Factors Shaping Trends in Corn Herbicide Use

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Managing weeds in corn accounts for more pounds of pesticide use than any other crop use. In crop year 2000 corn growers sprayed 153 million pounds of herbicides, or about 2.08 pounds on the average acre producing corn, based on annual field crop pesticide use data collected by the U.S. Department of Agriculture's National Agricultural Statistics Service (NASS, multiple years).

Corn herbicides account for about 40 percent of the total pounds of herbicides, insecticides, and fungicides that are applied annually by U.S. farmers (Table 3.2, Economic Research Service [ERS], 1997). Soybean weed management is the second biggest market; about 68 million pounds are applied annually. The herbicides applied to corn and soybeans each year account for about 80 percent of all herbicide use in production agriculture and 55 percent of total herbicide, insecticide and fungicide use on American farms (ERS, 1997).

As a result, attainment of national pesticide use reduction goals and minimizing environmental damage and public health risks from pesticide use in corn-soybean production areas depends in large measure on innovation in weed management in these major crops.

Since the introduction of Roundup Ready (RR) soybeans in 1996, much of the focus on changes in weed management in row-crop agriculture has focused on the impacts of herbicide-tolerant varieties, especially RR soybeans (see several items on RR soybeans at http://www.biotech-info.net/herbicide-tolerance.html#soy). Whether and to what extent RR soybeans have reduced herbicide use has been the subject of ongoing debate (Duffy, 1999; for a recent update, see Benbrook, 2001). Now that four years of USDA data are available on soybean herbicide use trends (1997-2000), four conclusions are widely accepted by independent analysts (ERS, 1999; Duffy, 1999; Benbrook, 2001):

- Slightly more pounds of herbicides are applied on the average acre of RR soybeans compared to the average acre planted to conventional soybean varieties.

- Fewer herbicide active ingredients are applied on the average acre of RR soybeans relative to the average acre planted to a conventional variety.

- Herbicide use in pounds on RR soybean acres exceeds several-fold herbicide use on the approximate 30 percent of soybean acres where farmers depend largely on low-dose imidazolinone and sulfonylurea herbicides.

- Herbicide use on RR soybean acres is gradually rising as a result of weed shifts, late-season weed escapes leading to a buildup in weed seedbanks, and the loss of susceptibility to glyphosate in some weed species (Hartzler, 1999; HRAC, 2001).

While RR soybean technology has not reduced herbicide use, it has certainly been a remarkable commercial success. Farmers have embraced the technology because it greatly simplifies soybean weed management and provides farmers additional degrees of freedom in managing weeds (Gianessi and Carpenter, 2000; ERS, 1999). It has also given farmers a welcomed alternative to the use of low-dose herbicides that are plagued by their own problems – high costs, especially when three or four ingredients must be mixed together; frequent control problems; a long and growing list of resistant weeds; and, a tendency to trigger crop damage if not applied with considerable care and precision (Fernandez-Cornejo and McBride, 2000).

Despite higher RR soybean seed costs and a modest genetic yield drag, RR soybeans are extremely popular, especially on problem fields where weeds have proven tough to manage (Gunsolus et al., 2001). Over 65 percent of soybeans planted in the U.S. in 2001 are growing RR soybean varieties.

The May 2001 report "Troubled Times Amid Commercial Success for Roundup Ready Soybeans: Glyphosate Efficacy is Slipping and Unstable Transgene Expression Erodes Plant Defenses and Yields" provides a recent update of the commercial success of RR soybeans (Benbrook, 2001). It presents detailed data on the impacts of RR soybeans on herbicide use relative to conventional soybean varieties, and covers recent university trial data useful in quantifying the magnitude of the genetic yield drag in RR soybeans. The report also discusses new evidence of adverse impacts on nitrogen fixation and possible impairment of plant defense responses, especially under conditions of stress. This Ag BioTech InfoNet Technical Paper is accessible at http://www.biotech-info.net/troubledtimes.html.

Despite the fact that about 2.5 to 3.0 pounds of herbicides are applied to corn for every pound applied to soybeans (ERS, 1997; NASS, multiple years), the factors driving change in corn weed management and herbicide use have received much less attention than changes in soybean weed management and herbicide use.

This report focuses on three major developments in corn weed management that were supposed to reduce corn herbicide use – the registration of the acetanilide herbicide acetochlor; the emergence of Roundup Ready corn; and, the introduction of S-metolachlor, a more active, lower-rate version of another widely used acetanilide herbicide. We compare and contrast the actual impacts of these technologies on average per acre corn herbicide use and the total volume of herbicides applied by U.S. corn producers. The empirical results are clear and surprising – only one of these three innovations had a significant and positive impact in the effort to reduce the pounds of herbicides required to mange weeds in corn fields.

Trends in National Corn Herbicide Use

Corn herbicide use trends have been remarkably stable. Since 1971 the number of distinct herbicide active ingredients applied on the average acre of corn has risen from

1.09 actives to 1.75 in 1982 and 1.98 in 1991 (NASS, multiple years). The trend continued gradually upward throughout the 1990s and reached 2.71 herbicides in crop year 2000, as shown in Table 1 (all tables appear at the end of this report). This means that the average corn acre surveyed by NASS in 2000 had 2.71 distinct herbicide active ingredients sprayed on it, what is often referred to in this report as "acre-treatments." (Note – Table 1 is based on NASS surveyed corn acres for 1991-2000, which typically account for 95 to 97 percent of total corn acres. Data for 1971 and 1982 reflect total corn acres).

Table 2 reports the pounds applied of each of the active ingredients, as well as the total pounds applied and average number of pounds applied per acre.

The dominant corn herbicides throughout this period, measured either by percent acres treated or pounds applied, have changed very little. Each year the triazine herbicide atrazine has alone accounted for about 30 percent of all corn herbicide acres treated and about 35 percent of pounds applied. The acetanilide herbicides alachlor (largely replaced by acetochlor in 1994-1995) and metolachlor (replaced by S-metolachlor in 1998-2000) have together accounted for another approximate 30 percent of total acres treated and over 40 percent of pounds applied.

Together, atrazine and the acetanilides account for about 60 percent of corn herbicide acre-treatments and over 75 percent of use when measured as pounds applied. Over 50 other active ingredients account for the other 40 percent of acres treated and 25 percent of pounds applied, with no active ingredient coming close to the market-leaders in either acres treated or pounds applied.

Note in Table 2 that the average pounds of herbicides applied to corn peaked in 1982 at almost 3 pounds per acre and hovered in the 2.6 to 2.8 pounds range from 1991 through 1997. The first significant reduction in pounds applied occurred in 1998, when rates dropped from 2.63 pounds per acre to 2.47 pounds, based on USDA/NASS data. By 2000 the rate had dropped to just 2.08 pounds, a 21 percent decline in average per acre corn herbicide use from 1997 to 2000. In the sections that follow the factors accounting for this encouraging reduction are clearly identified.

II. Registration of Acetochlor Fails to Achieve Promised Reduction in Corn Herbicide Use

In March 1994 after a tortuous process, the EPA registered a new acetanilide herbicide, acetochlor, after imposing "unprecedentedly stringent conditions" ("Acetochlor Desk Statement," Office of Pesticide Programs, 1994). The conditions were warranted by EPA's conclusion that acetochlor was a "probable human carcinogen" with considerable potential to leach to ground water or flow into surface waters, leading to drinking water exposures.

Registration of acetochlor was sought by the "Acetochlor Registration Partnership" comprised of Monsanto and Zeneca (now part of Syngenta). Despite the known risks associated with acetochlor use, its registration was supposed to reduce herbicide risks by reducing overall herbicide use. In particular, an acre treated with acetochlor would result, almost assuredly, in one less acre treated with the Monsanto herbicide alachlor. Like acetochlor, alachlor is also a B_2 carcinogen. Because it has been used so widely for so many years, alachlor is frequently detected in drinking water in corn-producing areas and was almost constantly in regulatory trouble in the 1990s.

In the year prior to acetochlor's commercial launch, alachlor was applied to 25 percent of corn acres at an average rate of 2.06 pounds of active ingredient per acre (see Tables 1 and 2). And since acetochlor was supposed to be used at a somewhat lower rate than alachlor, the shift of acreage from alachlor to acetochlor was supposed to reduce both use and risks.

EPA registered acetochlor conditionally and with great reluctance. Continued registration was contingent on the following requirements (OPP, 1994):

- Within 18 months, there must be a net cumulative reduction of four million pounds in the use of six other herbicides commonly used on corn (alachlor, metolachlor, 2,4-D, atrazine, butylate and EPTC).

- In three years, there must be a net cumulative reduction of 22.6 million pounds in use of the six identified herbicides, and a reduction of 66.3 million pounds in five years.

- "Automatic suspension of all use of acetochlor if residues are found in ground water exceeding certain specified levels."

- A 10-year sunset registration requiring the registrants to submit a new and complete registration in order to extend use beyond March 2004.

In "Talking Points" issued the day the decision was announced, the agency stated –

> "EPA's decision to register acetochlor will result in substantial reductions in the total use of corn herbicides in the United States."

According to EPA, "Achievement of these targets will result in a 33 percent reduction in the aggregate use of these herbicides."

In the first three seasons on the market, acetochlor use rose dramatically from 7 percent of acres treated in 1994 to 18 percent in 1995 and 22 percent in 1996. As the acres-treated with acetochlor rose, the acres-treated with alachlor declined, virtually one-for-one.

At the time acetochlor was registered, it was supposed to be applied at a rate about one-third lower than alachlor. In its first year of use, acetochlor was applied at an average rate of 1.78 pounds of active ingredient per acre, 10 percent less than the 1.98

pound rate that year for all alachlor applications to corn. Product performance at the average rate of 1.78 pounds per acre was apparently not competitive with acetochlor's major competition -- alachlor and metolachlor – and so in 1995, its second year of use, the average rate of acetochlor applied to corn rose to 2.01 pounds, well above the average 1.67 pounds of alachlor applied that year. The rate of application dropped modestly in 1996-1997 and is now at 1.7 pounds per acre, essentially identical to alachlor's rate of application in 2000 (NASS, multiple years).

Table 4 provides detailed data on the use of acetochlor and the six other corn herbicides targeted for reductions under the agreement with EPA. The terms of EPA's conditional registration included two incompatible, contradictory requirements.

First, EPA said that net cumulative use must be reduced by 4 million pounds in 18 months, by 22.6 million pounds in three years (in 1996), and 66.3 million pounds over five years (in 1999).

Second, the EPA also stated that registration of acetochlor had to reduce herbicide use by 33 percent over five years, with crop year 1992 serving as the baseline. Since the acreage of corn planted fluctuates from year to year, the fairest way to track attainment of this 33 percent reduction goal is to estimate the per acre rate of application of the six herbicides plus acetochlor in 1999 in contrast to the 1992 baseline. This comparison is also presented in Table 4.

In 1992 an average 2.14 pounds of the six herbicides were applied on corn acres. In 1999, 1.83 pounds were applied of these six herbicides plus acetochlor, a 14.5 percent reduction and well short of the 33 percent reduction goal.

Essentially none of this reduction, however, had anything to do with the registration of acetochlor.

From 1992 to 1999, the use of the six corn herbicides plus acetochlor dropped from 157.9 million pounds to 125 million, a 32.9 million pound reduction. There were 3 million more acres planted in 1992 compared to 1999, so the actual drop would have been about 28 million pounds if the same number of acres were planted in 1999 as in 1992.

What changes in the use of six corn herbicides plus acetochlor are responsible for this 28 million pound drop in pounds applied from 1992 to 1999?

The commercial phase-out of the obsolete herbicide butylate was well underway by 1992. Reduction in the use of this herbicide from 1992 to 1999 accounts for a drop in corn herbicide use of 8 million pounds.

A significant decrease in the use of EPTC, another old herbicide on its way out in the early 1990s, accounts for another 8 million pound reduction. Sixteen million of the total 28 million pound drop was brought about by the phase out of these two older products.

There were very modest changes in the percent acres treated and pounds applied of two other herbicides among the original six – atrazine and 2,4-D. These two active ingredients do not account for more than a tiny share of the 28 million pound reduction, as is clearly evident in Table 4.

There were also no significant differences in the percent acres treated, the average rates of application, and pounds applied of acetochlor in contrast to alachlor between 1994 and 1999. In 2000 acetochlor was applied to about the same acres as alachlor was in 1993, the year before acetochlor's introduction. The substitution of acetochlor for alachlor has been a wash in terms of corn herbicide use.

The balance of the 28 million pound reduction not accounted for by the phase out of butylate and EPTC is about 12 million pounds. This decrease in herbicide pounds applied was brought about by the registration of S-metolachlor, coupled with the phase out of metolachlor. S-metolachlor is herbicidally more active than metolachlor and as a result is applied at a rate 35 percent lower than metolachlor (compare the recommended rates for Dual MAGNUM to old Dual herbicide labels; Dual MAGNUM label accessible at http://www.cdpr.ca.gov/docs/epa/epachem.htm, use registration number 100-816 in conducting label search). Both metolachlor and S-metolachlor are composed of two isomers; the former product, old metolachlor, contains a 50-50 mixture, while S-metolachlor contains a higher concentration of the more active of the two isomers. Otherwise, on a pound-for-pound basis the products are essentially equal in terms of mammalian toxicology, environmental fate , and ecotoxicological profiles. The risk reduction equation is simple -- whatever the risk associated with an acre-treatment of old metolachlor, the risks would be 35 percent less if the same acre were treated with S-metolachlor.

S-metolachlor was first registered in 1997 with a small introductory program that crop year. Full commercial launch began in 1998. In granting the conditional registration for S-metolachlor dated March 14, 1997 (EPA Registration Number 100-815), the EPA required the registrant (at the time, Novartis Crop Protection) to submit a plan within 30 days specifying the time period and schedule for the phase out of old metolachlor and the phase in of S-metolachlor.

NASS did not report pesticide use data on S-metolachlor and metolachlor as two distinct active ingredients in the years 1997 through 1999, although in retrospect it should have. It is obvious that the reduction in the rate of application of metolachlor in 1998 and 1999 reported by NASS reflects a combination of metolachlor and S-metolachlor acre-treatments (for more details on how NASS data must be corrected to accurately reflect the introduction of S-metolachlor, see section IV).

III. Impact of Herbicide-Tolerant Corn on Herbicide Use

Roundup Ready (RR) corn hit the market in 1997. There are no accurate public sources of data on the acres planted to RR corn. A rough estimate of acres planted can be inferred from review of NASS corn pesticide use data. In the early 1990s, prior to the introduction of RR corn, glyphosate herbicide could only be applied to corn prior to planting, a use pattern almost exclusively associated with no-till planting systems. Farmer adoption of no-till corn was stable in the early 1990s and average about 5 percent of total corn acres per year, according to annual NASS data on the percent of corn acres treated with glyphosate (NASS, multiple years).

There was a small increase in the corn acres treated with Roundup in 1997 and 1998. But in 1999 and 2000, an estimated 9 percent of corn acres were treated with glyphosate (NASS, 2000 and 2001). Assuming no-till usage remained the same in 1999 and 2000 as it had been in the previous five years, an estimated 4 percent of corn acres must have been planted to Roundup Ready varieties. This percent of acres-treated produces the estimates of 2.732 and 2.952 million acres planted to RR corn, as shown in the first line in Table 3.

Monsanto's recommended RR corn systems include several optional herbicide programs ranging from a total-glyphosate system, to systems combining a pre- or at-plant residual herbicide followed by Roundup post-emergence, or a total post-emergence program involving applications of a residual post-product plus Roundup (Monsanto, 2000a and 2000b). The two most widely used programs though are:

- A largely-Roundup-reliant program involving a pre-plant or at-plant application of Roundup followed by one or two post-emergence applications, sometimes including a residual post-emergence product.

- Application of a pre-plant or at-plant residual herbicide plus one to two applications of Roundup post-emergence.

Table 3 summarizes the herbicide use impacts of these two most common RR corn herbicide programs, based on the products and rates recommended by Monsanto in its "2000 Technology Use Guide" (Monsanto, 2000b).

Under the "Roundup Reliant Program," it is assumed that farmers do not apply a pre-plant or at-plant residual herbicide. Instead, they rely on glyphosate applied at-planting and post-emergence, as well as applications of other post-emergent products with some residual control potential.

In this program, which accounts for an estimated 30 percent of all RR corn acres, Roundup was applied on average about 2.0 times. In 1999, an average application rate of 0.7 pounds is used, resulting in an estimate of 1.4 pounds of Roundup applied on the average acre of RR corn. Some growers were successful in 1999 with one application of Roundup at a rate of 0.75 to 1.0 pounds per acre; other growers required three applications and a total over 2.0 pounds per acre. But on average, about 1.4 pounds of glyphosate was applied to RR corn in 1999.

Many RR corn acres managed under the "Roundup Reliant Program" were treated with another post-emergence product. While there are dozens of combinations of post-emergence products that were applied on at least some RR corn acres, most applications involved low-dose products and accounted for on average about another 0.4 pounds of herbicides applied by farmers utilizing a program based largely on Roundup. Total herbicide use in 1999 under this program on RR corn acres is therefore estimated at 1.8 pounds of active ingredient per acre.

An estimated 70 percent of RR corn acres were managed under the "Residual Herbicide Applied" program. Either before or at-planting in such programs, farmers apply a tank-mix containing a residual broadleaf product like atrazine at about .8 pounds per acre, plus an acetanilide herbicide at a rate of about 1.2 pounds per acre on average, mostly for grass weed control (see recommended rates on either Roundup labels or the labels of several herbicide products containing mixtures of atrazine and an acetanilide). The rates of the residual broadleaf and grass products applied to RR corn in this program are about 75 percent of the average rates when these products are applied to conventional corn varieties (Monsanto, 2000b).

Table 3 estimates total herbicide use under the "Residual Herbicide Applied" program in 1999 at 2.75 pounds per acre on average, with Roundup accounting for 0.75 pounds of this total.

In 2000, many corn producers had to adjust their herbicide rates of application upward for combinations of three factors:

- Shifts in the composition of weeds toward those species less responsive to a contact herbicide like glyphosate.
- Loss of susceptibility and/or the emergence of resistance in some weed species.
- Greater weed pressure as a result of more frequent late-season weed escapes in RR crops, which in turn leads to increases in weed seedbanks.

Modest increases in rates of application are reflected in Table 3 and result in estimated total herbicide pounds applied of 2.1 pounds and 3.0 pounds under the two RR corn weed management programs.

In order to estimate the overall impact of RR corn on herbicide use, it is necessary to estimate average use rates across acres managed under different herbicide use programs. This is done in Table 3 by calculating the weighted average total pounds applied in 1999 and 2000, based on the estimate that 30 percent of RR corn acres were managed under the "Roundup Reliant" program and 70 percent under the "Residual

Herbicide Applied" program. Weighted average total herbicide use in 1999 was 2.47 pounds, rising to 2.73 pounds in 2000.

Last, these rates of application on RR corn acres are compared to the average total herbicide pounds applied per acre on all corn acres grown – 2.25 pounds in 1999 and 2.08 pounds in 2000. In 1999 the average RR corn acre was treated with 0.22 pounds more herbicide than the average corn acre, a 9.6 percent increase. Given that RR corn was planted on about 2.73 million acres, RR corn technology increased herbicide use an estimated 587,380 pounds, well less than one percent.

In 2000 RR corn led to an increase in herbicide use of 1.9 million pounds. The much bigger increase in 2000 reflects the 7.5 percent drop in average herbicide pounds applied per acre, combined with the 0.26 pound per acre increase in average herbicide use rates on RR corn in 2000 compared to RR corn in 1999. Still, the 1.9 million pound increase is just 1.2 percent of total corn herbicide use in 2000.

While the exact increase in herbicide use in RR corn will fluctuate from year to year, one thing is certain – on average RR corn has not and is never likely to reduce corn herbicide use. The only way to markedly reduce herbicide use through a plant variety engineered to be herbicide-tolerant is to base the technology on a low-dose herbicide.

IV. Registration of S-Metolachlor Accounts for a Major Share of the Reduction in Corn Herbicide Use Since 1997

In response to the EPA's reduced pesticide use initiative that was launched in the early 1990s, Novartis Crop Protection, Inc. initiated research to develop a more active version of its popular, widely used corn herbicide metolachlor as a way to reduce the pounds of pesticides applied in major corn producing areas. Throughout the 1980s and 1990s, metolachlor had been applied to between 29 percent and 35 percent of corn acres annually, as shown in Table 2 (NASS, multiple years). Use rates were very stable and fell in the range of 1.7 to 2.0 pounds per acre per crop year across most states and averaged about 1.9 pounds nationally.

Old metolachlor was composed of about an even mixture of an S-isomer and an R-isomer. Novartis scientists discovered that the S-isomer was much more herbicidally active and developed a new product with a greater concentration of the S-isomer, while retaining all the other desirable properties of old metolachlor.

A new data package with new studies was required for Novartis to gain a "reduced risk" conditional registration of S-metolachlor in March 1997. In addition, as a condition of registration, EPA required Novartis to phase out commercial sales of old metolachlor and seek voluntary cancellation of its registrations, a requirement that Novartis agreed to (see EPA decision approving the March 1997 label for S-metolachlor). The phase out of commercial sales of old metolachlor rapidly progressed and was essentially complete by the end of crop year 2000.

Table 5 provides an overview of the impact of the switch to S-metolachlor on corn herbicide use. The table includes unadjusted and – for reasons explained below -- adjusted NASS use data.

In 1998 and 1999 NASS enumerators did not differentiate between old metolachlor and new S-metolachlor accurately or consistently during onfarm interviews, despite the significant difference in rates of application. Farmers also were often unaware of the differences and thought of old and new metolachlor as essentially the same product. It is easy to understand why. For most products, the difference in trade names was modest – adding the word “Magnum” to an existing product name (old “Dual” became “Dual Magnum”).

Since NASS enumerators did not separately report old metolachlor and new S-metolachlor use in 1997-1999, NASS results for those years reflect an attempt to average the rates of application of old metolachlor and S-metolachlor. An average rate of application of “metolachlor” of 1.42 pounds per acre was reported by NASS in 1999, a rate about 0.2 pounds per acre above the average S-metolachlor rate and about 0.4 pounds less than the rate applied on average by farmers still using old metolachlor products. In 1998 and 1999 NASS-reported “metolachlor” rates are not representative of either old metolachlor or S-metolachlor

In 2000 steps were taken by NASS to more accurately report use of these two herbicides, yet in the initial release of crop year 2000 pesticide use data, serious errors were made in the rates of application reported for old and new metolachlor. NASS has since issued revised estimates of both the rates of application and pounds applied of old and new metolachlor in crop year 2000 (revised NASS field crop data for 2000 are accessible at http://usda.mannlib.cornell.edu/reports/nassr/other/pcu-bb/#field).

The revised NASS data are closer to actual use rates, but still not accurate, according to detailed herbicide use data compiled by the manufacturer of S-metolachlor, Syngenta Crop Protection (the company formed by the merger of Novartis and Zeneca). Syngenta data show that NASS estimates of the acres treated with old and new metolachlor combined are close to accurate, but estimates of rates per acre are inaccurate for 1998 through 2000. Their data show no change in the historic 1.8 to 1.9 pound per acre rate of old metolachlor through its phase out.

The S-metolachlor application rate as approved on EPA labels is about 35 percent less than the old metolachlor label rate. In 1998 and 1999 as the effort was underway to phase in S-metolachlor and phase out old metolachlor, Novartis widely distributed to dealers and farmers a “Conversion Chart” showing equivalent rates of Dual II (old metolachlor) and Dual MAGNUM (S-metolachlor), as well as Bicep II (contained old metolachlor and atrazine) and BICEP II MAGNUM (contains S-metolachlor and atrazine). The rates in the chart, expressed in both pints and quarts per acre, provided equivalent control and resulted in no change in grower cost per acre treated – a key variable monitored closely by farmers.

Moreover, Novartis made it clear that the simplest way for farmers making the switch to calculate an equivalent rate for S-metolachlor on their farm was to reduce their old metolachlor rate by 35 percent (Novartis, 1998). Accordingly in 1998-2000, the average S-metolachlor rate was, in all likelihood, very close to 65 percent of the average old-metolachlor rate in the 1995-1997 period, or 1.2 pounds of active ingredient per acre (1.9 pounds old metolachlor rate times 0.65).

Revised rates of metolachlor and S-metolachlor application are incorporated in Table 5 to more accurately estimate the impact of the switch to S-metolachlor. In addition, the estimates of herbicide use reduction assume that the phase out of old metolachlor was completed prior to the 1999 crop season, despite the fact that there was still a small amount of old-label metolachlor applied in that year and in 2000. Accordingly, the use reduction calculations in Table 5 modestly overstate the actual reduction achieved.

Table 5 shows a decline in the percent acres treated with metolachlor – from 35 percent in 1997 to 28 percent with S-metolachlor in 2000. The reduction in the average rate of application from 1.86 pounds in 1998 to 1.2 pounds in 1999 and 2000 brought about a 0.66 pound per acre reduction in herbicide use on each acre treated with S-metolachlor.

S-metolachlor was applied to 40.5 million acres in 1999 and 2000. On each of these acres, herbicide use was 0.66 pounds less than it would have been in the absence of the new, lower-rate product. So in just these two years, the registration of S-metolachlor, coupled with the phase out of old metolachlor, reduced corn herbicide use by 26.7 million pounds, or about 8.7 percent.

Unfinished Business

There will be another 12 million to 14 million fewer pounds of corn herbicides applied in 2001 because of the now-complete phase out of old metolachlor and phase in of S-metolachlor. Ironically, this large-scale pesticide use reduction "success story" may prove short-lived, since old metolachlor may stage a comeback.

A generic pesticide manufacturer, Cedar Chemical Company, has applied to the EPA for a "me-too" registration of old metolachlor. If the old metolachlor labels had been canceled in 1999, Cedar, or any other "me-too" manufacturer, would not have had the option in 2000 to request a follow-on registration of old metolachlor, based solely on the existing registrations held by Novartis. Cedar or other companies could still apply for a registration for old metolachlor – but they would have to start from scratch, with new data and a "clean slate" and they would need to be patient, since the review/approval time for a new, not-reduced risk active ingredient is over three years.

The agency has been studying its legal options and obligations for over a year since Cedar's initial request for a "me-too" registration for old metolachlor. EPA's decision will obviously impact both Cedar and Novartis/Syngenta. It is also a test of whether the agency believes that federal law mandates the use of regulation to assure incremental risk reduction when reduced risk alternatives are available.

The resolution of this case will also send an important message to the pesticide industry. Novartis undertook the research to develop S-metolachlor to reduce the pounds of pesticides applied in managing corn weeds in response to encouragement from the EPA, which had begun in the early 1990s a "reduced risk" initiative.

One major component of this EPA initiative was to convince registrants to develop safer versions of established pesticides through either chemical modifications or new formulation technology (see the section "EPA's Reduced Risk Initiative" in Chapter 8, *Pest Management at the Crossroads*, Benbrook et al., 1996). In addition, the EPA pledged to complete data reviews and regulatory approvals on an accelerated basis for new active ingredients, like S-metolachlor, that qualify as "reduced risk" registration candidates.

Most pesticide registrants are not willing to spend the money needed to discover a new and improved version of an established product like metolachlor, which was stable in the marketplace and not in regulatory jeopardy. There is, of course, no guarantee of success in the research phase. A new chemical will require a whole new data package and associated costs of meeting EPA regulatory requirements. In most cases a new production facility must be built and existing facilities must be retrofitted or written off prematurely.

If a company thinking about incurring such costs also thought it might one day have to compete with generic manufacturers of their old, higher-risk chemistry, they would be foolish to move forward with such a phase out-phase in process. But since pesticides are regulated under a risk-benefit standard, registration of a new reduced risk product should almost automatically tip the risk-benefit scales against the older, higher-risk product. And this should lead EPA to cancel the registrations of the older, now higher-risk product.

Even when registrants do not contest such cancellation actions, the EPA is bound by law to follow a complex, time- and resource-intensive process. In most cases, companies avoid the delays, bad press, and cost of an EPA-driven cancellation by requesting a voluntary cancellation of old-product registrations. This strategy also precludes the need for EPA to reach and publish in the Federal Register an adverse risk finding on the old chemical, an action required as part of the cancellation process. Pesticide manufacturers always try to avoid such an outcome, since a cancellation action can complicate exports of the pesticide and cause problems in other countries that follow the lead of the U.S. EPA in their own registration programs.

Novartis/Syngenta both expected and agreed to EPA's March 1997 conditional registration requirement that old-metolachlor labels be phased out and cancelled and the company did what it had promised to do when it submitted to EPA a request for voluntary cancellation of old metolachlor labels in late 1999. Once EPA processed the request to cancel old metolachlor labels, there would be virtually no chance a "me-too" or other manufacturer could gain registration for old metolachlor, because the risks associated with the now "new" active ingredient (old metolachlor) would be about 35 percent greater on an acre-treated basis in contrast to acres sprayed with S-metolachlor. EPA almost certainly would never grant such a registration for such a new active ingredient.

Because of the very nature of federal pesticide law, a company that does develop and gain registration of a "reduced risk" chemical that is closely related to another, established pesticide has every reason to be confident that EPA will not place in jeopardy the risk reduction gains inherent in the registration of the new chemical by allowing the old, higher-risk product to stay on the market.

A decision from EPA is expected soon on the "me-too" application from Cedar to register old metolachlor. If the registration is granted, the substantial corn herbicide use reductions achieved since 1998 will erode proportional to the share of the market recaptured by old metolachlor. Plus, damage will be done to the credibility of the EPA, both among environmental and consumer groups and the pesticide industry.

Reneging on the requirement to phase out use and cancel the old metolachlor labels will raise long-standing questions about where pesticide use reduction falls on the list of EPA priorities. Environmentalists will no doubt cite this development as another example of an ill-considered post-election change in EPA policy.

Such an action would also send a worrisome signal to the pesticide industry that the EPA cannot always be counted on to follow through and complete registration and/or voluntary cancellation actions it has promised to put in place as part of a coordinated set of actions conceived to move off the market older, higher-risk chemistry as new, reduced risk products are ready for commercial launch.

Phasing out one product as another, safer alternative is introduced often requires careful timing of actions by both companies and the EPA. If an old product is canceled before a new product is fully registered, farmers can get caught by surprise and face unexpected problems dealing with once-routine pest problems.

If old, higher-risk but similar products remain on the market, there will be downward pressure on pesticide prices and less incentive for companies – and farmers -- to invest in reduced risk alternatives and the transition to more prevention-based Integrated Pest Management systems.

Given the high degree of consolidation in the pesticide industry, there are going to be more and more instances when a company decides, for sound business and environmental reasons, to consolidate its product lines by phasing out higher risk products, while opening up marketshare for established or new, reduced risk pesticides and biopesticides. But accomplishing these intertwined goals typically requires a coordinated series of actions by the company and EPA that, among other things, do not allow old, higher-risk products to remain on, or sneak back onto, the market.

The new Bush administration has asserted many times that cooperation with private industry will deliver more significant environmental gains than contentious regulatory processes – and will often achieve them much faster. If EPA decides to register old metolachlor, the agency will have a harder time convincing other major pesticide companies to step forward and develop cooperative, voluntary strategies to incrementally phase out older, higher risk products when safer, better alternatives are discovered and ready to enter the marketplace. And that's an outcome that serves no one's interest.

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Table 1. Herbicides Applied to Corn Acres from 1991 - 2000 based on USDA Pesticide Use Data: Percent National Acres Treated and Acres Treated

	1971	1982	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
2,4,5-T	0.2%											
Acres Treated	123,000											
2,4-D	22.5%	14.0%	8.0%	10.0%	12.0%	14.0%	13.0%	11.0%	9.0%	12.0%	8.0%	8.0%
Acres Treated	16,626,000	11,464,889	5,488,000	7,140,000	7,884,000	8,750,000	8,333,000	7,733,000	5,598,000	8,568,000	5,464,000	5,904,000
acetamide										0.2%	1%	2%
Acres Treated										159,016	341,500	1,476,000
acetochlor						7.0%	18.0%	22.0%	24.0%	25.0%	27.0%	25.0%
Acres Treated						4,375,000	11,538,000	15,466,000	14,928,000	17,850,000	18,441,000	18,450,000
alachlor	9.0%	32.2%	27.0%	27.0%	24.0%	17.0%	8.0%	9.0%	4.0%	4.0%	4.0%	4.0%
Acres Treated	6,633,000	26,398,843	18,522,000	19,278,000	15,768,000	10,625,000	5,128,000	6,327,000	2,488,000	2,856,000	2,732,000	2,952,000
ametryn		0.03%	0.1%	0.2%			0.5%			0.2%	0.5%	0.1%
Acres Treated		28,449	68,600	135,185			316,049			150,000	341,500	100,000
atrazine	48.6%	58.4%	66.0%	69.0%	69.0%	68.0%	65.0%	71.0%	69.0%	69.0%	70.0%	68.0%
Acres Treated	35,993,000	47,832,294	45,276,000	49,266,000	45,333,000	42,500,000	41,665,000	49,913,000	42,918,000	49,266,000	47,810,000	50,184,000
bentazone		0.02%	2.0%	1.0%	1.0%	2.0%	2.0%	3.0%	3.0%	1.0%	2.0%	2.0%
Acres Treated		14,941	1,372,000	714,000	657,000	1,250,000	1,282,000	2,109,000	1,866,000	714,000	1,366,000	1,476,000
bromoxynil			7.0%	8.0%	8.0%	10.0%	8.0%	7.0%	6.0%	5.0%	4.0%	4.0%
Acres Treated			4,802,000	5,712,000	5,256,000	6,250,000	5,128,000	4,921,000	3,732,000	3,570,000	2,732,000	2,952,000
butylate	2.5%	18.2%	3.0%	3.0%	2.0%	1.0%	1.0%	1.0%		0.1%		
Acres Treated	1,843,000	14,920,844	2,058,000	2,142,000	1,314,000	625,000	641,000	703,000		60,507		
Carfentrazone-ethyl											0.5%	1.0%
Acres Treated											341,500	738,000
chloramben	0.1%	0.01%										
Acres Treated	60,000	4,332										
clopyralid								0.4%	3.0%	5.0%	11.0%	9.0%
Acres Treated								290,000	1,866,000	3,570,000	7,513,000	6,642,000
cyanazine		15.9%	19.0%	20.0%	20.0%	21.0%	17.0%	13.0%	14.0%	9.0%	4.0%	0.9%
Acres Treated		12,987,959	13,034,000	14,280,000	13,140,000	13,125,000	10,897,000	9,139,000	8,708,000	6,426,000	2,732,000	636,029
dalapon	0.1%	0.1%										
Acres Treated	73,000	77,377										
diallate		0.002%										
Acres Treated		1,712										
dicamba	2.2%	11.0%	16.0%	21.0%	21.0%	29.0%	27.0%	25.0%	29.0%	15.0%	14.0%	21.0%
Acres Treated	1,652,000	9,010,323	10,976,000	14,994,000	13,797,000	18,125,000	17,307,000	17,575,000	18,038,000	10,710,000	9,562,000	15,498,000
Dicamba dimethylamine salt												3.0%
Acres Treated												2,214,000
dicamba dimethylammonium											1.0%	
Acres Treated											683,000	
dicamba potassium salts										9.0%	8.0%	5.0%

	1971	1982	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Acres Treated										6,426,000	5,464,000	3,690,000
dichloroprop (2,4-DP)												0.1%
Acres Treated												41,667
Diflufenzopyr											1.0%	3.0%
Acres Treated											683,000	2,214,000
dimethenamid						3.0%	3.0%	6.0%	6.0%	7.0%	8.0%	7.0%
Acres Treated						1,875,000	1,923,000	4,218,000	3,732,000	4,998,000	5,464,000	5,166,000
EPTC	0.4%	2.2%	5.0%	3.0%	4.0%	2.0%	3.0%	2.0%	1.0%	2.0%	0.5%	1.0%
Acres Treated	292,000	1,822,927	3,430,000	2,142,000	2,628,000	1,250,000	1,923,000	1,406,000	622,000	1,428,000	341,500	738,000
flumetsulam						1.0%	1.0%	1.0%	4.0%	6.0%	12.0%	10.0%
Acres Treated						625,000	641,000	703,000	2,488,000	4,284,000	8,196,000	7,380,000
glufosinate ammonium										0.0%	0.0%	0.0%
Acres Treated										-	-	-
glyphosate		0.4%	2.0%	1.0%	5.0%	4.0%	6.0%	4.0%	4.0%	5.0%	9.0%	9.0%
Acres Treated		308,720	1,372,000	714,000	3,285,000	2,500,000	3,846,000	2,812,000	2,488,000	3,570,000	6,147,000	6,642,000
Halosulfuron												0.7%
Acres Treated												500,000
halosulfuron-methyl							1.0%	2.0%	1.0%	1.0%	2.0%	
Acres Treated							641,000	1,406,000	622,000	714,000	1,366,000	
imazapyr										2.0%	2.0%	2.0%
Acres Treated										1,428,000	1,366,000	1,476,000
imazethapyr					0.3%	1.0%	1.0%	1.0%	1.0%	3.0%	2.0%	3.0%
Acres Treated					177,390	625,000	641,000	703,000	622,000	2,142,000	1,366,000	2,214,000
Isoxaflutole											4.0%	3.0%
Acres Treated											2,732,000	2,214,000
linuron	1.9%	0.5%	0.2%	0.2%			0.3%			0.01%		
Acres Treated	1,427,000	392,945	137,200	145,455			193,548			4,651		
MCPA	0.5%											
Acres Treated	339,000											
mecoprop		0.02%										
Acres Treated		12,748										
metolachlor		14.2%	30.0%	30.0%	32.0%	32.0%	29.0%	30.0%	35.0%	32.0%	29.0%	12.0%
Acres Treated		11,635,347	20,580,000	21,420,000	21,024,000	20,000,000	18,589,000	21,090,000	21,770,000	22,848,000	19,807,000	8,856,000
metribuzin					0.4%	1.0%	1.0%	1.0%	1.0%	1.0%	0.5%	2.0%
Acres Treated					256,230	625,000	641,000	703,000	622,000	714,000	341,500	1,476,000
nicosulfuron			4.0%	6.0%	8.0%	13.0%	13.0%	12.0%	10.0%	8.0%	15.0%	15.0%
Acres Treated			2,744,000	4,284,000	5,256,000	8,125,000	8,333,000	8,436,000	6,220,000	5,712,000	10,245,000	11,070,000
norea (noruron)	0.1%											
Acres Treated	42,000											
paraquat dichloride		2.0%	1.0%	1.0%	2.0%	1.0%	1.0%	2.0%	1.0%	2.0%	0.5%	1.0%
Acres Treated		1,607,821	686,000	714,000	1,314,000	625,000	641,000	1,406,000	622,000	1,428,000	341,500	738,000

	1971	1982	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
pendimethalin		0.2%	3.0%	4.0%	4.0%	3.0%	4.0%	3.0%	3.0%	3.0%	1.0%	3.0%
Acres Treated		191,818	2,058,000	2,856,000	2,628,000	1,875,000	2,564,000	2,109,000	1,866,000	2,142,000	683,000	2,214,000
petroleum oils	2.1%											
Acres Treated	1,528,000											
primisulfuron-methyl			1.0%	2.0%	2.0%	3.0%	3.0%	7.0%	8.0%	6.0%	6.0%	9.0%
Acres Treated			686,000	1,428,000	1,314,000	1,875,000	1,923,000	4,921,000	4,976,000	4,284,000	4,098,000	6,642,000
propachlor	17.8%	1.7%	1.0%	1.0%	1.0%	1.0%		0.2%	3.0%			
Acres Treated	13,188,000	1,387,585	686,000	714,000	657,000	625,000		123,443	177,949			
propazine	0.2%											
Acres Treated	166,000											
prosulfuron								5.0%	5.0%	3.0%	3.0%	4.0%
Acres Treated								3,515,000	3,110,000	2,142,000	2,049,000	2,952,000
pyridate										0.4%	4.0%	5.0%
Acres Treated										274,510	2,732,000	3,690,000
rimsulfuron							1.0%	1.0%	2.0%	1.0%	11.0%	9.0%
Acres Treated							641,000	703,000	1,244,000	714,000	7,513,000	6,642,000
sethoxydim										0.1%		
Acres Treated										83,333		
simazine	0.9%	4.1%	1.0%	1.0%	1.0%	1.0%	3.0%	2.0%	1.0%	1.0%	2.0%	2.0%
Acres Treated	688,000	3,338,713	686,000	714,000	657,000	625,000	1,923,000	1,406,000	622,000	714,000	1,366,000	1,476,000
S-Metolachlor												16.0%
Acres Treated												11,808,000
Sulfosate											0.5%	0.3%
Acres Treated											341,500	258,209
thifensulfuron										1.0%	0.4%	0.8%
Acres Treated										714,000	273,200	600,000
thifensulfuron-methyl							1.0%	1.0%	2.0%			
Acres Treated							641,000	703,000	1,244,000			
tridiphane			1.0%	0.3%		0.2%						
Acres Treated			686,000	227,778		103,125						
trifluralin	0.1%	0.1%	0.3%		0.3%						0.5%	0.1%
Acres Treated	67,000	64,871	205,800		177,390						341,500	71,667
vernolate		0.1%										
Acres Treated		46,219										
Sum of Percent Acres Treated	109.0%	175.4%	197.6%	208.7%	216.9%	235.2%	230.8%	242.6%	249.0%	239.0%	268.4%	271.0%
Average Number of Herbicides Applied	1.09	1.75	1.98	2.09	2.17	2.35	2.31	2.43	2.49	2.39	2.68	2.71

Table 2. Pounds Applied of Corn Herbicides in 1971, 1982 and 1991 - 2000 based on USDA Pesticide Use Data

	1971	1982	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
2,4,5-T	50,000											
2,4-D	9,144,000	5,135,801	2,800,000	2,832,000	3,586,000	3,631,000	3,770,000	3,237,000	2,087,000	3,475,000	2,536,000	2,359,000
acetamide										97,000	185,000	792,000
acetochlor						7,447,000	23,312,000	29,850,000	28,158,000	32,955,000	31,824,000	31,442,000
alachlor	8,360,000	52,242,968	37,174,000	40,129,000	32,078,000	21,325,000	8,718,000	10,188,000	4,576,000	4,898,000	4,573,000	4,748,000
ametryn		27,881	59,000	146,000			256,000			138,000	25,000	114,000
atrazine	52,000,000	69,647,409	52,060,000	54,939,000	49,553,000	45,412,000	45,735,000	53,466,000	47,155,000	53,507,000	54,780,000	53,954,000
bentazone		8,234	478,000	550,000	497,000	584,000	516,000	806,000	942,000	371,000	1,033,000	327,000
bromoxynil			1,344,000	1,389,000	1,364,000	1,446,000	1,251,000	1,345,000	1,031,000	916,000	844,000	884,000
butylate	5,818,000	54,887,203	8,478,000	8,117,000	5,441,000	2,117,000	1,795,000	2,475,000		406,000		
Carfentrazone-ethyl											32,000	54,000
chloramben		44,000	4,332									
clopyralid								29,000	134,000	354,000	607,000	640,000
cyanazine		20,553,073	23,161,000	26,691,000	26,453,000	27,689,000	23,335,000	20,795,000	16,490,000	9,479,000	3,378,000	865,000
dalapon	34,000	49,328										
diallate		3,424										
dicamba	284,000	2,108,500	3,556,000	5,068,000	4,598,000	6,322,000	5,762,000	5,545,000	5,797,000	3,692,000	2,029,000	3,132,000
Dicamba dimethylamine salt												394,000
dicamba dimethylammonium											1,446,000	
dicamba potassium salts										2,632,000	1,997,000	1,407,000
dichloroprop (2,4-DP)												10,000
Diflufenzopyr											578,000	157,000
dimethenamid						2,241,000	2,256,000	4,110,000	4,728,000	6,735,000	6,185,000	5,738,000
EPTC	292,000	8,334,277	14,355,000	10,594,000	11,098,000	6,124,000	7,102,000	5,117,000	3,173,000	5,894,000	1,470,000	2,884,000
flumetsulam						52,000	44,000	49,000	82,000	163,000	291,000	301,000
glufosinate ammonium										745,000	424,000	585,000
glyphosate		479,803	1,156,000	746,000	1,973,000	1,776,000	2,358,000	2,200,000	1,429,000	2,601,000	4,162,000	4,438,000
halosulfuron-methyl							20,000	46,000	34,000	32,000	75,000	
Halosulfuron												15,000
imazapyr										4,000	1,000	3,000
imazethapyr					11,000	37,000	26,000	20,000	12,000	22,000	32,000	22,000
Isoxaflutole											213,000	171,000
linuron	804,000	336,991	93,000	96,000			120,000			2,000		
MCPA	159,000											
mecoprop		3,187										
metolachlor		21,658,785	38,792,000	41,327,000	39,026,000	39,213,000	35,075,000	41,135,000	43,772,000	43,479,000	29,554,000	14,232,000
metribuzin					46,000	41,000	85,000	38,000	30,000	95,000	54,000	190,000
nicosulfuron			76,000	140,000	165,000	249,000	224,000	245,000	160,000	147,000	150,000	199,000
norea (noruron)	51,000											
paraquat dichloride		687,520	201,000	423,000	630,000	400,000	447,000	637,000	381,000	535,000	369,000	570,000
pendimethalin		296,056	2,745,000	3,091,000	2,825,000	1,806,000	2,628,000	2,631,000	1,764,000	1,611,000	776,000	2,360,000
petroleum oils	11,173,000											
primisulfuron-methyl			29,000	30,000	40,000	47,000	42,000	106,000	82,000	85,000	100,000	140,000
propachlor	21,300,000	3,492,825	1,456,000	1,506,000	1,260,000	1,184,000		337,000	347,000			
propazine	583,000											
prosulfuron								59,000	50,000	28,000	21,000	25,000
pyridate										140,000	2,150,000	2,268,000
rimsulfuron							4,000	6,000	11,000	9,000	74,000	82,000
sethoxydim										9,000		

	1971	1982	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
simazine	920,000	3,252,542	1,081,000	1,147,000	1,118,000	972,000	1,977,000	2,059,000	979,000	915,000	1,555,000	2,029,000
S-Metolachlor												15,383,000
Sulfosate											77,000	173,000
thifensulfuron										3,000	123	6,000
thifensulfuron-methyl							2,000	3,000	6,000			
tridiphane			264,000	123,000		66,000						
trifluralin	29,000	52,654	111,000		114,000						41,000	43,000
vernolate		146,526										
All Herbicides Applied	111,001,000	243,448,986	189,473,332	199,084,000	181,876,000	170,181,000	166,860,000	186,534,000	163,410,000	176,174,000	153,641,123	153,136,000
Average Pounds per Planted Acre	1.50	2.97	2.49	2.79	2.77	2.72	2.60	2.66	2.63	2.47	2.25	2.08
Acres Planted	74,179,000	81857000	75951000	71,375,000	65,690,000	62,500,000	64,105,000	70,250,000	62,200,000	71,400,000	68,300,000	73,800,000

Table 3. Estimated Impacts of Roundup Ready Corn on Herbicide Use in 1999 and 2000 [See Notes]		
Active Ingredient	**1999**	**2000**
Acres Planted to RR Corn (estimated)	2,732,000	2,952,000
<u>Roundup Reliant Program</u>		
Pounds Glyphosate Applied per RR Acre (Average 2.0 applications)	1.4	1.6
Other Herbicides Applied per RR Acre	0.4	0.5
Total Herbicide Applied per RR Acre	1.8	2.1
<u>Residual Herbicide Applied</u>		
Pounds Glyphosate Applied per RR Acre	0.75	1
Other Herbicide Applied	2.0	2.0
Total Herbicide Applied per RR Acre	2.75	3.0
Weighted Average Herbicide Use per RR Corn Acre (Assumes 30% of acres under "No Residual" program, 70% treated with residual products)	2.47	2.73
All Corn Acres: Average Herbicide Pounds Applied per Acre	2.25	2.08
Change in Herbicide Use from the Planting of RR Corn	587,380	1,918,800
Percent Change in Pounds Applied per Acre on RR Corn Acres Compared to All Acres	9.6%	31.3%
Notes: Acres planted to Roundup Ready corn estimated from NASS pesticide use data, assuming the same percent of no-till corn acres were treated with glyphosate in 1998-2000.		
Source: Benbrook Consulting Services, based on data in annual field crop pesticide use surveys from USDA's National Agricultural Statistics Service.		

Table 4. Compliance with the Acetochlor Conditional Registration Agreement's Herbicide Use Reduction Goals, 1992 to 2000 based on USDA Pesticide Use Data [See Notes]

Active Ingredient	Units	1992	1993	1994	1995	1996	1997	1998	1999	2000
2,4-D	% acres planted	10.7	13.2	14.2	13.4	11	9	12	8	8
	Ave. number of applic.	1.03	1.05	1.09	1.04	1	1	1	1	1
	Pounds per acre	0.41	0.45	0	0.44	0.39	0.35	0.39	0.43	0.39
	1,000 Pounds Applied	2,832	3,586	3,631	3,770	3,237	2,087	3,475	2,536	2,359
Alachlor	% acres planted	28.9	25.3	17.3	8.6	9	4	4	4	4
	Ave. number of applic.	1.01	1	1.02	1.02	1	1	1	1	1
	Pounds per acre	2.07	2.06	1.98	1.67	1.64	1.8	1.71	1.87	1.73
	1,000 Pounds Applied	40,129	32,078	21,325	8,718	10,188	4,576	4,898	4,573	4,748
Atrazine	% acres planted	69.2	68	68.5	64.6	71	69	69	70	68
	Ave. number of applic.	1.04	1.05	1.07	1.08	1.1	1.1	1.1	1.1	1
	Pounds per acre	1.1	1.08	1.07	1.07	0.99	1.01	0.99	1.02	1.00
	1,000 Pounds Applied	54,939	49,553	45,412	45,735	53,466	47,155	53,507	54,780	53,954
Butylate	% acres planted	2.3	1.8	1	0.8	1				
	Ave. number of applic.	1	1	1.02	1.06	1		1		
	Pounds per acre	4.39	3.77	3.36	3.46	4.63		6.71		
	1,000 Pounds Applied	8,117	5,441	2,117	1,795	2,475		406		
EPTC	% acres planted	3.8	4.7	2.4	3.1	2	1	2		1
	Ave. number of applic.	1.01	1	1.02	1	1	1	1.3	1	1
	Pounds per acre	4.48	4.05	4.16	3.93	3.81	3.71	3.38	3.4	3.51
	1,000 Pounds Applied	10,594	11,098	6,124	7,102	5,117	3,173	5,894	1,470	2,884
Metolachlor	% acres planted	31	32	32	29	30	35	32	29	12
	Ave. number of applic.	1.01	1.01	1.02	1.02	1	1	1	1	1
	Pounds per acre	1.97	1.91	1.94	1.93	1.89	1.98	1.86	1.42	1.65
	1,000 Pounds Applied	41,327	39,026	39,213	35,075	41,135	43,772	43,479	29,554	14,232
S-Metolachlor	% acres planted									16
	Ave. number of applic.									1
	Pounds per acre									1.26
	1,000 Pounds Applied									15,383
Six A.I. Total Pounds Applied		157,938	140,782	117,822	102,195	115,618	100,763	111,659	92,913	93,560
Acetochlor	% acres planted	.	.	6.6	20	22	24	25	27	25
	Ave. number of applic.	.	.	1.02	1.01	1	1	1	1	1
	Pounds per acre	.	.	1.78	2.01	1.88	1.9	1.81	1.7	1.7
	1,000 Pounds Applied			7,447	23,312	29,850	28,158	32,955	31,824	31,442
Six Active Ingredients + Acetochlor		157,938	140,782	125,269	125,507	145,468	128,921	144,614	124,737	125,002
Goals for Six Target Active Ingredients										
3-Year Goal (1997) Net Cumulative Reduction							22,600			
5-Year Goal (1999) Net Cumulative Reduction									66,300	
Actual Reduction Six Active Ingredients										
Annual Reduction from 1992 (1,000 pounds)					55,743	42,320	57,175	46,279	65,025	64,378
Cumulative Reduction from 1992 (1,000 pounds)					55,743	98,063	155,238	201,517	266,542	330,920
Actual Reduction Six A.I.s + Acetochlor										
Annual Reduction from 1992 (1,000 pounds)					32,431	12,470	29,017	13,324	33,201	32,936
Cumulative Reduction from 1992 (1,000 pounds)					32,431	44,901	73,918	87,242	120,443	153,379
Per Acre Use										
Acres Planted (1,000)		71,375	65,690	62,500	64,105	70,250	62,200	71,400	68,300	73,800
Six A.I. Per Acre Planted		2.21	2.14	1.89	1.59	1.65	1.62	1.56	1.36	1.27
Six A.I. + Acetochlor/Planted Acre		2.21	2.14	2.00	1.96	2.07	2.07	2.03	1.83	1.69
1999 Goal for Pounds per Acre Based on 33% Reduction from 1992									**1.48**	
Source: Benbrook Consulting Services, based on data in annual field crop pesticide use surveys from USDA's National Agricultural Statistics Service.										

Table 5. Impact of the Registration of S-Metolachlor on Corn Herbicide Use, 1997 through 2000 based on USDA Pesticide Use Data [See Notes]

	1997	1998	1999	2000
Actual Use Based on NASS Data				
Metolachlor				
% acres planted	35	32	29	12
Ave. number of applic.	1	1	1	1
Pounds per acre	1.98	1.86	1.42	1.65
1,000 Pounds Applied	43,772	43,479	29,554	14,232
S-Metolachlor				
% acres planted			*	16
Ave. number of applic.			*	1
Pounds per acre			*	1.26
1,000 Pounds Applied			*	15,383
Adjusted Use Based on Corrected NASS Data and Full Switch to S-Metolachlor in 1999				
Metolaclor				
% acres planted	35	32		
Ave. number of applic.	1.00	1		
Pounds per acre	1.98	1.86		
1,000 Pounds Applied	43,772	43,479		
S-Metolachlor				
% acres planted			29	28
Ave. number of applic.			1	1
Pounds per acre			1.2	1.2
1,000 Pounds Applied			23,768	24,797
S-Metolachlor Reduction per Acre Treated from 1998 Rate (Pounds)			0.66	0.66
Corn Acres Treated with S-Metolachlor			19,807,000	20,664,000
Reduction in Herbicide Use from Switch to S-Metolachlor (Pounds)			13,072,620	13,638,240
S-Metolachlor Reduction as Percent of Total Corn Herbicide Use			8.5%	8.9%

Source: Benbrook Consulting Services, based on data in annual field crop pesticide use surveys from USDA's National Agricultural Statistics Service.