algae and an international standard test used to measure immobility of daphnids. Eighteen cottons from various origins with unknown insecticide spray schedules were tested by the bioassay method and analytical procedure. The analytical studies for organochlorine, organophosphate, pyrethroids and Thiram (Carbamate) compounds showed that seven out of eighteen cottons were contaminated with insecticides; five with varying amounts of organochlorine and two with varying amounts of organophosphate compounds. The same seven cottons were found toxic to algae and daphnids, however, less than 0.05 mg of carbamates per kg of lint could not be detected in a response to algae. The methodology showed good promise to be used in commercial application after some perfection. For more information on solvents used and determination of toxicity to target species contact Mr. H. Wefers or Mr. M. H. Riess at the Institut für Umweltchemie Bremen GmbH, Bremen, or Mr. B. Tennigkeit of the Faserinstitut Bremen e.V., Bremen, Germany (Fax: 49-421-3608913).

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