FUTURE OF HARVEST AIDS

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Abstract

The future of harvest aid chemicals is discussed. Predictions are based on past and present experience. It is predicted that there will be more pressure on current products and that promising new products may never make the marketplace. Even so, within the next 3-5 years there should be new and improved harvest aid chemicals with low use rates, minimal residues, and low odor, improved crop management practices, and non-chemical defoliation methods. Biotechnology and conventional breeding down the road offer the possibility for self-defoliating cotton plants without use of chemicals or with reduced chemical use, although this might require significant changes to the cotton plant. The future direction of the cotton industry will be guided by how well it controls stewardship of product use, awareness of public concerns, adherence to use restrictions and use of chemicals, and continued adoption of viable new technologies.

Introduction

Predicting the future is an unscientific process, since proposed/postulated hypotheses can not be tested. However, relevant information gathered about the past and the present can be used as a basis for choosing among possible futures. This includes:

Societal changes (i.e., urban society)
Increasing regulations (air, water, solid waste)
Past history with canceled products (e.g., Arsenic Acid)
New pesticide registration laws (FQPA)
Reregistration of Tribufos (DEF/Folex)
Chemical company research efforts for new and better products

This paper discusses the possible future of harvest aid chemicals based on past and present experience (Wakelyn et al., 2001).

Concerns/Regulalory Issuses

Societal Changes

In the 20th century the United States changed from a rural to an urban society. Less than 2% of the people in the U.S. now live on farms. As a result the majority of the population has lost direct contact with agriculture. Many individuals and groups have developed strong concerns about the potential social, economic, and environmental issues of modern U.S. agriculture related to food safety, air and water quality, and solid waste generation. These concerns have resulted in passage of numerous federal and state regulations that affect crop protection product use, air emissions [e.g., fugitive dust, particulate matter (PM_{10} and $PM_{2.5}$), hazardous air pollutants (HAP), volatile organic chemicals (VOC)], and disposal of wastes (e.g., composting, animal feed) (Wakelyn, et al., 2001).

As consumer concerns have increased, governments -- especially foreign governments – have responded by objecting to shipments of numerous products derived from crops treated with certain crop protection products, as well as to raw materials and products from biotechnology engineered (GE) plants.

The farm sector has responded to some degree by being environmentally responsible with production practices and by challenging the scientific validity and merits of questionable mandates and restrictions. However, in today's world, perception/perceived risk tends to be considered real and scientific facts are questioned or discounted. Perceptions can be very deceptive. As a result there are many misconceptions and statements made that are not scientifically supportable. It is important to recognize that assessing risk is an inexact and evolving science (Bailer, et al., 1999). It should be remembered that the dose (i.e., level of exposure) is the important factor in determining whether something, that is hazardous or toxic, is a risk (the probably of harm). The correct balance between risk, benefit, and regulation needs to be considered.

Increasing Regulations

The agricultural sector needs to be proactive, visibly and continually, in addressing issues related to food and fiber production and to environmental stewardship. In evaluating harvest practices used for cotton, factors other than cost and the lowest acceptable level of treatment efficacy need to be considered. Cotton producers also must consider not only the effect of their actions in producing raw cotton but the effect of raw cotton on the environment and workplace, of their downstream customers and consumers. These include the potential effects on downstream cotton industries, cotton gins, cottonseed oil mills, and textile mills. From an environmental and health and safety perspective, it is advantageous to leave as much extraneous (non-lint and seed) plant materials, soil particles, and other foreign materials as possible in the field.

Gins are required to meet EPA air-quality standards for PM (regulated as PM_{10}, particulate matter less than 10 microns; $PM_{2.5}$, PM less than 2.5 microns; and TSP, total suspended particulate) (40 CFR 50) and must obtain and maintain air-quality permits (Hughs, et al., 1997). In order to help reduce external gin emissions of PM and other potential air pollutants, it is important to minimize foreign material content in seed cotton and lower the levels of harvest-aid residues on lint and trash. The quantity and toxicity of harvest aids and other plant-protection product residues in gin emissions and gin by-products are of concern to some state regulators. Depending on the source and concentration of the contaminant, these residues could be classified as hazardous wastes, and more states may eventually require gins to obtain solid-waste permits. Leaving most of the trash in the field at harvest reduces the need for trash disposal, lowers gin external emissions, and reduces the potential for litigation on behalf of nearby residents for alleged health problems.

Extraneous materials (trash) in lint and seed affect cottonseed oil mills and textile mills. Trash in cottonseed can increase PM emissions at oil mills and require more cleaning of the seed prior to solvent extraction. Over-cleaning at gins creates more short fibers and fine trash, which subsequently result in textile mill processing problems (e.g., increased ends-down in spinning – stoppages in spinning because of broken yarn), higher workplace and external emissions, and waste disposal problems. All these factors add to cotton processing costs.

When this desiccant is applied to cotton, some arsenic (inorganic form) is deposited on the soil, plant materials, and cotton fibers; concerns have surfaced about the fate of these residues. For example, textile mills are concerned about the chemical residues contained in the dust and on the cotton because of health issues and chemical residues in the textile mill waste (unwanted solid materials) can cause it to be classified as hazardous waste and require disposal in a lined or hazardous landfill. Also effluents from textile dying and finishing operations can exceed chemical limits (e.g., for arsenic) for textile effluent guidelines and National Pollution Discharge Elimination System permit limits causing the textile mill to spend a large amount of capital to meet standards.

In the European Community and elsewhere, the presence of high levels of heavy metals and chemical residues from crop-protection products could prevent textile products from qualifying for an ecolabel status (EU Ecolabel

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for Textiles; the Oko-Tex Initiative for ecolabling), reducing their value or even marketability.

In the United States, air quality and other concerns may be grounds for new restrictions and even may threaten continued registration of some products. For example, tribufos (the active ingredient in Def/Folex) has been added to the list of toxic air contaminants (TAC) in California (1997) and was subject to reviews under the California Birth Defect Prevention Act of 1986 and by U.S. EPA under FQPA/FIFRA. These designations have lengthened the re-entry interval after application and have led to other restrictions.

Residues of harvest-aid products have a higher potential for being detected on lint, seed, and trash, because they are applied after all or most of the bolls are open. If residues of products exceed established tolerance levels, the feeding of whole cottonseed, cottonseed hulls, cottonseed meal, and gin by-products to animals must be limited or stopped altogether.

Case History: Arsenic Acid

The power of public perception and concern is exemplified in the case of arsenic acid, a harvest-aid product introduced in the 1950s, which was used for nearly 40 years as a highly effective and relatively inexpensive cotton desiccant.

This product was suited ideally for use in the Southwest (Texas and Oklahoma), where sparse and erratic rainfall limited yield potentials of large tracts of dryland cotton. The low yields and short plant stature made spindle picking impractical, but such crops were well suited for less-costly stripper harvesting, if the leaves and other plant materials could be dried economically and efficiently. Arsenic acid fit these harvest-aid criteria and was widely used throughout the Southwest from the mid 1950s until it was withdrawn from the market in 1993.

Arsenic is ubiquitous. It occurs naturally in soils, from where it is taken up in small quantities by plants and introduced into foods and other plant-derived products. Arsenic also is an essential element in the diets of some animals the FDA has set tolerance limits for residues of arsenic compounds when used as veterinary drugs (21 CFR 556.60).

Arsenic, although a natural part of the environment, is recognized universally as a "poison," and inorganic arsenic is a documented carcinogen. Over the years, concerns arose about arsenic accumulation in soils and human exposure risks following long-term use of this cotton desiccant. Monitoring studies showed that, over time, labeled applications of this desiccant added to the inherent levels of arsenic in soils, but not to the extent that long-term sustainability of crop production was at risk. Still, arsenic residues on plant material harvested along with the seed cotton were alleged to constitute a potential risk to workers at gins and to area residents. Suits were filed by area residents living within 5 miles of several gins for alleged health effects. Also, worker compensation claims have been filed by gin and textile workers citing acute and chronic health effects from arsenic in the cotton and airborne cotton-related dust in the working environment. These lawsuits ultimately were settled out of court for less than it would have cost to hear the cases, even though there was no evidence to support a conclusion that the exposure levels constituted a clear health risk. Since alleged health effects and environmental concerns continue to be raised, there could be further lawsuits. Current harvest aid chemicals also could be subject to lawsuits for alleged health effects from their use on cotton.

In 1986, EPA adopted a rule regulating inorganic arsenic as a hazardous air pollutant (HAP) under the Clean Air Act, but specifically did not cover cotton gins, because the estimated health risks to gin workers and area residents from cotton gins was too small.

In 1991, EPA published a preliminary determination to cancel registration of arsenic acid on cotton. The textile industry had become concerned about the product, because, in some cases, arsenic levels in the cotton textile mill waste had exceeded the EPA level for leachable arsenic (40 CFR 261.24), thereby classifying the mill waste as a hazardous waste. Also, levels of arsenic in textile effluent in some mills exceeded local or state effluent guidelines.

Because of these concerns and potential EPA actions, registration for arsenic acid was canceled voluntarily in 1993, and its use as a cotton desiccant was discontinued after the 1993 season. EPA noted in the 1991 proposal to cancel registration that the risk to applicators was unreasonable, but the risk to area residents and gin workers was still considered acceptable even when very conservative risk estimates were applied.

Overall, arsenic acid was in the marketplace for 37 years as a labeled cotton desiccant. Its record shows that, when used properly, it was a safe, effective product. Yet, it was withdrawn from use in large part because of "downstream" processing consequences and textile mill environmental concerns, rather than from in-field application risks. Ultimately, loss of arsenic acid, coupled with the lack of comparable, low-cost replacements, increased production costs, reduced cotton acreage in sections of Texas and Oklahoma, and threatened the economic viability of affected producers, as well as operators of key support industries.

What, if any, are the lessons to be learned from the experience with arsenic acid that can be applied in the future? Because of the new pesticide law (FQPA) in 1996, which can make registration/reregistration more severe (reasonable certainty of no harm/cumulative risk), it is very likely that other harvest-aid products will be challenged on the basis of health and environmental concerns; some even may be discontinued because of the loss or withdrawal of product registrations. Promising new products may never make it to the marketplace because of the difficult and costly processes of discovery, development, and registration.

Material Registration, Regulation, and Safe, Efficient Use

Registration/Reregistration of Defoliant Products

FIFRA and FQPA (7 U.S. Code 321 et seq.)--All crop protection products, including defoliants, are registered for use in the United States under Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Approval for use is granted through the Environmental Protection Agency, which oversees the registration process. Recent estimates detail how a candidate chemical product undergoes at least a 10-year process from discovery to registration. The product is submitted to more than 120 tests outlined by the EPA, to develop a complete toxicological profile. Total costs of bringing a product to market are estimated to exceed $50 million dollars.

FIFRA was amended in 1996 by the Food Quality Protection Act (FQPA). This legislation requires that all existing tolerances be reviewed with the intent of providing greater protection for infants and children. Under FQPA, risk of exposure to each active ingredient is measured for each route of exposure: dietary, drinking water, residential (indoors and outdoors), and other non-occupational situations, such as golf courses.

Tribufos (DEF/Folex)

The most prominent defoliant in the early EPA review process for FQPA is tribufos, the active ingredient of Def and Folex. Because it is an organophosphate (OP), it was included in the review along with other members of this group, which largely consists of insecticides. On Sep. 28, 2000, EPA signed an interim Reregistration Eligibility Document (iRED) for DEF. The iRED availability was published in the Federal Register on Dec. 15, 2000. Risk estimates were mitigated by adding more stringent protection requirements for workers, mixers, loaders, and applicators.

Closed system containers and closed application systems also will be required to further mitigate risks.

Chronological Events for DEF/Folex (Tribufos) Reregistration

Tribufos (DEF, Bayer Corp. and Folex, Rhone-Poulenc) is an organophosphate that is used solely to defoliate/dessicate cotton in preparation for machine harvesting. DEF has been safely used on cotton for almost 40 years (registered in 1960) and is applied to about 35% of the U.S. cotton acreage.

In the Sept. 24, 1999 Federal Register, EPA announced the availability of the revised risk assessments for tribufos. There was be no technical briefing as agreed upon in TRAC discussions for the pilot program for organophosphates. EPA, however, after objection by NCC, did agree to an informal discussion of the assessment. EPA initially sought a voluntary cancellation of tribufos.

EPA has no concern about dietary or drinking water exposures. There are no residential uses. Using models and databases, EPA has estimated high ecological and occupational risks. These estimates are extremely large and do not realistically correspond to the use of the product and its history of safety. Bayer Corp. also submitted to EPA biomonitoring data of workers under real field conditions and found no cholinesterase inhibition; the Agency refused to consider these data.

EPA claimed there are many alternatives to tribufos which are comparable in price and effectiveness. Cotton growers disagree. The alternatives mentioned by EPA are all much more expensive than DEF. Furthermore, growers need a variety of products to meet the conditions in their fields. Many of these "alternatives" do not work well when nighttime temperatures drop below 60 degress; DEF will work at these temperatures.

November 1-2, 1999: NCC sponsored a trip to Arizona for EPA staff involved in tribufos decisions to view cotton harvest and ginning operations first hand. EPA, at that time, was under the impression that cotton was still hand picked in the U.S.

November 29, 1999: The dialogue continued after NCC scheduled a meeting with EPA attended by Allen Helms, Jr., then chairman of the American Cotton Producers (ACP), Mark Williams, a NCC producer director, and Roger Isom, who represented the California Cotton Growers Association. The benefits of DEF was the emphasis of the discussion. EPA declined an offer by NCC of a written benefit statement claiming that the Agency clearly understood such benefits.

In conjunction with regional organizations, Bayer, and EPA, NCC negotiated mitigation proposals for worker risk concerns. These mitigations were: 1) reduce the maximum application rate to 1.5 pints/acre/year (1.125 lbs a.i./acre) in all states except California and Arizona which would maintain the higher rate of 2.5 pints/acre/year (1.875 lb/acre), 2) increase the restricted entry interval (REI) from 24 hours to 7 days, and, 3) distribute tribufos products in closed systems starting in 2002 growing season.

Despite these mitigations, EPA came back several months later and asked for a written benefits statement. NCC staff prepared and submitted a benefits statement on March 6, 2000.

June 2000: EPA again makes claims that there are numerous efficacious and cost-effective alternatives to tribufos.

July 28, 2000: Harold Coble, USDA and North Carolina cotton farmer, joined NCC staff in another discussion with EPA. Coble explained to EPA the difference between defoliation and dessication and why certain products are needed under specific field situations in order to clarify to the Agency why some of the products they were considering alternatives to DEF could not be classified as such. EPA asked Coble to submit his statements in writing which he did.

August 11, 2000: NCC staff submit a report to EPA entitled "Economic Impact of Using Tribufos Replacements".

End of August, 2000 – As a further mitigation measure, EPA added a buffer strip of 150 feet around waters that support wildlife for aerial applications of tribufos out of concern for spray drift into such waterbodies. NCC contested this last minute addition explaining to the Agency that such a restriction would severely impact cotton farmers particularly in the MidSouth where cotton fields tend to be smaller and waterbodies are numerous. EPA decided to drop the buffer zone requirement.

September 8, 2000: EPA conducted a "closure" conference call with NCC and Bayer to review all the final decisions.

September 28, 2000: EPA signs for approval intermediate Reregistration Eligibility Document (iRED). (It is referred to as intermediate because EPA will add the cumulative risk later).

October 24, 2000: Bayer Corp. received by certified mail a copy of iRED for tribufos.

The iRED avilability was published in the Federal Register on Dec. 15, 2000 (65 FR 78488). New mitigation measures were added: application rates of 1½ pints/acre/year, except in CA and AZ, which maintain a rate of 2½ pints/acre/year; an increased reentry interval of seven days, up from the current 24 hours; and closed delivery systems by 2002. There was also a data call in for ULV (ultra low volume) in the iRED and EPA also wants more research on pharmacokinetics. So, it is not yet a final decision although it appears tribufos will be able to be used for the forseeable future.

Future

Research based chemical companies are committed to the continued advancement of crop protection/production products and continue to look for new and better products. The performance, safety and compatibility of new, non-organophosphate defoliant chemistries are currently being evaluated under varying local conditions. These new defoliant classes are defined by low use rates, low persistence, minimal residues and low odor. These chacteristics are beneficial to everyone in the cotton industry, particularly those that produce cotton near urban settings. The chemical companies hope to add these products to the growers list of harvest aid options in the near future. Most products are 3-5 years away.

Optimal management of the crop is very important. Reseach is leading to a better understanding of the use of harvest aid chemicals. The most cost effective and enviromentally friendly crop management practices for production of the highest quality cotton will be determined.

Down the road biotechnology and conventional breeding offer possibilities for crop termination (self defoliation) without use of chemicals or with reduced use of chemicals (N. Trolinder, 2001). However, this could possibly have to require changing the cotton plant from a perennial to an annual and making the cotton plant more determinant.

Non-chemical methods for defoliation are also being researched (P.A. Funk et al., 2001). These include steam and hot air. These treatments can desiccate but not necessarily defoliate the cotton plant and presently are very costly. These non-chemical harvest aid methods could have applicability near urban areas and where chemical use is strongly restricted.

Whatever new systems are used have to compete with and replace existing chemicals like DEF by offering advantages that are significant.

Summary/Conclusions

What are the lessons to be learned from past and present experience that can be applied in the future? It is expected that there will be more pressure (regulation, potential lawsuits) on current products and systems. It is very likely that new and existing harvest-aid products will be challenged on the basis of health and environmental concerns; some even may be discontinued because of the loss or withdrawal of product registrations. Promising new products may never make it to the marketplace because of the difficult and costly processes of discovery, development, and registration. At the same time, there will be new and improved chemicals and crop management will be significantly improved. It is also possible in the future that biotechnology and conventional breeding could produce self defoliating cotton plants.

The future direction of the cotton industry will be guided by how well it controls stewardship of product use, knowledge and awareness of public concerns, careful adherence to use restrictions, refinements of use practices with old -- as well as new -- products, and continued adoption of viable new technologies. With the use of harvest-aid products (as with other crop protection products), special attention must continue to be directed at limiting off-target movement (drift and volatilization), especially with compounds that have activity on non-target vegetation (e.g., paraquat on small grains) or that can have adverse effects on people, domestic animals, wildlife, and other organisms.

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