Appendix J. Effects of Changes in Farming Practices on Water, Soil, and Air Due to Use of Glyphosate-Tolerant Alfalfa

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Effects of Changes in Farming Practices on Water, Soil, and Air Due to Use of Glyphosate-Tolerant Alfalfa

Executive Summary

Glyphosate-tolerant (GT) crops came on the market in 1996 and have been widely adopted since. The primary selling feature of GT crops is the ability to apply the broad spectrum herbicide, glyphosate, directly on plants. Glyphosate is an attractive herbicide for farmers because it does not have restrictions regarding which crops can be planted in the field following the GT crop rotation.

Herbicide use Associated with GT Crops

The adoption of GT crops has shifted herbicide use away from many other herbicides to glyphosate. The overall amount of herbicides usage, however, has been debated. Several analyses of pesticide use concluded that herbicide use has been reduced due to the adoption of herbicide- tolerant crops (Brimner et al., 2005; Fernandez-Cornejo, 2006; Gianessi and Reigner, 2006; Kleter et. al., 2007; Sankula, 2006; Johnson et al., 2008). Additional analysese of pesticide use concluded that herbicide use has increased due to herbicide-tolerant crops (Benbrook, 2004; Benbrook, 2009). All the studies agreed that herbicide use has shifted toward glyphosate. Using standardized methods for ranking environmental impact, researchers have concluded that glyphosate is less harmful to the environment than many other herbicides and that the shift of herbicide use has resulted in a net lower environmental impact from herbicides (Kleter et al., 2007).

Glyphosate Occurrence in Water, Soil, and Air

Glyphosate adsorbs strongly to soil so it does not generally move vertically below six inches (Cerdeira and Duke, 2006; U.S. EPA, 2006; Vereecken, 2005). Glyphosate is rapidly degraded by soil microbes in the environment primarily to aminomethyl phosphonic acid (AMPA), which degrades in the soil to form carbon dioxide (U.S. EPA, 2006). The half-life of glyphosate in soil laboratory studies is two days. In agricultural soils, the half-lie of glyphosate ranges from 1.7 to 197.3 days, but is typically less than 60 days (Giesy et al., 2000). Although glyphosate and AMPA have been detected in surface water and groundwater, the concentrations are limited because of sorption onto variable-charged soil minerals and microbial degradation (Borggaard and Gimsing, 2007). Glyphosate has low volatility and has not been detected in air, other than possibly adhered to dust particles.

Non-glyphosate-tolerant, Glyphosate-tolerant, and Organic alfalfa

Non-GT and GT alfalfa can be treated similarly regarding cultivation techniques and most herbicide applications. The difference between non-GT and GT alfalfa is glyphosate use. With non-GT alfalfa, glyphosate can be used for stand removal but cannot be used for whole-field weed control. With GT alfalfa, glyphosate can be used for in-crop weed control but cannot be used for stand removal. Organic farming practices do not permit the use of any herbicides. Cultivation weed control practices are permitted in organic farming.Herbicides Associated with Alfalfa Farming

Herbicides related to alfalfa farming can be divided into two major groups: herbicides that do not kill alfalfa, which can be used to control weeds in alfalfa, and herbicides that kill alfalfa, which can be used for stand removal. Adoption of GT alfalfa decreases the number of herbicides used to control weeds in alfalfa because glyphosate is the preferred herbicide for GT alfalfa. For stand removal, adoption of GT alfalfa could result in a shift from glyphosate to other herbicides. Herbicide shifts due to stand removal would be smaller in magnitude than herbicide shifts due to weed control.

Crop Rotations with Alfalfa

Alfalfa is used in crop rotation because it provides nitrogen to the soil, which decreases fertilizer inputs in other rotations. Perennials and annuals promote and restrict different weeds, so rotating perennials with annuals helps control weeds from year to year.

Adoption of GT alfalfa affects crop rotations because glyphosate cannot be used for stand removal or volunteer alfalfa control. Therefore other herbicides, which might have rotation restrictions, might need to be used along with tillage to remove GT alfalfa stands. GT alfalfa stands may also persist longer than non-GT alfalfa stands, due to the improved efficacy of weed control in older GT alfalfa stands. Generally, the capacity of non-GT alfalfa stands to compete with weeds decreases with stand life. Thus, when overall alfalfa forage quality is reduced due to negative weed impacts, farmers will rotate crops. With the use of GT alfalfa, glyphosate is used to control weeds and the alfalfa will be of higher quality longer. Monsanto recommends that rotations not consist of all GT crops (Monsanto, 2008). Because several of the crops that are popular in rotation with alfalfa (corn, soybeans) have GT varieties, farmers might have to decide which GT crop provides the most benefit to the rotation plan and overall farm production.

Companion Crops

There are several types of companion cropping practices. These include crops that are interseeded with alfalfa to provide protection from wind and harsh weather or to outcompete weeds in the stand establishment year, crops that are planted to cover the soil and prevent erosion between growing seasons, and barrier crops that are planted alongside fields to serve as a refuge for beneficial insects and distract pests.

Soil Conservation

Soil conservation practices include chiseling and subsoiling, conservation cover, conservation tillage (no-till, ridge-till, mulch till), contour farming, cover or green manure (legumes), critical

area planting (erosion zones), crop residue use, filter strips, grade-stabilization structures, grass and legume in rotation, grassed waterways, strip cropping, and terracing. GT alfalfa is compatible with all soil conservation practices. GT crops are known to enhance the adoption of conservation tillage (Fawcett and Towery, 2002).The cultural practices associated with GT crops and GT alfalfa have a net benefit on soil conservation and quality (Fawcett and Towery, 2002).

1.0 Introduction

GT alfalfa is cultivated in a similar manner to conventional alfalfa, except that glyphosate can be applied "in crop" and cannot be used for stand removal of GT alfalfa. Alfalfa, a perennial crop, can be grown for forage, seed, or sprouts. This technical report discusses mainly forage (hay) alfalfa. Alfalfa grown for seed is noted where cultivation is different (e.g., herbicide use is more common in seed crops than hay crops). Seed for alfalfa sprouts is not within the scope of this technical report. For a discussion of alfalfa sprouts, refer to the technical report *Glyphosate-Tolerant Alfalfa Presence in Human Food and Animal Feed* (appendix Q).

The lifecycle of an alfalfa hay field includes field preparation, planting, stand establishment (first year), established stand maintenance (3-8 years), and stand termination (Orloff et al., 1997). If a crop is being harvested for hay, it is harvested multiple times per growing season, up to 11 times depending on region. Seed crops are harvested once at the end of each growing season (Putnam et al., 2001). There are varying management practices that depend on the preference of the grower, such as harvest time, weed control method (herbicides or mowing), crop rotation, companion crop choice, insect and other pest control measures, and stand removal techniques. In general, the choice of methods can depend on the region, climate, weed spectrum, and intended market. Growers are assumed to fall into three broad categories of farming practices. These include conventional, GT, and organic alfalfa production. This technical report discusses alfalfa forage production, herbicide use, tillage practices (during field preparation and stand removal), crop rotations, and companion crops for each of the three categories of farming and the effect these practices have on water, soil, and air. It also contains an herbicide usage analysis conducted to predict the use of herbicide with the adoption of GT alfalfa. Insect pests and other pests (e.g., small mammals, nematodes, and diseases) might be controlled differently in organic farming versus conventional farming. However, because the use of GT alfalfa does not influence these control measures, they are not discussed in this technical report. Weed control is the only pest control for which GT alfalfa and conventional alfalfa differ.

1.1 Conventional Farming

Conventional farming includes any farming system where synthetic pesticides or fertilizers might be used. The definition of conventional farming usually includes the use of genetically engineered crops, but genetically engineered GT alfalfa is considered separately for this report. Conventional farming covers a broad scope of farming practices, ranging from farmers who only occasionally use synthetic pesticides and fertilizers to farmers whose harvest depends on regular pesticide and fertilizer inputs.

1.2 GT Farming

GT alfalfa can be integrated into conventional farming practices. Farming GT alfalfa is mostly the same as farming conventional alfalfa, with a few important exceptions. Weeds can be controlled by the application of glyphosate directly on top of growing alfalfa, and when alfalfa stands reach the end of their life cycle (typically after 3-8 years depending on growing region), glyphosate cannot be used to kill the stand to prepare for another rotation (Miller et al., 2006). In GT alfalfa, herbicides other than glyphosate, combined with tillage, are required to obtain 100 percent removal of an unwanted stand. Several of the recommended GT alfalfa stand removal herbicides result in restrictions regarding what crops can be planted next, so careful crop rotation plans are necessary when using GT alfalfa. Glyphosate can be used to prepare a field for alfalfa in the stand establishment year and also to mitigate areas of GT alfalfa fields that fail to establish following seeding, preventing the buildup of mature weed populations within field boundaries. Farmers can apply glyphosate early to weed patches within fields that have failed to establish followed with reseeding of GT alfalfa.

Companion crops (usually annual grasses) are sometimes interseeded with alfalfa to provide benefits such as erosion control, protection of alfalfa seedlings from wind and frost, and reduced weed germination. The density of companion crops needs to be carefully managed, so the alfalfa seedlings do not suffer from too much competition (Orloff et al., 1997). For some farmers another important difference is that non-GT crops cannot be used as companion crops for GT alfalfa. For farmers that plant pure alfalfa stands this difference does not matter. For farmers that traditionally use companion crops, this difference is important. Companion crops can increase overall forage yield but decrease hay quality (McCordick et al., 2008).

Monsanto's Stewardship Program for GT alfalfa varieties includes the following features: 1) provides users of GT alfalfa with appropriate crop rotation practices, thereby enabling a smooth transition in and out of GT alfalfa; 2) provides vegetation control personnel (e.g., highway department personnel) with control options for feral alfalfa; 3) uses grower agreements to prevent unauthorized seed production; 4) provides the alfalfa seed production industry with gene flow information and analytical tools that will be used in the production of conventional and GT alfalfa varieties; and 5) provides Monsanto field personnel with ongoing training to address anticipated and unforeseen issues that might arise because of the introduction of the technology (Rogan and Fitzpatrick, 2004)

1.3 Organic Farming

For this report, organic production is only those cropping systems that fall under the United States Department of Agriculutre (USDA) National Organic Program (NOP) definition of organic farming and are certified organic production systems. In organic systems, the use of synthetic pesticides, fertilizers, and genetically engineered crops is strictly limited. NOP publishes a list of approved substances for organic farming inputs[1]). GT alfalfa is not approved for use in organic systems because it is genetically engineered and because glyphosate application is not permitted in organic systems.

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1 http://www.ams.usda.gov/AMSv1.0/ams.fetchTemplateData.do?template=TemplateN&navID=NationalListLinkNOPNationalOrganicProgramHome&rightNav1=NationalListLinkNOPNationalOrganicProgramHome&topNav=&leftNav=NationalOrganicProgram&page=NOPNationalList&resultType=&acct=nopgeninfo

1.4 Methodology

A literature search was designed to identify peer review articles and grey literature (e.g., government reports, State Agricultural Extension Office publications) on cultivation practices in alfalfa and their effects on water, soil, and air (appendix J-3 of this technical report). Several databases were searched with Dialog™. Google, Google Scholar, and Yahoo search engines supplemented the Dialog™ search. Calculations for percentages of harvest were done with Microsoft Excel. Alfalfa harvest statistics were obtained from The USDA National Agricultural Statistics Service (http://www.nass.usda.gov/index.asp). In addition, the USDA Economics, Statistics and Market Information System (ESMIS), which is a collaborative project between Albert R. Mann Library at Cornell University and USDA, provided information on alfalfa harvesting (http://usda.mannlib.cornell.edu/MannUsda/homepage.do). The USDA Agricultural Marketing Service also provided information on harvests (http://www.ams.usda.gov).

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2.0 Herbicide Use in Alfalfa and GT Crops

This section discusses herbicide use on GT crops in general and in GT alfalfa. It does not discuss insecticides or genetically modified crops with traits other than glyphosate tolerance. This section also builds on some of the information shown in section 3.0, Alfalfa Farming Practices.

2.1 Current and Historical Herbicide Use on GT Crops

The first GT crops were introduced in 1996. In 2007, the United States had the most biotech crops (herbicide and pest resistant combined) of any country (57.7 million hectares; James, 2007). Each year the International Service for the Acquisition of Agri-biotech Applications (ISAAA) publishes a report tracking global adoption of biotech crops. Figure J-1 presents the most current data. Brookes and Barfoot (2006) determined that on a global level, pesticide use has been reduced by 224 million kg of active ingredient (6.9 percent reduction) from 1996 to 2005.

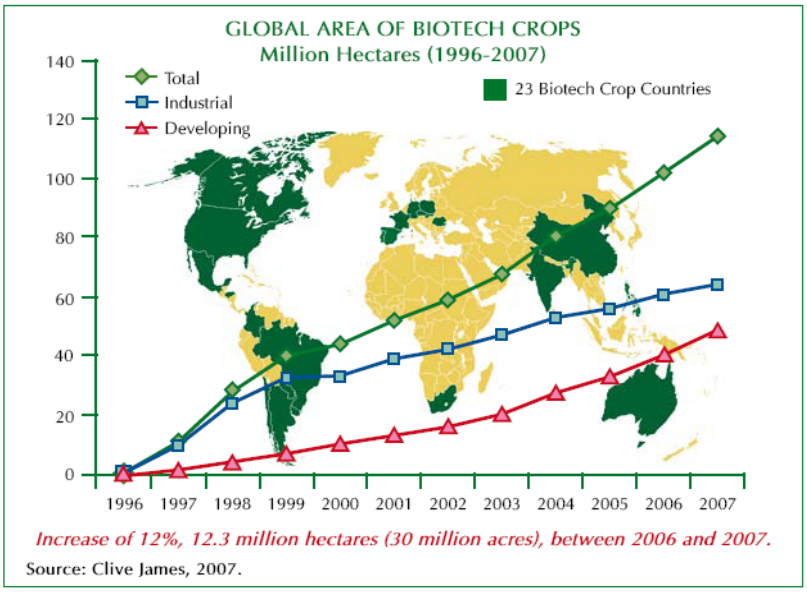

Figure J-1: Global biotech crop adoption (James, 2007)

USDA Economic Research Service (ERS) evaluates U.S. statistics on biotech crops and herbicide use. The primary source of data for agricultural statistics in the United States is USDA's National Agricultural Statistics Service (NASS). This report focuses on herbicide-tolerant biotech crops only. Insect resistant crops are not explicitly included. United States adoption of herbicide resistant crops in 2005 was as follows (Sankula, 2006):

- Herbicide resistant canola – 93 percent of national acreage (62 percent of national acreage was GT canola, 31 percent was glufosinate-tolerant)
- Herbicide resistant soybean – 88 percent of national acreage
- Herbicide resistant cotton – 80 percent of national acreage
- Herbicide resistant corn – 35 percent of national acreage

One result of GT crop adoption was an herbicide shift to glyphosate, which is one of the less hazardous herbicides compared to the range of herbicides that are available for weed control. Glyphosate-resistant soybean has a high percentage of adoption (89 percent of soybeans in the United States in 2006 were herbicide-tolerant) and serves as an example to illustrate the shift in herbicide use (Kleter et al., 2007). Figure J-2 presents the acreage for glyphosate application and five other herbicides on soybean fields. Figure J-3 presents the change in herbicide active ingredient per hectare.

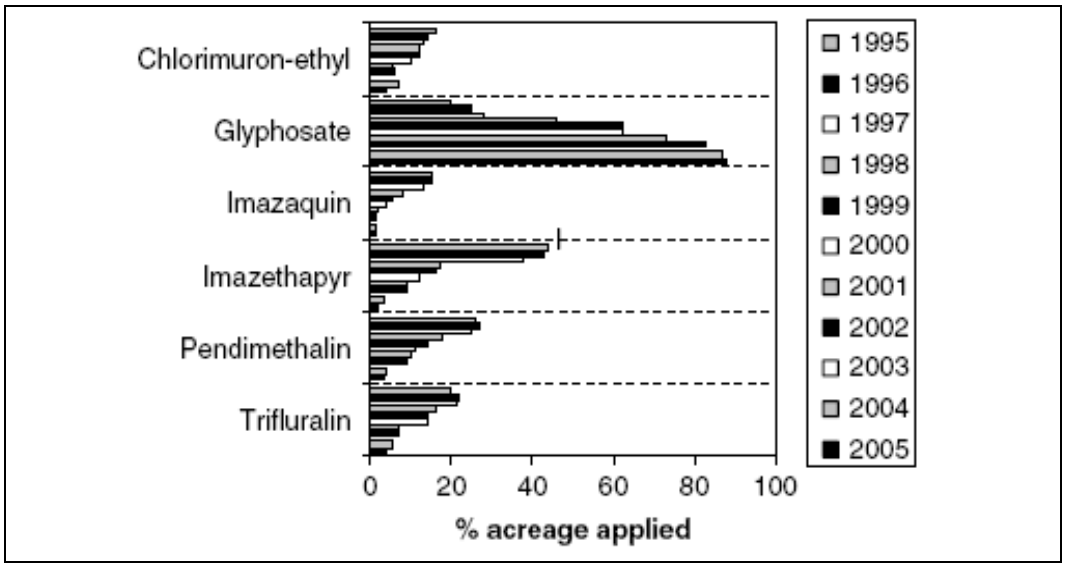

Figure J-2: Herbicide use in soybeans, percent of total acres, 1995-2005. Use of selected herbicides on soybeans in the USA, percentage of total acreage treated with herbicides. Data from NASS,[-35] herbicides selected with minimally 10 percent acreage in 1995; no survey was carried out in 2003 (Reproduced from Kleter et al., 2007).

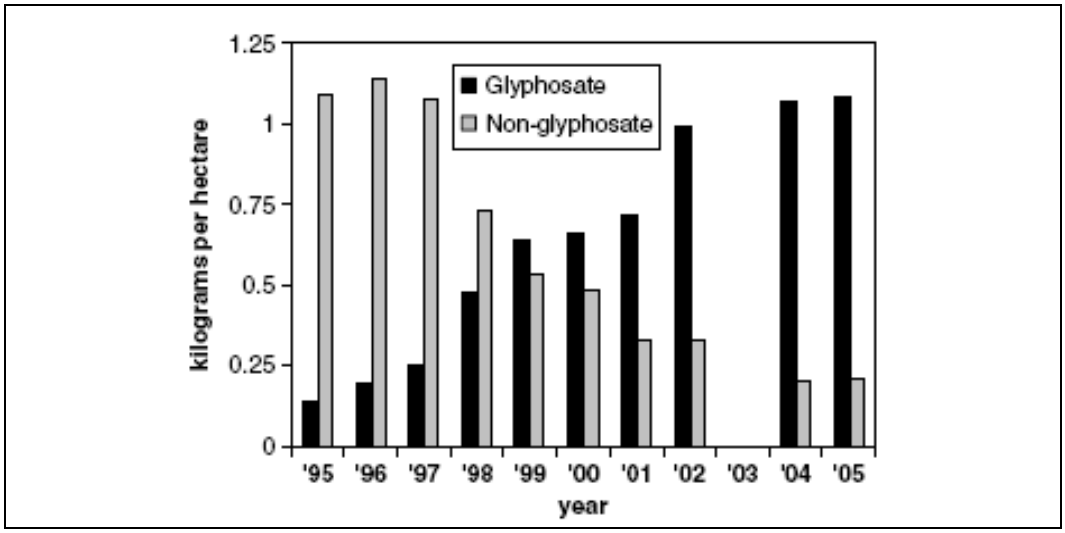

Figure J-3: Herbicide use in soybeans, active ingredient per hectare, 1995-2005. Herbicide use on soybeans in the USA, average active ingredient per area treated with herbicides, 1995-2005. Data from NASS,[-35] no survey was carried out in 2003; data have been converted to metric values employing a conversion factor of 1 lb acre^{-1} = 1.121 kg ha^{-1} (Reproduced from Kleter et al., 2007).

Overall, herbicide use in the United States shows a downward trend between 1995 and 2002, especially in corn (Fernandez-Cornejo, 2006). Figure J-4 from the USDA ERS Agricultural Resources and Environmental Indicators (AREI) report presents herbicide application rates in corn, cotton, and soybean from 1995 to 2002.

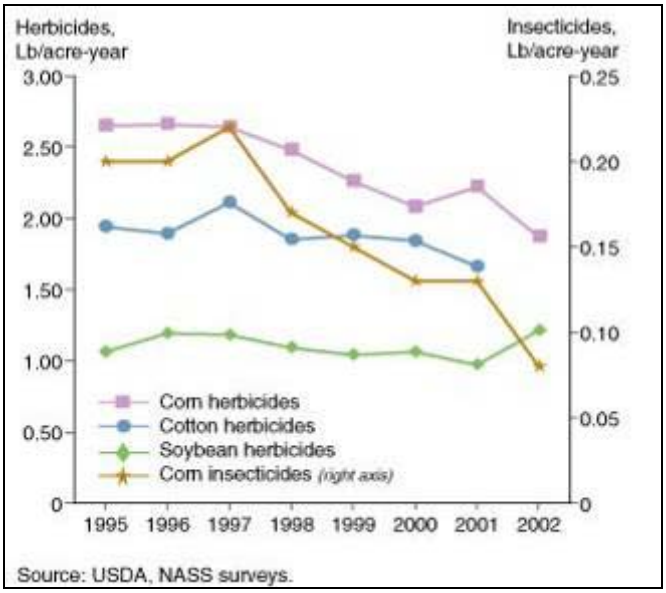

Figure J-4: Pesticide use in major field crops (Fernandez-Cornejo, 2006)

Brimner et al. (2005) evaluated herbicide use in Canada on canola from 1995 to 2000. The amount of herbicide active ingredient used in conventional canola fluctuated and increased by 29.5 percent from 1996 to 2000 (figure J-5). In contrast, herbicide use in herbicide-resistant canola declined by 20.4 percent during the same time (Brimner et al., 2005).[2]

[2] Herbicide resistant canola includes imidazolinone tolerant, glufosinate tolerant, and glyphosate-tolerant varieties of canola.

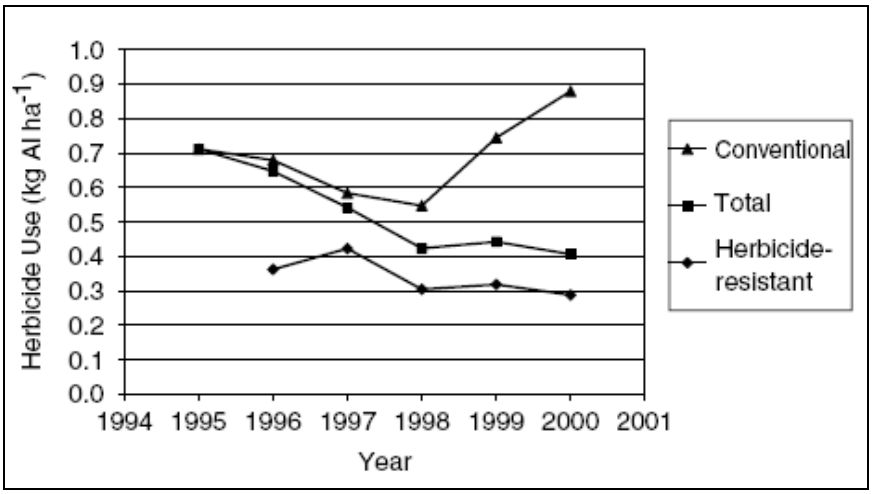

Figure J-5: Herbicide active ingredient use per hectare of canola (Brimner et al., 2005)

Benbrook (2004) evaluated the USDA NASS data on genetically modified crop acreage along with data on pesticide volumes used, from 1996 to 2008, and determined that genetically modified herbicide-resistant corn, soybean and cotton have led to a 138 million pound increase in herbicide use since 1996, which is a 5 percent increase. Benbrook (2004) attributes this increase to increasing weed resistance to glyphosate and reduction in glyphosate prices after the patent expired. Benbrook (2004) concluded that across all crops, genetically modified crops reduced pesticide use from 1996 to 1998, but from 1999 to 2004, pesticide use increased. The USDA NASS data does not directly report amount of herbicide applied based on conventional versus GT varieties. NASS pesticide surveys report the percent of acres treated with a given pesticide, the average rate of application (for each distinct application), the average number of applications, the rate per crop year (average one-time rate multiplied by the number of applications), and the total pounds applied. NASS also reports total acres planted to corn, soybeans, and cotton by year and the percent of acres planted to various genetically modified crops. Using these two sources of data, Benbrook (200), estimated herbicide use on conventional versus herbicide resistant crops using the following equation:

$$\frac{\text{Average herbicide rate (pounds per acre) for all acres of crop X} - \left[\text{\% acres HT varieties for crop X} \times \text{Rate herbicide application (pounds per acre) on HT crop X}\right]}{\text{\% acres non-HT varieties of crop X}} = \text{Herbicide Pounds Applied per Acre of Non-HT Variety of Crop X}$$

The “rate of herbicide application in herbicide-tolerant acres” was estimated using NASS pesticide use data, coupled with information from herbicide manufacturers and universities.

At the request of Benbrook Consulting Services, USDA ERS reported for only 1998, both the percent of total soybean acreage by category (conventional varieties, no glyphosate applied; conventional varieties, glyphosate applied (mostly on no-till acreage); Roundup Ready® varieties; and other herbicide-tolerant varieties), as well as the average number of herbicides and

pounds of herbicides applied in each category. The average acre of herbicide-tolerant soybeans in 1998 was treated with 0.07 pounds more herbicide than conventional acres. Benbrook's (2004) summary is presented in figure J-6.

Annual percent change in pesticide use brought about by herbicide-tolerant and *Bt* transgenic corn, soybeans and cotton.

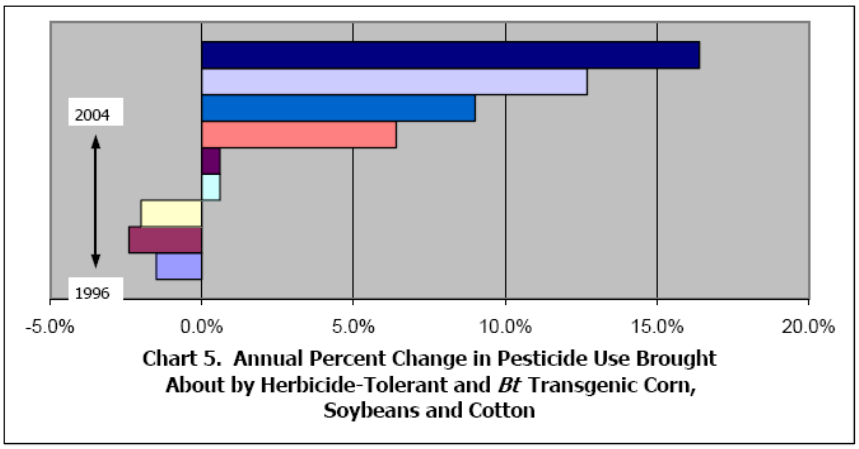

Figure J-6: Annual percent change in pesticide use after introduction of genetically modified crops, 1996-2004 (Benbrook, 2004).

Gianessi (2005) suggests additional factors besides increased weed resistance that could lead to increased herbicide use. The alternative explanations include: wet weather that could result in greater weed flushes, more no-till acres resulting in extra glyphosate applications, and lower cost of glyphosate resulting in growers increasing the rate of application to improve control of perennial weeds. Dill et al. (2008) indicate that GT corn shows a trend for increasing use of non-glyphosate herbicides, from 42 percent of acreage in 2002 to 55 percent of acreage grown in 2006.

Although Benbrook (2004) makes the case that there was a 138 million pound increase in herbicide use from 1996 to 2004, Gianessi and Reigner (2006) make the case that herbicide use decreased 51 million pounds (of active ingredient) between 1997 and 2002. Both studies used similar data sources, but Benbrook (2004) is based on only NASS data and Gianessi and Reigner (2006) used the National Pesticide Use Database (NPUD), which is based on the following:

- Surveys by NASS [2,631 records]
- USDA Crop Profiles/Strategic Management Plans [657 records]
- State of California Department of Pesticide Regulation [1,054 records] - The State of California requires full reporting of pesticides used in agriculture.
- Survey of Extension Service Specialists [4,830 records]
- Other Sources [538 records] - Mint Industry Research Council, Cranberry Institute, U.S. Hop Plant Protection Committee, Oregon Hop Commission, and the New England Vegetable and Berry Growers Association. Estimates for statewide aggregations for Arizona and Nevada. Individual survey reports prepared at the state-level were available

for certain crops in several States: Nebraska, Washington, North Dakota, Georgia and Virginia.

- Assignments [567 records] - In cases where use profiles for a crop in a State were not available from the above sources, use estimates were assigned by assuming that a State's pesticide use profile for an active ingredient/crop combination is similar to that of a nearby State.

Table J-1 below presents the NPUD data for glyphosate, and for 20 other herbicides that are commonly used in alfalfa cultivation, reported by Gianessi and Reigner (2006) for 1992, 1997, and 2002. Those data indicate an increase in total glyphosate use in the United States between1992 and 1997, even though GT crops were first used in 1996. A substantial further increase is evident in the 2002 data. Considering 1992 to 2002, there appears to be an overall increase in the total amount of the 21 herbicides used; however, when glyphosate is removed from the total, there actually is a 30 percent reduction in use for the remaining 20 herbicides in aggregate. Other notable findings include the increases in total use of clethodim, clopyralid, and hexazinone; however, the aggregate herbicide use still shows a decrease.

Table J-1. Total Herbicide Use (in lbs) in the United States Across All Crops for Glyphosate and 20 Other Herbicides Commonly Used on Alfalfa (Gianessi and Reigner 2006)

Herbicide	1992[1]	1997[2]	2002[3]	Percent Difference (1992 to 2002)
	Lbs a i. applied			
Glyphosate	**16,793,371**	**34,817,639**	**102,325,419**	**+509**
2,4-D	41,938,491	40,589,955	40,071,957	-4
2,4-DB	980,980	603,975	522,486	-47
Benefin	478,205	161,983	104,880	-78
Bromoxynil	3,444,727	2,920,222	2,058,153	-40
Clethodim	80,003	670,721	619,944	+675
Clopyralid	89,112	891,662	956,046	+973
Dicamba	9,064,161	10,447,441	7,558,786	-17
Diuron	3,994,531	4,370,448	3,580,627	-10
EPTC	14,457,278	8,791,984	5,593,753	-61
Hexazinone	460,058	332,116	623,344	+35
Imazamox	-	-	86,662	Not Determined
Imazethapyr	914,090	1,253,046	343,422	-62
Metribuzin	3,440,715	3,320,231	1,802,371	-48
Norfluzaon	2,670,328	2,459,703	1,198,022	-55
Paraquat	4,658,597	6,884,630	3,997,753	-14
Picloram	2,042,016	1,322,430	1,915,653	-6
Pronamide	239,773	206,779	212,166	-12
Sethoxydim	1,350,566	1,717,271	638,796	-53
Terbacil	298,026	342,277	243,730	-18
Trifluralin	25,686,076	22,263,693	8,985,861	-65
Total	**133,081,104**	**144,368,206**	**183,439,831**	**+37**
[Total acreage]	**[435,365,878 A]**	**[445,324,765 A],**	**[434,164,946 A]**	
[lbs/acre]	**0.305676468**	**0.324186341**	**0.422511842**	

Table J-1. Total Herbicide Use (in lbs) in the United States Across All Crops for Glyphosate and 20 Other Herbicides Commonly Used on Alfalfa (Gianessi and Reigner 2006)

Herbicide	1992[1]	1997[2]	2002[3]	Percent Difference (1992 to 2002)
	Lbs a i. applied			
Total excluding Glyphosate	**116,287,733**	**109,550,567**	**81,114,412**	**-30**
Total Herbicide Used on Alfalfa	**4,921,532**	**3,960,058**	**4,325,029**	**-12**

[1] Total cropland in 1992 was approximately 435,365,878 acres, including wheat (NASS 2007).
[2] Total cropland in 1997 was approximately 445,324,765 acres, including wheat (NASS 2007).
[3] Total cropland in 2002 was approximately 434,164,946 acres, including wheat (NASS 2007).

Heimlich et al. (2000) noted that using glyphosate has resulted in the replacement of herbicides that are at least three times as toxic and persist almost twice as long as glyphosate. Additionally, Trewavas and Leaver (2001) conducted an analysis which revealed that 3.27 million kg of other herbicides have been replaced with 2.45 million kg of glyphosate in soybean fields in the United States. Carpenter and Gianessi (2003) concluded that the introduction of GT soybeans has resulted in a decrease in the total volume of herbicides used. Gianessi (2005) estimates that averaged over all GT crops, GT technology has reduced herbicide use by 17 million kg/year in the United States. However, Gianessi's (2005) calculations indicate that if GT sugarbeets were adopted, reduction in herbicide use would not be as great as for combined GT crops, because the herbicides used now in nontransgenic sugarbeets are mainly low use rate compounds in the United States.

In cotton and soybeans between 1997 and 2002 the following herbicides were reduced, presumably replaced by glyphosate (Gianessi and Reigner, 2006):

- Bentazon reduced by 4.4 million pounds
- DSMA reduced by 0.8 million pounds
- Fluometuron reduced by 4.5 million pounds
- Imazethapyr reduced by 1.0 million pounds
- Metribuzin reduced by 1.5 million pounds
- MSMA reduced by 1.7 million pounds
- Paraquat reduced by 2.9 million pounds
- Pendimethalin reduced by 14 million pounds
- Sethoxydim reduced by 1.1 million pounds
- Trifluralin reduced by 13 million pounds

Other reductions in herbicides between 1997 and 2002 are attributed to the following (Gianessi and Reigner, 2006):

- Metolachlor was withdrawn from the market between 1997 and 2002 (1997 application was 67 million pounds). Corn growers switched to S-metolachlor, which has a lower application rate than metolachlor.
- Glyphosate was adopted on many soybeans acres that were previously treated with metolachlor.

- Cyanazine was withdrawn from the market between 1997 and 2002 (1997 application was 20 million pounds). Cyanazine use is corn was replaced by glyphosate, mesotrione, rimsulfuron, and simazine.
- A 48 million reduction in corn herbicide was due to replacement of high rate herbicides (butylate, cyanazine, EPTC, metolachlor) with lower rate herbicides (flufenacet, mesotrione, rimsulfuon, S-metolachlor).

Sankula (2006) evaluated the impact of biotechnology-derived crops planted in the United States in 2005. A summary of the herbicide analysis follows:

- Herbicide-tolerant canola used less herbicide active ingredient per acre than conventional canola, which represented a reduction of 0.69 million pounds of herbicide use in 2005.
- Herbicide-tolerant corn reduced herbicide use in corn by 21.8 million pounds in 2005, which corresponds to a grower cost savings of $269 million. Compared to 2004, grower returns were 94 percent higher and pesticide use was 18 percent lower due to a 67 percent increase in the adoption of herbicide resistant corn (due to EU approvals).
- Herbicide-tolerant cotton reduced herbicide use by 18 million pounds and reduced production costs by $39 million.
- On average glyphosate-tolerant soybean programs used 1.03 pounds active ingredient per acre (lbs a.i./A) whereas conventional herbicide programs used an additional 0.32 lb a.i./A. This translates to a reduction of 39.4 million pounds of herbicide and a cost savings of $134 million.

Johnson et al. (2008) evaluated the USDA NASS database and concluded that herbicide use in 2006 was reduced by 100.5 million pounds of active ingredient based on estimates of biotechnology-derived crop replacement of conventional crops.

Data presented in supplemental tables by Benbrook (2009) indicate increasing use (i.e., lbs per acre) of glyphosate on GT corn and soybeans considering the period from 1996 to 2008, consistent with some reports above. Over the same period, however, there was not much change in use of other herbicides on those crops (Benbrook, 2009, supplemental table 15, see appendix N). Benbrook's (2009) analysis of the USDA's NASS data indicates the possibility of an increasing trend in the number of glyphosate applications per year from an average of 1.0 to 1.3 for corn, although the trend is not significant (supplemental table 16, appendix N). The data presented by Benbrook (2009) in supplemental table 16 (see appendix N-2) does indicate an upward trend in the number of glyphosate applications per year for soybeans (with a gradual and monotonic increase from an average of 1.1 to 1.7 between 1996 and 2006) and corn (with a gradual and monotonic increase from an average of 1.0 to 2.4 between 1996 and 2007).

Between 1996 and 2008, the proportion of the total acres planted in corn that were planted with GT corn increased from 3 to 63 percent (see supplemental table 13 in Benbrook, 2009). The data indicate that total herbicide use on GT corn was much less, in pounds per acre, than total herbicide use on conventional corn when GT corn was first introduced (i.e., 1.88 lbs/acre for GT corn compared with 2.67 lbs/acre for conventional corn in 1996). The magnitude of the

difference in total herbicide application to GT and conventional corn, however, appears to be decreasing over time, with little difference in recent years (supplemental table 13).

Between 1996 and 2008, the proportion of the total acres planted in soybean that was GT soy increased from 7.4 to 92 percent (Benbrook, 2009). Total herbicide use, in pounds per acre, on soybeans also was lower when GT-soybeans were first introduced (i.e., 0.89 lbs/acre for GT soybeans compared with 1.19 lbs/acre for conventional soybeans in 1996). In Benbrook's (2009) analysis, however, that trend appears to have reversed between 1998 and 2008 (supplemental table 15). The reversal appears to be due in part to an increased average number of applications of glyphosate on soybeans each year (supplemental table 16) and in part to a decrease in total pounds of herbicide applied to conventional soybeans per acre each year. Benbrook (2009) speculated that the latter trend was due to adoption of more potent herbicides in weed control for soybeans.

No calculations or speculation on GT alfalfa's impact on herbicide use have been published. In 2005, when GT alfalfa was introduced commercially, only 0.2 percent of the total harvested alfalfa was GT alfalfa. In 2006, 3 million pounds of seed were made available for planting. Without reliable estimations on the market share of GT alfalfa out of total alfalfa, estimating the increase in herbicides and glyphosate use require assumptions.

Benbrook (2004, 2009) suggests that there will be an increase in the use of nonglyphosate herbicides. However, his analysis is not peered reviewed and is based on a series of assumptions that are not validated. Benbrook uses data provided by NASS, but this data does not distinguish between GE and non-GE crops.

Please see section 2.7 for predicted future glyphosate use based on GT alfalfa.

2.2 Current Levels of Glyphosate in the Environment

Glyphosate was first introduced as an herbicide under the trade name of Roundup® by Monsanto in 1974. Glyphosate is a non-selective herbicide registered for use on many food and non-food field crops as well as non-crop areas where total vegetation control is desired. Glyphosate is among the most widely used pesticides by volume (U.S. EPA, 1993). Glyphosate use increased more than six-fold between 1992 and 2002 to become the most used herbicide in the United States, in most part due to approval of several GT crops (Gianessi and Reigner, 2006). In 1997, it was listed on the Agency of Toxic Substances and Disease Registry's (ATSDR) 100 most frequently released substances (USHHS, 1997).

2.2.1 Current Levels of Glyphosate in Water

In a U.S. Geological Survey (USGS) monitoring study of surface water, groundwater, and soil conducted from 2001 to 2006, the metabolite AMPA was observed more frequently than the parent compound glyphosate (Scribner et al., 2007). The sample collections were from several USGS studies including the National Stream Quality Accounting Network Program, the National Water-Quality Assessment Program, and the Toxic Substances Hydrology Program. Additionally, glyphosate and its metabolite AMPA were found in surface water more frequently

than in groundwater. Higher occurrences of glyphosate and AMPA in ground and surface waters were observed when samples were taken from an area with greater proximity to agricultural areas with recent applications of glyphosate that coincided with recent rainfall. During 2002, 171 samples were collected from 51 streams in 9 Midwestern States. Glyphosate was detected in 63 samples with a maximum concentration of 8.7 µg/L and AMPA was detected in 117 samples with a maximum concentration of 3.6 µg/L. From 2001 to 2003 water samples were collected twice a month from the Mississippi River at Baton Rouge, Louisiana to help determine the presence and fate of glyphosate in the lower Mississippi River Basin and the delivery to the Gulf of Mexico. Out of the 35 samples collected, glyphosate was detected in none and AMPA was detected in 31, with a maximum concentration of 0.38 µg/L. In vernal pools glyphosate was detected in 31 of 76 samples with a maximum concentration of 328 µg/L and AMPA was detected in 30 samples with a maximum concentration of 41 µg/L. One area that had higher levels of contamination was the Leary Weber Ditch Basin, which is part of the White River Basin in Indiana. Of 117 groundwater samples, glyphosate was detected in 40 samples with a maximum concentration of 4.7 µg/L, and AMPA was detected in 85 samples with a maximum concentration of 2.6 µg/L. Of 64 surface water samples, glyphosate was detected in 54 samples with a maximum concentration of 427 µg/L, and AMPA was detected in 52 samples with a maximum concentration of 29 µg/L. Glyphosate and AMPA were detected in 12 of 14 rainfall samples and concentrations ranged from 0.02 to 1.1 µg/L. This was due, however, to the association of glyphosate with particulate matter (dust), and not to its existence as vapor (Scribner et al., 2007).

Glyphosate dissipated from the surface of small forest ponds in southern Manitoba (half life of 3.5 to 11.2 days). Glyphosate and AMPA increased in sediment samples to day 36, suggesting that the sediments adsorption was a major sink (Goldsborough and Brown, 1993). In another study by the same researchers, a comparison of glyphosate dissipation from small forest ponds versus in situ water microcosms, the half life in the ponds was 1.5 to 3.5 days and glyphosate remained at treatment levels in the watermicrocosms without sediments (Goldsborough and Beck, 1989).

Major et al. (2003) studied sediments following application of glyphosate (Rodeo® formulation) to control smooth cordgrass in marine bay environments. Their data indicate that glyphosate degradation is slower in estuarine habitats than in freshwater environments, and is more similar to degradation rates reported for agricultural soil.

In a study of the contribution of wastewater treatment plants (WWTP) to glyphosate and AMPA levels in surface waters, 40 samples were collected upstream and downstream of 10 WWTPs and directly from WWTP effluent (Kolpin et al., 2006). Glyphosate and AMPA were detected in 67.5 percent of the samples. Concentrations were generally low, with nine samples exceeding 1 µg/L of AMPA and three samples exceeding 1 µg/L of glyphosate. Among these samples exceeding 1 µg/L, with the maximum concentration of AMPA measured at 3.9 µg/L and the maximum concentration of glyphosate measured at 2.2 µg/L. There was roughly a two-fold increase in the frequency of detection for both AMPA and glyphosate downstream of the WWTPs relative to samples upstream. The authors conclude that urban uses of glyphosate contribute to glyphosate and AMPA concentrations in streams (Kolpin et al., 2006). It is worth noting, however, that AMPA can also be derived from phosphonic acid degradation, a product

contained within detergents. Detergent compounds have previously been commonly detected in WWTP effluent (Kolpin et al., 2006).

Wauchope et al. (2001) used computer models to predict herbicide concentrations in surface water reservoirs under scenarios with different herbicide applications. To simulate GT corn versus non-GT corn, glyphosate and glufosinate were compared to atrazine and alachlor. In the monitoring data used to build the computer model, in almost all years, a single run-off event dominated the input into the reservoir. As a result annual herbicide concentrations were highly correlated with annual maximum daily values. Glyphosate and glufosinate concentrations in run-off were generally 80 to 90 percent less than the total concentrations of atrazine and alachlor in run-off. The simulations indicate that if glyphosate and glufosinate (post-emergent herbicides with high soil adsorption) completely or partially replace atrazine and alachlor (pre-emergent herbicides) there would be improvements in water quality.

Table J-2 presents a summary of the fate properties for glyphosate.

Table J-2. Chemical Fate Properties of Glyphosate (U.S. EPA, 2006)

Property	**Value**
Common Name	Glyphosate
Chemical Name	*N*-(phosphonomethyl)glycine
Log Kow	-3
Hydrolysis	Stable ≥30 days at pH 3, 6, and 9 at 5 and 35°C
Photolysis	Does not absorb light energy pH 5, 7, and 9
Metabolism in soil, half life	1.85 – 2.06 day
Metabolism water-sediment system, half life	Aerobic: 7 days Anaerobic: 8.1 – 199 days
Soil Mobility, $K_{ads,\ Freundlich}$	9.4 – 700 mL/g
Soil water partition coefficient $K_{d\ (adsorption)}$	62 Drummer silty clay loam 90 Ray silt 70 Spinks sandy loam 22 Lintonia sandy loam 175 Cattail swamp sediment
Soil adsorption K_{oc}	2100 (500 – 2600) (L/kg) 2600 – 4900 (L/kg) 8 to >500,000 (L/kg) 54 (L/kg)
Metabolite	aminomethyl phosphonic acid (AMPA)
Field dissipation (application rate: 7.95 lb a.e./acre, 10.7 lb a.i./acre), half life	13.9 days (median) 2.6 days in Texas 140.6 days Iowa

A measure of pesticide persistence (half-life) and adsorption in soil (K_{OC}) is the Groundwater Ubiquity Score (GUS), which can be calculated for pesticides in order to rank their potential to leach toward groundwater (Vogue et al., 1994). GUS = log10 (half-life) x [4 - log10 (K_{OC})], and values between 1 and 2 are low, 2 and 3 are moderate, 3 and 4 are high, and pesticides with a GUS greater than 4 has a very high potential to move toward groundwater. Glyphosate has a GUS of 1.17 with a half life of 13 days and a K_{OC} of 884, showing its low mobility and low risk

of moving to groundwater. POEA (surfactant) has a GUS of 0.69 with a half life of 14 days and a K_{OC} of 2,500, showing that POEA also has very low potential to leach to groundwater. The GUS for other herbicides can be calculated from the values presented in table J-3. Glyphosate has a low vapor pressure and Henry's law constant; thus, it has a low potential to volatilize from soil and water (Vogue et al., 1994).

Table J-3 shows the results of a model that examined the environmental risks of various herbicides, all of which have low groundwater concentrations. These herbicides were evaluated in relation to glyphosate, and the relative risk gives an indication of which herbicides have greater impact on the environment. Relative risk is calculated by determining Risk Quotients (RQs), the estimated environmental concentration (based on environmental fate properties and application rates) divided by estimated concentrations in groundwater, and dividing the RQs by glyphosate's RQ. A relative risk less than one presents less risk than a relative risk greater than one. Glyphosate had less relative risk than most other active ingredients (Peterson and Hulting, 2004).

Table J-3. Predicted Groundwater Concentrations of Active Ingredients Based on SCI-GROW Modeling (Peterson and Hulting, 2004)

Active Ingredient	Application rate (g a.i./ha)	Groundwater value (ppb)	Relative Risk [2]	K_{OC} [3]	Aerobic soil half-life (days)
Glyphosate	840	0.0005	1	2,100	2
2,4-D	560	0.005	10	48	5.5
Bromoxynil	1,100	0.0004	0.8	1,003	2
Clodinafop	67	0.00003	0.06	252	1
Clopyralid	146	0.06	120	36	26
Dicamba	280	0.1	220	13	18
Fenoxaprop	90	0.000006	0.01	9.490	1
Flucarbazone	34	0.2	400	NA	NA
MCPA	1,457	0.26	520	110	25
Metsulfuron	9	0.004	8	42	28
Thifensulfuron	22	0.0001	0.2	28	6
Tralkoxydim	280	0.001	2	30	5
Triallate	1,100	0.04	80	1,601	54
Triasulfuron	34	0.05	100	105	114
Tribenuron	16	0.00003	0.06	52	2
Trifluralin	1,100	0.009	18	7,200	169

[2] Relative risk compared with glyphosate; values highlighted in grey indicate greater risk relative to glyphosate
[3] K_{OC}, soil adsorption coefficient

Malone et al. (2004) tested the preferential flow of several herbicides after simulated rainfall using USDA-Agricultural Research Service (ARS) maintained lysometers. The lysometers have 8.1 m^2 in surface area, are 2.4 meters deep, and wall strips to prevent side wall leakage. Collection pans collect percolate that is directed to a collection tank. The researchers found that because of preferential flow, the breakthrough time of herbicides was independent of their sorptive properties, but the transport time was dependent on the herbicide sorptive properties. Although rapid glyphosate transport occurred through preferential flow (macropore flow), glyphosate was not detected in percolate samples. None of the concentrations were close to the glyphosate EPA Maximum Contaminate Level (Malone et al., 2004).

Fomsgaard et al. (2003) also studied leaching of pesticides through soil using lysometers. Normal till and low-till conditions were maintained for 2 years, with one initial glyphosate application corresponding to 0.8 kg active ingredient per ha. The mean yearly concentration of leached glyphosate and/or AMPA was significantly below 0.1 mg/L from both sets of lysometers. The highest amounts of glyphosate were found in samples of leachate taken two years after spraying. The concentrations of residual AMPA in the soil were significantly higher in the in low-tillage soil than in normal-till soil. The reason for these higher concentrations could be differences in extraction efficiency and/or residuals from prior experiments that had more frequent sprayings with Round Up in the low-tillage soil (Fomsgaard et al., 2003).

Another Danish study at agricultural fields determined that leaching of glyphosate was mainly governed by pronounced macropore flow during the first months after application. Also, AMPA was frequently detected more than 1.5 years after application (Kjaer et al., 2005).

Torstensson et al. (2005) examined glyphosate and AMPA mobility on Swedish railway embankments and found that most of the glyphosate and AMPA was found in the upper 30 cm layer of soil and the half life was generally less than 5 months, though longer half lives were observed in some sites. Glyphosate and AMPA were also detected in groundwater at these railway embankments. Based on the finding that transport to groundwater is dependent on application rate, the authors concluded that Roundup® Bio application rate should not exceed 3 L/ha.

In summary (Borggaard and Gimsing, 2007), groundwater and surface water contamination by glyphosate is limited because of sorption onto variable-charged soil minerals and microbial degradation. Glyphosate leaching is mainly determined by soil structure and rainfall, while leaching to drainage systems occurs due to preferential flow in macropores. In contrast, other herbicides are often found in groundwater (Kolpin et al., 1998).

2.2.2 Current Levels of Glyphosate in Soil

Glyphosate adsorbs strongly to soil and is not expected to move vertically below the six inch soil layer; residues are expected to be immobile in soil (Cerdeira and Duke, 2006; U.S. EPA, 2006; Vereecken, 2005). Glyphosate is primarily and rapidly degraded by soil microbes in the environment. The major degradate of this process is AMPA, which further degrades in the soil to form carbon dioxide. The half-life of glyphosate in soil laboratory studies is two days (U.S. EPA, 2006). In agricultural soils, the half-life of glyphosate ranges from 1.7 to 197.3 days, but is typically less than 60 days, and one study determined the disappearance time for 50 percent (DT_{50}) to be 13 days following a single application of glyphosate (Giesy et al., 2000). DT_{50} depends on climate, weather, and application rates, but in general, glyphosate will continue to degrade even after multiple applications. AMPA was found to have a longer half life than glyphosate, and it has the potential to accumulate in the soil after extensive glyphosate applications (Cerdeira and Duke, 2006).

Polyethoxylated alkyl amine (POEA) is a class of surfactants used with glyphosate to increase the plant uptake of the glyphosate. Microbial degradation is the primary degradation process for POEA as well, and the half-life for POEA in soil is estimated at 7-14 days (Giesy et al., 2000). Glyphosate and POEA have similar dissipation rates, so accumulation of POEA in the soil is not

anticipated with increased glyphosate use. Both toxicity and concentration of POEA in experimental water microcosms decreases more rapidly in the presence of sediment, higher total organic carbon, clay, and microbial biomass (Wang et al., 2005).

Soil microbes readily metabolize glyphosate into AMPA and other metabolites (USDA FS, 2003). Microorganisms produce aromatic amino acids through the shikimate pathway, similar to plants. Since glyphosate inhibits this pathway, it could be expected that glyphosate would be toxic to microorganisms. Field studies show, however, that glyphosate has little detrimental effect on soil microorganisms as a whole, and, in some cases, field studies have shown an increase in microbial activity of specific microbes (USDA FS, 2003). The addition of microbes via compost made from organic solid waste did not enhance glyphosate degradation in soils (Getenga and Kengara, 2004). In one study the population size of *Pseudomonas* spp. bacteria was highly correlated with high mineralization rates of glyphosate. In addition the mineralization rates were higher in soil sampled from organically managed soils than in soil from conventional farming (Gimsing et al., 2004). In a field study on GT versus non-GT crops, there was a small but statistically significant effect on soil microbial community structure as measured by total fatty acid methyl ester analysis following 5 years of continuous GT crop as compared with the non-GT crop system (Locke et al., 2008). Bohm et al. (2009) found no effects on soybean yield, total nitrogen accumulation, nodulation, and nitrogen-fixation after glyphosate was applied to the glyphosate-resistant variety of soybeans. Kremer and Means (2009) discovered the frequency of root-colonizing *Fusarium* increased significantly after glyphosate application to glyphosate-resistant corn and soybean. Powell and Swanton (2008), however, concluded there is insufficient evidence to prove or disprove a link between glyphosate and crop diseases associated with *Fusarium*. The effect of glyphosate on soil biota is discussed more in the Technical report *Potential Impacts on Wildlife, Amphibians, Plants, And Ecosystems from Increased Glyphosate and Other Chemical Use* (appendix N).

Due to glyphosate and AMPA's strong adsorptive characteristics, they are not likely to leach to groundwater from the soil, and compared to most herbicides, leaching is very limited (Cerdeira and Duke, 2006; Grunewald et al., 2001). Studies indicate that glyphosate leaching is dominated by preferential flow mechanisms and that it is dependent on the clay particles, iron oxides, and organic matter present in the soil (Vereecken, 2005). Glyphosate and its metabolite adsorb to soil particles that become suspended in runoff water and can potentially contaminate surface waters as a result of erosion of this soil. Once in surface water, glyphosate and AMPA are not readily broken down by water or sunlight (U.S. EPA, 1993), but can be removed through standard water purification processes and disinfection processes such as ozonation and chlorination (Speth, 1994). There is also evidence that glyphosate is translocated through plants from foliar application to roots to soil (Laitinan et al., 2007).

The USGS study that monitored glyphosate and AMPA in groundwater, surface water, and rainfall, also monitored soil at the Leary Weber Ditch Basin site (Scribner et al., 2007). Of 193 soil cores, glyphosate was detected in 119 with a maximum concentration of 476 μg/kg, and AMPA was detected in 154 with a maximum concentration of 956 μg/kg. For the soil samples, the maximum level of AMPA measured was 23 μg/kg, and it was detected prior to application of glyphosate (April). The authors suggest it persisted from the previous year.

Studies show that glyphosate does not move deep into the soil, it does not get transported at high levels to or through groundwater, and it does not persist long in the soil (Major, 2003; Miller et al., 1995; Torstensson, 2005). It is highly adsorptive and remains in the soil until mineralizing bacteria breaks it down into AMPA (Gimsing et al., 2004). K_f (from table J-4) is a measure of adsorption that relates the concentration of the solute on the surface to the concentration of the solute in the liquid with which it is in contact (Vereecken, 2005). It is a constant, and the higher the value of K_f is, the more immobile the glyphosate in the soil. Soil composition does have an effect on glyphosate adsorption, with presence of minerals increasing adsorption (lessening movement of the glyphosate) and the presence of soil organic matter inhibiting adsorption (Getenga and Kengara, 2004; Vereecken, 2005). Table J-4 presents parameters for glyphosate adsorption in different soils. The Freundlich Equation is an adsorption isotherm, or a curve relating the concentration of a solute on the surface of an adsorbent to the concentration of the solute in the liquid with which it is in contact. The equation is defined by:

$$c_s = K_f * c^n$$

Where K_f is the Freundlich adsorption constant (a constant for a given adsorbate at a particular temperature, related to sorbent capacity) and "n" is the Freundlich exponent related to the degree of deviation from isotherm linearity (Lee et al., 2001).

Table J-4. Freundlich Parameters of Glyphosate Adsorption in Different Soils. (Vereecken, 2005)

Soil Type	C (%)	Sand (%)	Silt (%)	Clay (%)	pH	n	K_f
Clay Loam	1.56	9.9	37.5	52.6	7.5	0.67	76
Silt Loam	2.60	42.29	44.71	13	5.96	0.83	88.97
Sandy Loam	3.35	79.99	12.63	8.51	6.1	0.81	75.95
Sandy Silt	3.7	46	37	17	5.8	0.77	40.64
Loamy Silt	0.5	2	82	16	8.3	0.44	152.9
Sand	0.94	-	-	-	5.10	1	100641.1
Clay	3.67	32.6	20.8	43.43	6.49	0.99	113.14
Muddy Clay	12.6	-	-	57	6.9	0.91	84
Organic Soil	26	78	13	9	5.2	1.14	303
Coarse Sandy Loam	1.7	65	17	15	7.40	0.83	35.15
Sandy Soil	3.1	90	2.9	4	5.32	0.79	57

Mamy et al. (2005) studies the environmental fate of five herbicides. The main dissipation pathways were mineralization for glyphosate and sulcotrione, volatilization for trifluralin and non-extractable residues formation for metazachlor and metamitron. All five herbicides had low persistence, and glyphosate had the shortest half-life, which varied with soil type. Trifluralin had the longest half-life. Glyphosate, metazachlor and sulcotrione were degraded into persistent metabolites. At 140 days after herbicide applications, the amounts of glyphosate and AMPA in soils were the lowest in two soils, but not in the third soil, a loamy sand with low pH. The authors concluded that the environmental advantage in using glyphosate due to its rapid degradation is counterbalanced by accumulation of AMPA specifically in the context of extensive use of glyphosate (Mamy et al., 2005).

2.2.3 Current Levels of Glyphosate in Air

Herbicides can pollute air either through drift, the movement of herbicide through the air to unintended sites, or volatility, evaporation into the air. Glyphosate is essentially not volatile at

25ºC and has not been reported as an atmospheric contaminant (Cerdeira and Duke, 2006). When glyphosate is applied directly to plant leaves, the risk of drift is low, but when glyphosate is applied broadly to a field, the risk of drift increases (Owen, 1998). Glyphosate poses very little risk of contaminating air, but as its use increases, the opportunity for drift and application to unintended sites can increase. Glyphosate concentrations found in a few rainwater samples were considered due to glyphosate's association with particulate matter in the air (dust), and not to its existence as vapor (Scribner et al., 2007).

2.3 Environmental Effects of Herbicides Used on GT Crops

The use of herbicides impacts the environment in multiple ways. In this report, the focus is the impact of herbicides on the soil, water and air. However, a general Environmental Impact Quotient (EIQ) was devised in 1992 that gives an indication of the effect of an herbicide on the environment in general (Kovach et al., 1992). It is calculated from the following parameters and is the average of the farm worker, consumer and ecological components:

$$\mathbf{EIQ=\{C[(DT*5)+(DT*P)]+[(C*((S+P)/2)*SY)+(L)]+[(F*R)+(D*((S+P)/2)*3)+(Z*P*3)+(B*P*5)]\}/3}$$

DT = dermal toxicity, C = chronic toxicity, SY = systemicity, F = fish toxicity, L = leaching potential, R = surface loss potential, D = bird toxicity, S = soil half-life, Z = bee toxicity, B = beneficial arthropod toxicity, P = plant surface half-life (Kovach, 1992).

EIQs are universal indicators, updated annually, that effectively integrate various environmental impacts of individual pesticides into a single value that is consistent and comprehensive. EIQs have been calculated by Kovach for common herbicide ingredients, and table J-5 lists the herbicides relevant to alfalfa cultivation and their EIQs (Kovach et al., 2007).

Table J-5. Calculated EIQs for Alfalfa-Related Herbicides (Kovach et al., 2007)

Herbicide	EIQ
2,4-D*	18.67
Atrazine (Atrazine)*	22.9
Bromoxynil (Buctril)	20.0
Clethodim (Prism, Select)	17.0
Clopyralid (Stinger)*	18.1
Dicamba (Dicamba)*	28.0
Diflufenzopyr (Distinct)*	17.5
Diuron (Karmex, Direx)	20.5
EPTC (Eptam)	9.4
Glufosinate-ammonium (Rely)*	28.25***
Glyphosate (Roundup®)**	15.3
Halsulfuron methyl (Sandea)*	17.0
Hexazinone (Velpar)	18.0
Imazamox (Raptor)	19.5
Imazethapyr (Pursuit)	27.3
Metribuzin (Sencor)	28.4
Norfluzaon (Solicam)	18.8

Table J-5. Calculated EIQs for Alfalfa-Related Herbicides (Kovach et al., 2007)

Herbicide	EIQ
Paraquat (Gramoxone Inteon)	31.0
Picloram (Pathway)*	18.0
Primsulfuron-methyl (Beacon)*	27.33
Sethoxydim (Poast)	27.5
Terbacil (Sinbar)	16.8
Trifluralin (Treflan/TR-10)	18.8

* Indicates an herbicide used for control of alfalfa, not weeds in alfalfa
** Glyphosate can be used to control alfalfa if it is non-GT and it can be used to control weeds in GT alfalfa
*** The EIQ for glufosinate-ammonium has dropped to 20.2 in the 2010 update of these values (Kovach et al. 2010).

The effects of GT crops other than GT alfalfa have been studied. In a study examining the Environmental Impact (EI, calculated by multiplying the EIQ of an herbicide by application rate to get an environmental impact per acre measurement) of GT canola, researchers found that on average, the environmental impact of GT canola was lower than the environmental impact of conventional canola. It appears this is the case because the herbicides used in GT canola, such as glyphosate and imazethapyrs, tend to have lower application rates than the herbicides used in conventional canola, such as ethalfluralin and trifluralin, instead of just being more environmentally benign (Brimner et al., 2005). Table J-6 presents EIQ and EI for canola in Canada.

Table J-6. EIQ and EI per Hectare of Canola for Common Herbicides Used in 1995, 1998, or 2000[1] (Brimner et al., 2005)

Active ingredient	EIQ	EI ha^{-1}
Herbicides used in herbicide-resistant canola		
Glufosinate-ammonium	34.3	10.3
Glyphosate	32.4	8.5
Imazamox	27.3	0.4
Imazethapyr	27.3	0.4
Herbicides used in conventional canola		
Ethalfluralin	30.7	25.8
Sethoxydim	27.5	4.0
Trifluralin	26.8	21.6
Clopyralid	18.0	2.7
Ethametsulfuron-methyl	16.0	0.2

[1] EI was determined by multiplying the EIQ for each active ingredient by the lowest recommended application rate of that ingredient in kg a.i. ha^{-1}

Another study calculated EI for GT cotton, corn and soybean, as well as canola in the United States, and concluded that, in general, a downward trend in pesticide use was observed for transgenic crops when compared to non-transgenic crops (Kleter et al., 2007). The exception was a slight increase in herbicides applied to GT soybean, but this corresponded to an increased use of less environmentally persistent herbicides. Table J-7 shows a decrease of 25 to 33 percent in the quantities of herbicide active ingredients (a.i.) applied to GT crops versus non-GT crops in 2004 (Kleter et al., 2007).

Table J-7. Environmental Impact of Herbicide Use in Herbicide-Resistant Transgenic Crops in the United States in 2004[1] (Kleter et al., 2007)

Item	Non-transgenic	Transgenic herbicide-resistant	Difference	Difference, %
Herbicide-resistant canola				
Pesticide use (kg a.i. ha−1)	0.6	0.4	-0.2	-30
Total impact (EI ha−1)	14.8	8.6	-6.2	-42
Farm worker impact (EI ha−1)	8.9	4.1	-4.8	-54
Consumer impact (EI ha−1)	3.8	2.5	-1.3	-35
Ecology impact (EI ha−1)	31.8	19.4	-12.4	-39
Herbicide-resistant cotton				
Pesticide use (kg a.i. ha−1)	5.4	3.7	-1.7	-32
Total impact (EI ha−1)	113.4	66.1	-47.4	-42
Farm worker impact (EI ha−1)	57.7	34.4	-23.4	-40
Consumer impact (EI ha−1)	33.1	21.7	-11.4	-35
Ecology impact (EI ha−1)	249.5	142.4	-107.1	-43
Herbicide-resistant maize				
Pesticide use (kg a.i. ha−1)	3.8	2.5	-1.2	-33
Total impact (EI ha−1)	87.9	53.6	-34.4	-39
Farm worker impact (EI ha−1)	48.4	29.0	-19.3	-40
Consumer impact (EI ha−1)	26.2	16.2	-10.1	-38
Ecology impact (EI ha−1)	189.1	115.6	-73.5	-39
Herbicide-resistant soybean				
Pesticide use (kg a.i. ha−1)	1.2	1.4	-0.4	-25
Total impact (EI ha−1)	42.8	17.7	-25.1	-59
Farm worker impact (EI ha−1)	29.3	9.2	-20.1	-68
Consumer impact (EI ha−1)	14.1	5.8	-8.4	-59
Ecology impact (EI ha−1)	85.0	38.1	-46.9	-55

[1] Based on pesticide use data for 2004 from Sankula et al. (2005). Units have been converted to metric, e.g. 1 lb a.i. acre−1 = 1.121 kg a.i. ha−1. The EIQ values have been multiplied by the values of the application rates expressed as kg a.i. ha −1 in order to calculate the environmental impact per hectare (EI ha−1).

Researchers at Ghent University developed the pesticide occupational and environmental risk (POCER) indicator (Devos et al., 2008). POCER is a similar concept as EIQ and includes ten modules; (1) risk to pesticide operator; (2) risk to worker; (3) risk to bystander; (4) persistence in the soil; (5) risk of groundwater contamination; (6) acute risk to aquatic organisms; (7) acute risk to birds; (8) acute risk to bees; (9) acute risk to earthworms; and (10) risk to beneficial arthropods. The toxicological reference values used in the effect assessment are certified endpoints defined in Annex VI of Directive 91/414/EEC. Using GT corn and non-GT corn as an example, the POCER values for glyphosate or glufosinate used alone were about one sixth less than other herbicide regimes (31 regimes were evaluated). This environmental benefit of glyphosate over other herbicides was attributed to lower potential for leaching and lower toxicity to aquatic organisms (Devos et al., 2008).

Using the above standardized methods for ranking environmental impact, researchers have concluded that glyphosate is less harmful to the environment than many other herbicides (Devos et al., 2008).

2.4 Herbicide Use in Conventional Alfalfa Farming

Herbicides are used at three different phases in conventional alfalfa farming: stand establishment, established stands (to control weeds), and during stand removal to kill alfalfa.

2.4.1 Establishing and Maintaining Stands

The 16 herbicides that can be used for weed control in conventional alfalfa farming are summarized in table J-8 (based on Canevari et al., 2007; Loux et al., 2007; OMAFRA, 2008; Rogan and Fitzpatrick, 2004).

Table J-8. Herbicides Used to Control Weeds in Conventional Alfalfa

Herbicide (Brand)	Stand Stage	Notes
2,4-DB (Butyrac, Butoxone)	1-4 trifoliolate or established stands	No harvesting or grazing allowed for 60 days following treatment
Benefin (Balan)	Before seeding	Not for use on soils high in organic matter
Bromoxynil Buctril)	2-4 trifoliolate	Often tank mixed with other herbicides
Clethodim (Prism, Select)	2-4 trifoliolate or established stands	Well established perennials require multiple applications Allow 15 days between application and grazing, feeding, or harvesting of alfalfa
Diuron (Karmex, Direx)	Established stands	Persists in soil for one year, so cannot be used in last year of stand
EPTC (Eptam)	Established stands	Applied before germination Controls for 30 to 45 days so repeated applications might be necessary
Glyphosate	Established stands	Spot application directly to weeds (applied by hand with backpack sprayer)
Hexazinone Velpar)	6 inches of root growth in new stands or established stands	Many crops cannot be planted for 18 months without yield damage
Imazamox (Raptor)	2-4 trifoliolate or established stands	Preharvest interval is 20 days
Imazethapyr (Pursuit)	2-4 trifoliolate or established stands	Follow-up planting restrictions range from 4 to 40 months
Metribuzin (Sencor)	Established stands	No grazing or harvesting allowed for 28 days following application
Norfluzaon (Solicam)	Established stands	Cannot be applied within 28 days of harvest Does not control emerged weeds 24 month rotation interval
Paraquat (Gramoxone Inteon)	3, 6, or 9 trifoliolate; established stands	Rescue treatment when weeds form a canopy over alfalfa No harvest or grazing until 60 days after application Often used in the last year of the stand

Table J-8. Herbicides Used to Control Weeds in Conventional Alfalfa

Herbicide (Brand)	Stand Stage	Notes
Pronamide (Kerb)	First trifoliate leaf stage	No grazing or harvesting allowed for 120 days following application
Sethoxydim (Poast)	2-4 trifoliolate or established stands	Well established perennials require multiple applications
Terbacil (Sinbar)	Established stands	Cannot plant any other crop for 2 years after Sinbar application
Trifluralin (Treflan/TR-10)	Established stands	Applied before germination Rainfall or sprinkler irrigation is required within 3 days after irrigation to incorporate the herbicide Controls dodder before germination

Based on an extensive survey[3] performed from 1988 to 1992, herbicides are used much more often with seed fields than with hay fields (herbicides are used on 78.3 percent of total seed acreage but are used on only 16.7 percent of total hay acreage) (Hower et al., 1999). Mechanical and cultural methods for weed control (e.g. tillage and companion crops) were used for ~80 percent of the spring planted alfalfa and 18 percent of the fall planted alfalfa (Hower et al., 1999). Table J-9 presents data from Hower et al. (1999) on the acreage of alfalfa hay that is treated with herbicide versus cultural methods for weed control broken down by spring versus fall plantings and established stands.

Table J-9. Alfalfa Hay Acreage (in thousands) Treated with Various Herbicides and Weed Management Strategies (U.S. 1988-1992) (Hower et al., 1999)

Management Option	South	Northeast	North Central	West	U.S. total
Spring Seedings (3.2 million acres annually)					
Benefin	0.8	5.2	71.0	3.6	80.6
Bromoxynil	0	4.9	18.7	10.3	33.9
EPTC	0.2	17.4	66.8	20.8	105.2
Glyphosate	0.2	11.8	265.3	2.6	279.9
Imazethapyr	0.2	12.9	148.7	5.4	167.1
MCPA	0	0.6	57.2	0	57.8
Paraquat	0.5	6.3	69.4	3.4	79.6
Pendimethalin	0	0	2.4	1.3	3.6
Sethoxydim	0.2	5.3	76.7	3.2	85.5
Trifluralin	0	0	34.5	5.1	39.6
2,4-DB	1.8	23.7	117.3	13.2	156.0
Pronamide	0	0	0	0.3	0.3
2,4-D	0	3.6	1.9	1.3	6.8
Herbicide Total	3.9	91.7	929.9	70.5	1095.9
Percentage Herbicide of U.S. Acres (Spring)	0.12%	2.87%	29.06%	2.20%	34.25%
Clipping	0.6	162.8	755.4	48.2	966.9
Companion crop	0	95.4	1371.0	107.9	1574.4
Flash grazing	0	5.9	12.0	0.4	18.3
Early harvest	0	3.1	0	0	3.1
Cultural Total	0.6	267.2	2138.4	156.5	2562.7

[3] Data collected in the herbicide survey represented 90.1% of the 25.6 million acres produced annually from 1988-1992 as reported by the NASS.

Table J-9. Alfalfa Hay Acreage (in thousands) Treated with Various Herbicides and Weed Management Strategies (U.S. 1988-1992) (Hower et al., 1999)

Management Option	South	Northeast	North Central	West	U.S. total
Percentage Cultural of U.S. Acres (Spring)	0.02%	8.35%	66.83%	4.89%	80.08%
Fall Seedings (1.4 million acres annually)					
Benefin	1.3	0.8	0.1	22.0	24.2
Bromoxynil	0	1.9	14.3	20.1	36.2
EPTC	0.3	3.3	0.4	54.2	58.1
Glyphosate	0.3	4.4	16.7	28.2	49.6
Imazethapyr	0	6.2	12.4	9.7	28.3
MCPA	0	0.2	0	0	0.2
Paraquat	0.5	3.4	68.8	12.1	84.8
Sethoxydim	1.0	2.2	16.9	28.5	48.5
Trifluralin	0	0	0	12.9	12.9
2,4-DB	3.8	5.6	5.4	66.1	80.9
Pronamide	0.3	0	0	5.1	5.4
2,4-D	0	0.6	0	0	0.6
Herbicide total	7.5	28.6	135	258.9	429.7
Percentage Herbicide of U.S. Acres (Fall)	0.54%	2.04%	9.64%	18.49%	30.69%
Clipping	0.5	2.8	19.3	166.5	189.1
Companion crop	0.1	5.9	8.8	21.0	35.7
Flash grazing	0.5	2.4	4.1	17.4	24.5
Cultural Total	1.1	11.1	32.2	204.9	249.3
Percentage Cultural of U.S. Acres (Fall)	0.08%	0.79%	2.30%	14.64%	17.81%
Established Stands (23,024,800 acres annually)					
Glyphosate	0	0.6	62.0	53.9	116.4
Imazethapyr	0	33.4	65.1	216.3	314.9
MCPA	0	0	0	3.9	3.9
Paraquat	10.6	95.4	315.1	373.1	794.3
Sethoxydim	12.6	15.8	470.3	131.8	630.4
Trifluralin	0	0	81.0	302.5	383.5
Diuron	1.2	0	43.7	135.4	180.3
2,4-DB	55.4	6.5	79.3	26.1	167.3
Pronamide	0.5	6.1	23.6	78.6	108.8
Metribuzin	1.3	39.0	618.5	404.7	1063.5
Hexazinone	0	53.2	198.3	749.4	1000.9
Terbacil	1.2	42.4	72.3	202.4	318.3
Herbicide total	82.8	292.4	2029.2	2678.1	5082.5
Percentage Herbicide of U.S. Acres (Established)	0.36%	1.27%	8.81%	11.63%	22.07%
Clipping	7.6	0	237.8	88.4	333.8
Companion crop	0	0	0	16.3	16.3
Flash grazing	5.0	64.8	156.2	292.2	518.2
Cultivation/tillage	1.2	19.1	96.4	642.4	759.2
Burning	0	0	158.7	4.6	163.4
Cultural Total	13.8	83.9	649.1	1043.9	1790.9
Percentage Cultural of U.S. Acres (Established)	0.06%	0.36%	2.82%	4.53%	7.78%

The exact use of herbicide on alfalfa crops typically depends on region, weed spectrum and farmer preference, among other things. One herbicide rarely takes care of all weed control issues in a crop, and farmers usually have sequential combinations of herbicides to take care of summer and winter weeds. In California, research has shown that with the proper sequence and application rates, farmers can achieve weed-free alfalfa hay (Gianessi et al., 2002). In field experiments in southwestern Michigan, researchers found no net economic benefit to herbicide use in alfalfa establishment (Brothers and Hesterman, 1991).

2.4.2 Stand Removal and Volunteer Control

After about 3-8 years alfalfa stands are usually thinning and vulnerable to weeds, so the stand is removed by killing the alfalfa by either plowing or herbicide application or both (Orloff et al., 1997; Rogan and Fitzpatrick, 2004). Based on data on herbicides that remove alfalfa (Hower et al., 1999), about 2 percent of acres per year are believed to remove their stands using herbicides (including glyphosate), while the remaining 98 percent of acres either undertake stand removal with tillage alone or simply establish or maintain stands. This value of 2 percent is consistent with the observation noted above that herbicides are used on about 16.7 percent of alfalfa acres. That is, assuming acres that use herbicides in general also usually (e.g., 75 percent of the time) use herbicides for stand removal, and stand life is about 5.5 years, then 16.7 percent / 5.5 years stand life x 75 percent = 2.3 percent. Herbicides that are used for stand removal or to control volunteer alfalfa (including GT alfalfa) include (Dillehay and Curran, 2006; Miller et al., 2006; Renz, 2007; Rogan and Fitzpatrick, 2004):

- 2,4-D
- Clopyralid
- Dicamba
- Dicamba and diflufenzopyr
- Glufosinate
- Glyphosate (not for removing GT alfalfa)
- Primsulfuron-methyl
- Mixtures of dicamba, 2,4-D, and clopyralid
- Picloram
- Picloram and 2,4-D
- Halsulfuron and dicamba
- Acetochlor
- Acetochlor and atrizine
- Acetochlor and atrizine and dicamba
- Atrazine and dicamba
- Clopyralid and flumetsulam

See tables J-10 and 11 for more detailed information on the herbicides used for alfalfa control.

Table J-10. Effectiveness of and Restrictions for Herbicides Used for Alfalfa Control

Herbicide	Effect/Efficiency/ Resprouting Level	Tillage	Crop Restrictions	Effect as Volunteer Alfalfa Control (after 2,4-D stand take-out)	Source
2,4-D	Alfalfa was controlled in tilled and nontilled treatments at 51% and 55%, respectively. Thirty-six days after stand take-out herbicide treatment, 22 days after tillage, and seven days after irrigation, the same treatment provided 100% and 18% control of Roundup Ready® alfalfa in tilled and nontilled treatments, respectively.	Both tilled and nontilled fields tested	Only the low rate (0.5 L/acre) should be used in the spring. Only field corn or spring cereals can be planted after a spring application, however a 14 day interval between application and planting is required. No specific crop restrictions when applied alone or with glyphosate in the fall. To be safe the following is recommended: If applied alone or with glyphosate before September 1st, then field corn, soybean, spring cereals and canola can be planted in the spring. If applied after September 1st or in the spring, then only field corn can be planted after application. There must be a 60-day harvest interval in new seedlings and 30 days in established alfalfa.	95%	1, 2, 3
Clopyralid	When Stinger (clopyralid) was applied to crops at a rate of 3 oz/A, alfalfa was controlled at 84%, 100%, and 96% in no-tillage, plow, and chisel plow conditions, respectively. At a rate of 4 oz/acre, 91%, 100%, and 99%, respectively; and at 6 oz/ acre, 93%, 100%, and 100%, respectively	Both tilled and nontilled fields tested	Rotational restrictions: peas, lentil, potato, and dry bean cannot be planted until 18 months following clopyralid application. Application time: in spring before boot stage and/or as a postharvest fall treatment. To control late-emerging Canada thistle, treat preharvest after grass seed is fully developed; apply after most basal leaves emerge but before bud stage.	95%	1, 2, 3
Dicamba	When Clarity (Dicamba-diglycolamine salt) was applied to crops at a rate of 4 oz/ acre, alfalfa was controlled at 32%, 90%, and 85% with no-tillage, plow, and chisel plow, respectively. When applied at a rate of 8 oz/ acre, effectiveness ranges from 37% (no-tillage), 91% (plow), and 89% (chisel plow).	Both tilled and nontilled fields tested	Can be applied in the fall or spring prior to corn, but should be applied to alfalfa that is actively growing with at least 10 inches of spring growth or 5 inches of post-harvest regrowth. Dicamba should not be used prior to planting soybean or other susceptible crops. It can severely stunt bromegrass. Trees, legumes, and broadleaved plants are sensitive to drift and soil residues.	25%	1, 2, 3
Dicamba and diflufenzopyr	When Distinct (dicamba and diflufenzopyr) was applied to alfalfa at a rate of 4 oz/ acre, 25% of alfalfa was controlled under no-tillage conditions; 88% under plow; and 82% under the chisel plow. When 8 oz/ acre was applied, 34% control was achieved under no-tillage; 90% under plow; and 87% under the chisel plow.	Both tilled and nontilled	Acceptable control of alfalfa can better be reached in a competitive cropping system involving small grains.	75%	3

Table J-10. Effectiveness of and Restrictions for Herbicides Used for Alfalfa Control

Herbicide	Effect/Efficiency/ Resprouting Level	Tillage	Crop Restrictions	Effect as Volunteer Alfalfa Control (after 2,4-D stand take-out)	Source
Glufosinate	In tilled land after 36 days, glufosinate took out 98% of Roundup Ready® alfalfa. In nontilled land, after 36 days, it controlled 35% control alfalfa.	Both tilled and nontilled	Canola, corn, and soybean best tolerate glufosinate.	95%	1, 4
Primsulfuron -methyl			Primsulfuron-methyl recropping restrictions: corn: 0.5 months; sorghum: 8 months; wheat: 3 months; oats: 8 months; rye: 3 months; alfalfa: 8 months; clover: 18 months; soybeans: 8 months. If a field was previously treated with primsulfuron-methyl, sorghum is not a recrop option.	95%	5
Picloram	After Tordon (Picloram) application to Roundup Ready® alfalfa at a rate of 8 oz/ acre, 98% of alfalfa was controlled under no-tillage, 100% under plow, and 100% under the chisel plow.	Both tilled and nontilled	Should be applied when the plant is at least 12 inches tall and actively growing. If applied from late June until mid August, there is better residual control the following growing season than either spring or fall treatments. The plants should be mowed in early to mid summer to promote active regrowth prior to a fall treatment. Can be used in pastures, rangeland, and noncropland only. Fields previously treated with Tordon 202C Liquid Herbicide can be seeded to rapeseed, (including canola) mustard, flax, wheat, oats, barley or can be summer fallowed. These crops are tolerant to residues of picloram remaining in the soil. Sunflower, soybean, dry edible bean, and potato are especially susceptible to Tordon		1, 3, 6, 7
Acetochlor			Corn herbicide recropping restrictions: corn: the next year; sorghum: the next year; wheat: 4 months; oats: 2nd year; rye: 2nd year; alfalfa: 2nd year; clover: 2nd year: soybeans: next year. Rotational options: four months for wheat and to next spring (nine months) for soybean, oats, barley, rye, dry beans, sugar beets and potatoes		5

1-Rogan and Fitzpatrick 2004
2-SDSU, 2010
3-Miller et al. 2006
4-http://www.bayercropscienceus.com/products_and_seeds/herbicides/liberty.html
5-University of Illinois, 2010
6-Dow AgroSciences, 2007
7-Zollinger 2008

Table J-11. Benefits and Consequences of Various Tillage Systems

Tillage Types	Defined	Use	Benefits	Consequences
Conventional Till	Full width tillage which disturbs all of the soil surface and is performed prior to and/or during planting. Leaves **less than 15 percent residue cover** after planting, or less than 500 pounds per acre of small grain residue equivalent throughout the critical wind erosion period. It typically involves plowing or intensive tillage. Weed control is accomplished with herbicides and/or row cultivation.	Weed control, field preparation	Highly effective weed control, stand removal, loosens compacted soil	Causes soil erosion, reduces soil quality and productivity by destroying soil structure, reduces organic matter content and harms beneficial invertebrates such as earthworms, fouls aquatic systems, runoff water contributes to flooding, destroys wildlife food sources, reduces surface crop residues that serve as wildlife cover.
Reduced Till	Full-width tillage involving one or more tillage trips which disturbs all of the soil surface and is performed prior to and/or during planting. Leaves **15 to 30 percent residue cover** after planting or 500 to 1,000 pounds per acre of small grain residue equivalent throughout the critical wind erosion period. Weed control is accomplished with crop protection products and/or row cultivation.			
Conservation Till	Any tillage and planting system that leaves **more than 30 percent residue cover** on the soil surface, after planting, to reduce soil erosion by water. Where soil erosion by wind is the primary concern, any system that maintains at least 1,000 pounds per acre of flat, small grain residue equivalent on the surface throughout the critical wind erosion period. No-till, ridge-till, and mulch-till are types of conservation tillage.	Weed control, field preparation	Reduces soil erosion, consumption of fuel to operate equipment, labor cost/hours, improves moisture content in soil, results in healthier, more nutrient-enriched soil, more earthworms and beneficial soil microbes, the return of beneficial insects, birds and other wildlife in and around fields, lessens sediment and chemical runoff entering streams, reduces potential for flooding, decreases amount of dust and smoke to pollute the air,	Dependence on herbicides, weed spectrum shifts to perennial weeds, increases herbicide resistant weeds, increases herbicide use, increases danger of crop injury due to reduced tolerance to herbicides or presence of herbicides in the soil affecting crop rotations, inconsistent yields based on climate or soils, complex nutrient management due to higher residue levels and reduced options with regard to method and timing of nutrient applications, nutrient stratification, need to supplement nitrogen in soil for some crops, , high residue cover prevents soil
Mulch Till	Full-width tillage involving one or more tillage trips which disturbs all of the soil surface and is done prior to and/or during planting. Tillage tools such as chisels, field cultivators, disks, sweeps, and blades are used. Weed control is accomplished with herbicides and/or mechanical cultivation.			
Ridge Till	Tillage on ridges with sweeps, disk openers, coulters or row cleaners along with nutrient injection. Residue is left on the surface between the ridges. Weed control is accomplished with herbicides and/or mechanical cultivation. Ridges are rebuilt during cultivation.			

Table J-11. Benefits and Consequences of Various Tillage Systems

Tillage Types	Defined	Use	Benefits	Consequences
No Till	The soil is left undisturbed from harvest to planting except for planting and nutrient injection. Planting or drilling is accomplished in a narrow seedbed or slots created by coulters, row cleaners, disk openers, in-row chisels or rotary tillers. Weed control is accomplished primarily by herbicides. Cultivation can be used for emergency weed control. Other common terms used to describe no-till include direct seeding, slot planting, zero-till, row-till, and slot-till.		lessens carbon dioxide released into the atmosphere.	from warming quickly, so plants emerge and grow slowly

Sources: Fawcett and Towery, 2002; Conservation for Agriculture's Future; Wiebe and Gollehon, 2006; Johnson, 2005

2.5 Herbicide Use in GT Alfalfa Farming

2.5.1 Establishing and Maintaining Stands

Glyphosate can be used for both hay and seed fields at stand establishment, in order to prepare the field for planting. The effectiveness of this first application depends on the weed species present, their germination period, and how long until the alfalfa grows big enough to compete with weeds on its own. If the application was effective, successive treatments would not be needed, but if the first application was not effective, it is possible that multiple glyphosate treatments would be needed (Canevari et al., 2007). In the technical report *Potential Impacts on Wildlife, Amphibians, Plants, And Ecosystems From Increased Glyphosate And Other Chemical Use* (appendix N), the maximum use rate accepted for quantitative risk assessment was 1.99 lb a.e./acre for a single use, with minimum reapplication after 7 days and not to exceed 7.98 lb a.e./acre in a year. Monsanto recommends a maximum of 1.5 lb a.e./acre for a single application, with a seasonal maximum of 4.5 lb a.e./acre and a combined total of all pre-emergence and post-emergence applications of glyphosate per year of 6 lbs a.e./acre (Rogan and Fitzpatrick, 2004). Table J-12 presents rates of glyphosate use on GT alfalfa based on different tillage practices (Rogan and Fitzpatrick, 2004).

Table J-12. Typical Agronomic Practice for Glyphosate Applications to GT Alfalfa – Stand Establishment Year (Rogan and Fitzpatrick, 2004)

Type of Application	Application Rate[1]	Purpose
No-Till Farming		
Pre-plant, at planting or pre-emergence	Up to 1.5	No-till. Weed control prior to alfalfa emergence.
Post-emergence: emergence to 4-trifoliate stage	0.75	Weed control and removal of non-Roundup Ready® alfalfa seedlings (null application)[2]
Post-emergence: 5-trifoliate to 5 days prior to first cut	0.75	2nd weed control application for heavy infestations
Combined total of all applications per year	*3.00*	
Conventional Tillage		
Post-emergence: emergence to 4-trifoliate stage	0.75	Weed control and removal of non-Roundup Ready® alfalfa seedlings (null application)[2]
Post-emergence: 5-trifoliate to 5 days prior to first cut	0.75	Weed control (annual and perennial)
Combined total of all applications per year	*1.50*	

[1] pound per acre glyphosate acid equivalents
[2] Due to the biology and breeding constraints of alfalfa, up to 10 percent of the seedlings might not contain the Roundup Ready® gene. See appendix of Rogan and Fitzpatrick 2004

There are specific herbicide mixtures recommended by the Roundup® label (http://www.monsanto.com/monsanto/ag_products/pdf/labels_msds/roundup_orig_max_label.pdf) to control various weeds of alfalfa. These weeds are either naturally resistant to glyphosate or have

recently evolved resistant biotypes. For more discussion of glyphosate-resistant weeds refer to the Technical report *Effects of Glyphosate-Tolerant Weeds in Agricultural Systems* (appendix G). Weeds for which mixtures are recommended include:

- Common ragweed
- Common waterhemp
- Giant ragweed
- Horseweed (Marestail)
- Italian ryegrass
- Johnsongrass
- Palmer Amaranth
- Rigid ryegrass
- Junglerice
- Burning nettle
- Cheeseweed
- Common lambsquarters
- Field bindweed
- Filaree
- Large crabgrass
- Morning glory
- Purslane
- Velvet leaf

2.5.2 Stand Removal and Volunteer Control

Glyphosate can be used to kill old stands of conventional alfalfa for crop rotations however, GT alfalfa has to be removed through other mechanisms. Thus, alternative herbicide use or mechanical removal could be necessary for stand removal if low-level presence (0.5-1.0 percent) of GT alfalfa occurs in conventional alfalfa farming. Additionally, management of GT alfalfa volunteers in fields where farmers employ no-till seeding of other GT crops, such as corn, would require alternative herbicides or mechanical methods for complete removal. Application of an herbicide (e.g., 2,4-D, dicamba (Banvel®), and clopyralid (Stinger®)) and tillage is effective. In no-till systems 2,4-D and dicamba can be applied together. Dicamba, however, cannot be used before planting soybean (Dillehay and Curran, 2006).

Renz (2007) reported that dicamba and 2,4-D (WeedMaster®) applied at 2 pt/acre achieved zero resprouting of alfalfa in the spring following herbicide application. Lower concentrations of WeedMaster resulted in 0.3 to 2.5 percent resprouting. The other herbicides applications (dicamba or 2,4-D only) resulted in 0.5 to 26.5 percent resprouting. In another study, picloram and 2,4-D was more effective than dicamba and 2,4-D (Miller et al., 2006). Combined with plowing, clopyralid, clopyralid plus 2,4-D, dicamba plus 2,4-D, picloram, and picloram plus 2,4-D all controlled alfalfa 100 percent. Plowing alone provided 75 percent control of alfalfa (Miller et al., 2006).

Multiple other combinations of herbicides and tillage can be used for stand removal. See tables J-10 and 11 for a more detailed description of these possible treatments, their effects, and

possible restrictions. Figure J-7 presents Monsanto's Technical User Guide stand takeout guidance.

STAND TAKEOUT AND VOLUNTEER MANAGEMENT

Crop rotations can be divided into two main groups, alfalfa rotated to: 1) grass crops (e.g. corn and cereal crops); and 2) broadleaf crops. More herbicide alternatives exist for management of volunteer alfalfa in grass crops. The recommended steps for controlling volunteer Roundup Ready Alfalfa are:

Diligent Stand Takeout

Use appropriate commercially available herbicide treatments alone for reduced tillage systems or in combination with tillage to terminate the Roundup Ready Alfalfa stand. Refer to your regional technical bulletin for specific stand takeout recommendations. NOTE: Roundup agricultural herbicides are **not** effective for terminating Roundup Ready Alfalfa stands.

Start Clean

If necessary, utilize tillage and/or additional herbicide application(s) after stand takeout, and before planting of the subsequent rotational crop to manage any newly emerged or surviving alfalfa.

Plan for Success

Rotate to crops with known and available mechanical or herbicidal methods for managing volunteer alfalfa, keeping in mind that Roundup agricultural herbicides will not terminate Roundup Ready Alfalfa stands.

- Rotations to certain broadleaf crops are not advisable if the grower is not willing to implement recommended stand termination practices.
- In the event that no known mechanical or herbicidal methods are available to manage volunteer alfalfa in the desired rotational crop, it is suggested that a crop with established volunteer alfalfa management practices be introduced into the rotation.

Timely Execution

Implement in-crop mechanical or herbicide treatments for managing alfalfa volunteers in a timely manner; that is, before the volunteers become too large to control or begin to compete with the rotational crop.

Figure J-7: Monsanto technology user guide for stand removal (Monsanto, 2008)

For stand takeout procedures, Monsanto, using information from the Crop Data Management System's (CDMS) Ag Product Label Service database, recommends 2,4-D, clopyralid (Stinger®), dicamba - dimethylamin salt (Banvel®), dicamba – diglycolamine salt (Clarity®), diflufenzopyr + dichloro-o-anisic acid (Distinct®), glufosinate (Liberty®), glyphosate (Roundup®), and primsulfuron-methyl (Beacon®) for control of alfalfa. Independent research has demonstrated that dicamba, 2,4-D, tank mixtures of dicamba and 2,4-D, and clopyralid were often more effective than glyphosate for terminating alfalfa stands (Rogan and Fitzpatrick, 2004).

In order to control volunteer alfalfa, growers currently use a combination of tillage and herbicide treatments, both prior to planting and again after crop emergence. 2,4-D, dicamba - dimethylamin salt (Banvel), dicamba - diglycolamine salt (Clarity), clopyralid (Stinger), rimsulfuron (Matrix®), primisulfuron-methyl (Beacon) and diflufenzopyr + dichloro-o-anisic acid (Distinct) are registered for in-crop use to remove volunteer alfalfa in 35 crops. They are also labeled for control of feral alfalfa in 15 noncrop settings, such as roadsides, fencerows, and ditch banks and in 22 forestry, turf or municipal settings, such as Douglas fir (*Pseudotsuga* spp.), turfgrass, or golf courses (Rogan and Fitzpatrick, 2004).

Acetochlor, acetochlor and atrazine, acetochlor, atrazine and dicamba, atrazine and dicamba, and clopyralid and flumetsulamcan herbicides and mixes can control volunteer GT alfalfa in corn (Rogan and Fitzpatrick, 2004). Clopyralid is effective at controlling volunteer alfalfa in broccoli (Tickes, 2002). Clopyralid or 2,4-D provide control of volunteer alfalfa in 33 different crops. Exceptions include potatoes and popcorn (Rogan and Fitzpatrick, 2004).

Feral alfalfa (alfalfa not in fields) is discussed in more depth in the technical report *Effects of Glyphosate-Tolerant Weeds in Nonagricultural Ecosystems* (appendix H).

Adoption of GT alfalfa decreases the number of herbicides used to control weeds in alfalfa because glyphosate is the preferred herbicide for GT alfalfa. Adoption of GT alfalfa could increase use of some herbicides used for stand removal. For stand removal adoption of GT alfalfa could result in a shift from glyphosate to other herbicides. Herbicide use to control weeds occurs mainly in the first year during stand establishment and as needed during subsequent years of stand life. Herbicide use for stand removal occurs once during stand life-cycle, which is 3-8 years. Herbicide shifts due to stand removal would be smaller in magnitude than herbicide shifts due to weeds control.

2.6 Herbicide Use in Organic Alfalfa Farming

In organic systems, where use of synthetic herbicides is limited, the area to be seeded with alfalfa is tilled and allowed to sit for seven to ten days. Two or more discing passes might be necessary if weed germination is observed. The field should also be treated with nutrients, such as compost and boron, and left for a week to check for further weed germination. Planting can occur once weed growth potential is minimized (Guerena and Sullivan, 2003). Manure fertilizer should be composted to kill weed seeds (Canevari et al., 2007).

The USDA NOP standards list the following approved inputs to control weeds (http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5068682&acct=nopgeninfo):

a) As herbicides, weed barriers, as applicable.
   i) Herbicides, soap-based—for use in farmstead maintenance (roadways, ditches, right of ways, building perimeters) and ornamental crops.
   ii) Mulches.
      (1) Newspaper or other recycled paper, without glossy or colored inks.
      (2) Plastic mulch and covers (petroleum-based other than polyvinyl chloride (PVC)).

In 1994 organic farmers used several weed control practices that are presented in figure J-8.

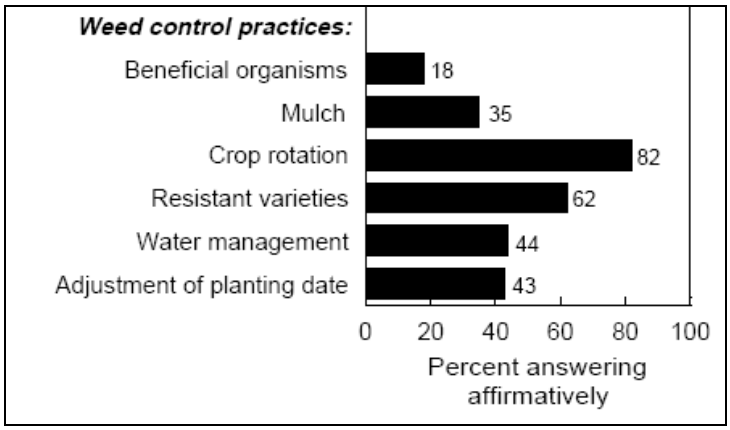

Figure J-8: Weed control practices used by organic farmers to produce vegetables, 1994 (Padgitt et al., 2000)

2.7 Herbicide Use Under Deregulation

In order to determine the potential impact of GT alfalfa production on herbicide use as accurately as possible, Animal and Plant Health Inspection Service (APHIS) conducted an herbicide use analysis under the conditions of the deregulation alternative only, The rate of adoption in Isolation/Geographic Restriction Alternative is expected to fall in the range of the scenerios described. The No Action Alternative would be similar to the baseline year given the other assumptions in the analysis as described below (e.g., no changes in weed pressures).

2.7.1 Baseline data

To evaluate the potential impact of the adoption of GT alfalfa on herbicide use given the adoption rates projected by Forage Genetics, Inc. (FGI), APHIS first determined a baseline level of herbicide usage. Herbicide usage data for alfalfa were available from Hower et al. (1999), based on surveys covering the 5-year period from 1988 to 1992. The number of acres of alfalfa planted for both hay and seed, on average per year from 1988 to 1992, are presented below (table J-13).

Table J-13: Yearly Average Alfalfa Acreage, 1988 to 1992

	Total Acreage*	Acres Treated With Herbicides*	% of AcreageTreated
Alfalfa for Hay	23,024,800	3,833,500	16.7%
Alfalfa for Seed	179,100	140,200	78.3%

*from Hower (1999), table 33

Hower et al. (1999) reports acreage grown for hay and seed that have been treated with various herbicides (tables 36 and 40, respectively). Total quantities of herbicide used are reported for hay and seed, respectively (table J-14). Additionally, Hower et al. (1999) provides data on average application rates per acre for both hay and seed. Average application rates were broken out according to use type by Hower et al. (1999): spring seeding, fall seeding, and established

stands. An overall average of the rate (in lbs. active ingredient per acre) for these three use types was used for this analysis and can be seen in table J-15 below.

As discussed in section 4.1, Hower et al. (1999) showed that about 2 percent of acres used stand removal herbicides annually (including glyphosate). Thus, it is assumed in this analysis, based on the available data, this use was indeed for stand removal and that the remaining 98 percent of the acreage either was conducting stand removal with tillage alone or was simply maintaining or establishing a stand.

Table J-14: Total Herbicide Usage for Seed and Hay from Hower et al. (1999), Tables 41 and 37

Herbicide	Use	Total Herbicides used in alfalfa grown for seed in the U.S., Yearly Average, 1988-92 (lbs. a.i.)	Total Herbicides used in alfalfa grown for hay in the U.S., Yearly Average, 1988-92 (lbs. a.i.)
2,4-DB	M	16,500	398,700
Benefin	E	17,000	127,600
Bentazon	M	300	ND
Bromoxynil	M, E	3,300	18,200
DCPA	E	1,500	ND
Diclobenil	M	200	ND
Diuron	M	93,400	285,800
EPTC	M, E	186,000	492,500
Ethalfluralin	E	22,900	ND
Fluazifop	M	1,400	ND
Hexazinone	M	40,700	670,800
Imazethapyr	M, E	100	31,500
MCPA	M	0	15,100
Metribuzin	M	9,000	593,000
Paraquat	M	3,500	446,100
Pendimethalin	M, E	18,800	3,970
Pronamide	M, E	3,700	129,000
Sethoxydim	M	4,100	178,900
Simazine	M	4,100	ND
Terbacil	M	7,100	194,600
Trifluralin	M	43,700	407,300
Total M&E Herbicides		477,300	3,993,070
2,4-D	R	-	3,200
Glyphosate	R	3,500	446,500
Total R Herbicides		3,500	449,700
Total Herbicide Usage		480,800	4,442,770

E=Stand Establishment, M=Stand Maintenance, R=Stand Removal, ND=No Data, ai=active ingredient. Usage data from Hower et al. (1999).

Table J-15: Herbicide Type and Usage Characteristics – Baseline Data

Active Ingredient	Herbicide Usage Pattern	Average Application Rate for Hay (lbs. a.i.per acre)	Total Acres Alfalfa Grown for Hay (Yearly Average 1988-1992) Treated With Herbicide	Average Application Rate for Seed (lbs. per acre)	Total Acres Alfalfa Grown for Seed (Yearly Average 1988-1992) Treated with Herbicide
Maintenance and Establishment Herbicides					
2,4-DB	M	0.97	404,200	1.15	13,700
Benefin	E	1.25	104,800	1.42	12,100
Bentazon	M	ND	ND	1.00	400
Bromoxynil	M, E	0.26	70,200	0.33	10,100
DCPA	E	ND	ND	2.75	500
Diclobenil	M	ND	ND	1.90	100
Diuron	M	1.59	180,300	1.70	93,400
EPTC	M, E	2.99	163,400	3.08	55,000
Ethalfluralin	E	ND	ND	0.65	35,200
Fluazifop	M	ND	ND	0.14	10,000
Hexazinone	M	0.67	1,000,900	0.73	55,900
Imazethapyr	M, E	0.06	510,300	0.06	2,000
MCPA	M	0.25	61,900	ND	ND
Metribuzin	M	0.56	1,063,500	0.59	15,300
Paraquat	M	0.48	958,600	0.50	7,200
Pendimethalin	M, E	1.09	3,700	1.25	15,000
Pronamide	M, E	1.14	114,200	1.46	2,600
Sethoxydim	M	0.23	764,500	0.27	15,200
Simazine	M	ND	ND	0.80	5,100
Terbacil	M	0.61	318,300	0.54	13,000
Trifluralin	M	0.68	436,000	0.79	46,800
Stand Removal Herbicides*					
2,4-D	R	0.43	7,400	ND	ND
Dicamba*	R	0.14	14,285	ND	ND
Glyphosate	R	1.21	446,000	0.89	4,900

E=Stand Establishment, M=Stand Maintenance, R=Stand Removal, ND=No Data, ai=active ingredient, ae=acid equivalent. Usage data from Hower (1999).
*Other stand removal herbicides mentioned in the DEIS (clopyralid and picloram) are not included here because they were not evaluated by Hower, with the exception of Dicamba. Data were available for dicamba usage from 1998 NASS data.

Data gaps and other limitations of the baseline data include:

- Hower et al. (1999) did not report data on dicamba usage, so the NASS data for 1998 was used for that herbicide. Hower et al. (1999) collected data on herbicides used in hay and seed production over 5 years (1988-1992) and averaged the usage data for yearly amounts. These data were obtained from surveys of farmers and are presented in a variety of ways, including use patterns and regional applications. Information on number of acres treated as well as total pounds per acre were presented. The NASS data were available for one year only (1998), and were reported for use on alfalfa hay only. The data do not include information on number of acres treated, but do provide total amounts and average application rates. NASS data are limited to 17 herbicides; whereas, the data from Hower et al. (1999) includes information on 23 herbicides.

- Hower et al. (1999) does not clearly break out stand removal in his presentation of usage statistics. For this analysis, we assume that stand removal herbicides (2,4-D, glyphosate, and dicamba) were used as such and compare those acres to the acres treated. The survey was over a 5 year period, so presumably stand removal is included, but the reported acreage and uses are not explicit regarding this.

- Hower et al. (1999) does not specify whether glyphosate and 2,4-D data are in lbs. ai or ae. For the projections, we use lbs. a.e. because that is the conventional units for glyphosate, 2,4-D and Dicamba. Most likely, Hower et al. (1999) did not go into that level of detail given the scope of his estimates.

2.7.2 Herbicide use Assumptions for Alfalfa Hay

A thorough analysis of herbicide options available to alfalfa growers, and the characteristics and limitations of those herbicides were reviewed in the Petition (section VII, subsection D). Based on the adoption of other GT crops, it is expected that GT alfalfa will displace a significant portion of other alfalfa varieties, especially where alfalfa is highly managed (e.g., Western and Southwestern States). As GT alfalfa is adopted, it is expected that glyphosate will replace other forms of weed control currently used in alfalfa.

Hower et al. (1999) reported spot usage of glyphosate from 1988 to 1992. This is likely because mature conventional alfalfa is not very susceptible to glyphosate for most of the growing season, as glyphosate merely injures it (which explains its use during seedling or maintenance only) (Endres, 1999; Mayerle, 2002; Manitoba Agriculture and Food, 2002). Glyphosate is about 80 percent effective in stand removal and killing conventional alfalfa, when it is sprayed in the fall. During the fall, alfalfa is directing the majority of the sugars to the roots for storage over the winter, and thus will take in more glyphosate deeper into the plant, making glyphosate more effective. While glyphosate is more effective during the fall than other times, because it is not fully effective during stand removal as other herbicides and/or tillage methods, these alternate methods are preferentially used even in conventional alfalfa (Rogan and Fitzpatrick, 2004).

J101 and J163 are highly tolerant to glyphosate and show no yield loss or loss in forage quality when treated over multiple seasons over and above maximum glyphosate application rates (Pierson and Reyes, 2006). Recommended use rates are provided by Monsanto to growers in Regional Technical Bulletins (See appendix I of Document Number 04-AL-116U-1). In-season maximum application of glyphosate is up to 1.5 lbs a.e. per acre at a single application, and total per-year applications is 4.5 lbs a.e./acre. These application rates were used by Monsanto when conducting residue studies and for event selection purposes. In practice, these maximum rates will rarely be used since the vast majority of weeds are controlled using recommended rates and it would be uneconomical for growers to apply excess herbicide. See appendix J-1, table J-1A for information on herbicide use patterns and application rates in GT alfalfa. These values form part of the baseline assumptions used in the herbicide usage analysis.

The acreage of hay that may be converted to GT alfalfa hay is based on market adoption predictions provided by FGI (FGI 2010). The FGI estimates include their expectations for regional differences in initial adoption rate, incremental increase in adoption rate, and stand life expectations. FGI estimates that 51percent of hay acres could be GT alfalfa 10 years after

deregulation (table J-16). The FGI estimates start with the hay acre count from the 2007 USDA census.

Table J-16: Projected Market Adoption Rates by Region, Glyphosate-Tolerant Alfalfa (FGI, 2010)

		Year 3		Year 5		Year 10	
Group*	**Existing Hay Acres**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
Alaska	0	-	0%	-	0%	-	0%
E. Central	3,481,278	313,315	9%	696,256	20%	1,148,822	33%
Hawaii	89	-	0%	-	0%	-	0%
Intermountain	4,188,766	733034	18%	1,396,255	33%	2,303,821	55%
N. Central	6,746,940	1012041	15%	2,024,082	30%	3,103,592	46%
Plains	2,367,814	532758	23%	986,589	42%	1,479,884	63%
Pacific Northwest	2,188,924	591009	27%	1,094,462	50%	1,379,022	63%
Southeast	26,297	2367	9%	5,259	20%	8,678	33%
Southwest	1,244,389	513310	41%	777,743	63%	914,626	74%
Grand Total	20,244,497	3,697,835	18%	6,980,647	34%	10,338,445	51%

*States included in each group are as follows: Alaska: Alaska; E. Central: Arkansas, Connecticut, Delaware, Illinois, Indiana, Maine, Maryland, Massachusetts, Michigan, Missouri, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont; Hawaii: Hawaii; Intermountain: Colorado, Montana, Utah, Wyoming; N. Central: Iowa, Minnesota, North Dakota, South Dakota, Wisconsin; Plains: Kansas, Nebraska, Oklahoma, Texas; Pacific Northwest: Idaho, Nevada, Oregon, Washington; Southeast: Alabama, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, West Virginia; Southwest: Arizona, California, New Mexico.

To allow for a scenario with less market penetration, an estimated market adoption rate of 16.7 percent was also considered. This lower rate of adoption is based on an assumption that only acreage that historically used herbicides would be converted to GT alfalfa. Hower et al., (1999) indicates that 16.7 percent of hay acres (yearly average for 1988 to 1992) were treated with maintenance herbicides (stand removal herbicides not included). This 16.7percent of acreage is considered “under weed pressure” for this analysis.

APHIS assumed that all acreage grown for hay and treated with herbicides, as reported in the baseline calculations, will make the transition to GT alfalfa. For estimating projected herbicide use on GT alfalfa at year 10, two maintenance schedules patterned after Orloff et al. (2009) are used. These schedules are based on a 4.25-year stand renewal rate (4 full years plus the initial fall season for stand establishment). Data from Forage Genetics, Inc. obtained for this analysis show a weighted average renewal rate of 5.26 years, or 19 percent renewal on a yearly basis. For the purposes of this analysis, APHIS extended Orloff’s recommended treatment schedules one year by repeating the year 3 recommendations, to give a total regimen of 5.25 years (table J-17).

Though the maintenance recommendations of Orloff et al. (2009) are specifically tailored to GT Alfalfa, APHIS does not assume that all acres which are planted with GT alfalfa will use every

application of herbicide in the maintenance regimen proposed by Orloff and colleagues. Instead, APHIS assumed that three different maintenance schedules will be used in varying proportions for the acreage planted with GT alfalfa. Schedules 1 and 2 are laid out in appendix J-1, table J-2A and J-3A, and Schedule 0 is laid out in appendix J-1, table J-4A. The assumption for conventional alfalfa scenarios is that no herbicide is used for stand establishment and maintenance. In all schedules, APHIS assumed that stand removal herbicides are used for 2 percent of the acres planted, which is consistent with the proportion of acres treated with stand removal herbicides from the baseline analysis. APHIS assumed that the 16.7 percent of acres under weed pressure (Hower et al., 1999) are all converted to GT alfalfa. These acres will need the most aggressive herbicide regime (i.e., Orloff Schedule 1 or 2) and the remaining GT alfalfa acres will only need one glyphosate application per year (i.e., Schedule 0). As a bounding estimate APHIS also assumed that all GT alfalfa acres would use Orloff Schedule 1 or 2 (table J-17).

Table J-17: GT Alfalfa Maintenance Strategies (from Orloff et al. 2009)

Year	Season	Schedule 1	Schedule 2
Seedling	**Fall**	Glyphosate	Glyphosate
1	**Winter (late)**	Glyphosate	Glyphosate
	Spring		
	Summer		
	Fall		
2	**Winter (late)**	Glyphosate	Soil Residual Herbicide or tank mix of soil residual herbicide with glyphosate*
	Spring		
	Summer	Glyphosate	
	Fall		
3	**Winter (late)**	Glyphosate	Soil Residual Herbicide or tank mix of soil residual herbicide with glyphosate*
	Spring	Glyphosate	
	Summer	Glyphosate	
	Fall		
4	**Winter (late)**	Glyphosate	Soil Residual Herbicide or tank mix of soil residual herbicide with glyphosate*
	Spring	Glyphosate	
	Summer	Glyphosate	
	Fall		
5	**Winter (late)**	Glyphosate	Glyphosate
	Spring	Glyphosate	
	Summer	Glyphosate	Glyphosate
	Fall removal**	Tillage and/or 2,4-D + Dicamba	Tillage and/or 2,4-D + Dicamba
	Total # of Glyphosate Applications	13	7

*Soil residual herbicides recommended include: hexazinone, diuron or metribuzin. An application of a dinitroaniline herbicide (pendimethalin or trifluralin) is also recommended. This analysis assumes that one of each of the soil residual herbicides and one of each of the dinitroaniline herbicides was chosen at each application, and all were chosen in equal amounts by group.

** Assume 2 percent of acres per year use herbicide and tillage and 98 percent of acres maintain a stand or use tillage alone, based on baseline herbicide use data.

For Schedule 0, AHPIS assumed a single application of glyphosate at establishment to kill nulls and any weed seedlings, as well as a single application of glyphosate in the spring of each year of the stand life to kill emerging weeds. This may even be an overestimate, in that some acreage may only need to be treated with glyphosate once during its lifetime (DEIS page J-28, citing Canevari et al., 2007).

For Schedules 1 and 2, APHIS also assumed that a representative number of acres planted with GT alfalfa for hay will require the full treatment schedule laid out by Orloff and colleagues (table J-17). APHIS assumed that the same proportion of acres where herbicides are applied in conventional alfalfa, namely 16.7 percent of the acres based on the data from Hower et al. (1999), will be treated with either Schedule 1 or Schedule 2 for the 51 percent adoption scenarios. Thus, this analysis will consider 2 different scenarios: one scenario will consider a combination of Schedule 1 and Schedule 0, while the other scenario will consider a combination of Schedule 2 and Schedule 0. The two scenarios are summarized below in table J-18. These scenarios will be considered for the projected 51 percent adoption at year 10. The latter scenarios (3, 4, and 5) assume that only the proportion of acres which are currently managed with herbicides (16.7 percent) will make the transition to GT alfalfa, and that the remaining acres will not be treated with herbicides. These scenarios also are summared in table J-18.

Table J-18. Assumed Herbicide Use Scenarios Under Deregulation*

	Scenario 1: 51% Adoption			
	Schedule 0	**Schedule 1**	**Conventional**	**Total**
Acres	6,967,736	3,370,709	9,906,052	20,244,497
% of Total	34.42%	16.7%	48.93%	100%
	Scenario 2: 51% Adoption			
	Schedule 0	**Schedule 2**	**Conventional**	**Total**
Acres	6,967,736	3,370,709	9,906,052	20,244,497
% of Total	34.42%	16.7%	48.93%	100%
	Scenario 3: 16.7% Adoption			
	Schedule 0		**Conventional**	**Total**
Acres	3,370,709		16,873,788	20,244,497
% of Total	16.7%		83.3%	100%
	Scenario 4: 16.7% Adoption			
	Schedule 1		**Conventional**	**Total**
Acres	3,370,709		16,873,788	20,244,497
% of Total	16.7%		83.3%	100%
	Scenario 5: 16.7% Adoption			
	Schedule 2		**Conventional**	**Total**
Acres	3,370,709		16,873,788	20,244,497
% of Total	16.7%		83.3%	100%

*Summary of schedule descriptions:
Schedule 0 = single application of glyphosate at establishment and in the spring of each year, with minimal use of other herbicides. See table J-4A.
Schedule 1 = similar to Schedule 0, but more frequent use of glyphosate. See table J-17.
Schedule 2 = similar to Schedule 0, but more frequent use of other herbicides. See table J-17.

Both conventional and GT alfalfa are assumed to have a stand life based on the assumptions about stand life used by FGI in generation of the market adoption prediction (FGI, 2010). Using a weighted average based on regional differences the national average stand life is 5.25 years.

Data gaps and other limitations of the hay assumptions include:

- Quantitative data on stand removal practices was not found. As discussed in section 2.4.1 of appendix J, stand removal practices vary from herbicide mixes, herbicide mixes plus tillage, to tillage only.

- The assumption that the percentage of acres under weed pressure is the same between the baseline year and year 10 probably does not reflect possible changes in weed pressure. Weed pressure from glyphosate-resistant weeds has been increasing and will likely continue to increase, but the rate of future increases is not clear and will depend on farmer weed-management practices that cannot be predicted.

- Only a few of the possible herbicides that could be used in tank mixtures were considered. Factors such as ease of use, price, farmer safety perceptions, rotation plans, and personal experience influence the choices farmers make.

- While the average stand life was calculated based on weighted regional differences, it is possible that stand life could extend up to 8 years or be as little as 2 years (Rogan and Fitzpatrick, 2004).

2.7.3 Projected Herbicide use in Alfalfa Hay

Based on the baseline data and assumptions described above, APHIS calculated the amount of herbicide projected to be used on alfalfa hay for the various scenarios. Summary results can be found below, and detailed results can be found in appendix J-1.

As shown in table J-19, compared to baseline, Scenario 1 shows a large increase in the use of glyphosate, with a substantial decrease in the use of other herbicides. The total amount of herbicides used is much higher than baseline, which can mainly be explained by the large increase in acres treated with at least one herbicide. Scenario 2 shows a large increase in the use of glyphosate, but overall a smaller increase than in Scenario 1. As would be expected, there is a larger percentage of the non-glyphosate herbicides in Scenario 2. However, the amount reflects a proportional decrease in non-glyphosate herbicides as compared to the baseline percentage.

Table J-19: Change in Herbicide Application Amounts and Rates Vs. Baseline for Schedule 1 and Schedule 2 Herbicide Usage in GT Alfalfa and Conventional Alfalfa for Hay at Year 10

Scenario 1 vs. Scenario 2 vs. Baseline from Hower for the 51% GT Alfalfa Adoption Projection	Scenario 1 Total	Change vs. Baseline, Scenario 1	Scenario 2 Total	Change vs. Baseline, Scenario 2	Baseline Herbicide Usage, Alfalfa Grown for Hay
Total Herbicide Usage (lbs. ai or ae)	24,666,783	20,224,013	27,558,432	23,115,662	4,442,770
Total Glyphosate used in hay prod. (lbs. ae)	24,474,421	24,027,921	18,703,011	18,256,511	446,500
% Glyphosate	99.22%	887.27%*	67.87%	575.29%*	10.05%
Total non-Glyphosate in hay prod. (lbs. ai or ae)	192,362	-3,803,908	8,855,422	4,859,152	3,996,270
% non-glyphosate	0.78%	-99.13%*	32.13%	-64.28%*	89.95%

*These percentages are proportional changes. That is, they represent the percent change in the proportion of overall herbicide use, which indicates how much the proportional use of an herbicide would change relative to the baseline, even though the acreage treated or absolute herbicide use could be much different between the projection and baseline.

Scenarios 3, 4, and 5 are summarized in table J-20, below. These estimates all show an expectedly lower total herbicide use than in Scenarios 1 and 2 due to the lower adoption rate, as well as a relative decrease in the proportion of non-glyphosate herbicides used. Scenarios 3 and 4 both predict a substantial decrease in the amount of non-glyphosate herbicides used, along with a large increase in the amount of glyphosate used.

Table J-20: Change in Herbicide Application Amounts and Rates vs. Baseline for Scenarios 3, 4, and 5 Herbicide Usage in GT Alfalfa and Conventional Alfalfa for Hay, Assuming 16.7% Adoption of GT Alfalfa

Scenario 3 vs. Scenario 4 vs. Scenario 5 vs. Baseline (Hower)	Scenario 3 Total	Change vs. Baseline, Scenario 3	Scenario 4 Total	Change vs. Baseline, Scenario 4	Scenario 5 Total	Change vs. Baseline, Scenario 5	Baseline Herbicide Usage, Alfalfa Grown for Hay
Total Herbicide Usage (lbs. ai or ae)	6,055,895	1,613,125	12,784,478	8,341,708	15,676,127	11,233,357	4,442,770
Total Glyphosate used in hay prod. (lbs. ae)	5,863,553	5,417,053	12,592,155	12,145,655	6,820,745	6,374,245	446,500
% Glyphosate	96.82%	863.42%*	98.50%	880.06%*	43.51%	332.94%*	10.05%
Total non-Glyphosate in hay prod. (lbs. ai or ae)	192,342	-3,803,928	192,323	-3,803,947	8,855,382	4,859,112	3,996,270
% non-glyphosate	3.18%	-96.47%*	1.50%	-98.33%*	56.49%	-37.20%*	89.95%

*These percentages are proportional changes. That is, they represent the percent change in the proportion of overall herbicide use, which indicates how much the proportional use of an herbicide would change relative to the baseline, even though the acreage treated or absolute herbicide use could be much different between the projection and baseline.

2.7.4 Herbicide usage assumptions for alfalfa seed

As can be seen in tables J-13, J-14, and J-15, for both hay and seed alfalfa crops Hower et al. (1999) reports acreage of alfalfa grown that have been treated with various herbicides, total quantities of herbicide used, and average application rates per acre. Table J-21 presents the relative percent of alfalfa seed acres treated with herbicide. APHIS used the seed data provided from Hower et al. (1999) for the baseline of the herbicide usage analysis in seed crops.

Table J-21: Relative Percentage of Acres Treated with Herbicides, Alfalfa Grown for Seed (data from Hower et al. 1999)

Active Ingredient	Herbicide Usage Pattern	Average Application Rate for Seed (lbs. per acre)	Relative % of Acres Treated
Maintenance and Establishment			
2,4-DB	M	1.15	3.31%
Benefin	E	1.42	2.93%
Bentazon	M	1	0.10%
Bromoxynil	M, E	0.33	2.44%
DCPA	E	2.75	0.12%
Diclobenil	M	1.9	0.02%
Diuron	M	1.7	22.59%
EPTC	M, E	3.08	13.30%
Ethalfluralin	E	0.65	8.51%
Fluazifop	M	0.14	2.42%
Hexazinone	M	0.73	13.52%
Imazethapyr	M, E	0.06	0.48%
MCPA	M	ND	ND
Metribuzin	M	0.59	3.70%
Paraquat	M	0.5	1.74%
Pendimethalin	M, E	1.25	3.63%
Pronamide	M, E	1.46	0.63%
Sethoxydim	M	0.27	3.68%
Simazine	M	0.8	1.23%
Terbacil	M	0.54	3.14%
Trifluralin	M	0.79	11.32%
Stand Removal			
2,4-D	R	ND	ND
Dicamba*	R	ND	ND
Glyphosate	R	0.89	1.19%

According to the data, 1.19 percent of seed acres are treated with stand removal herbicides (data only available on glyphosate for seed production), so this analysis assumes stand removal herbicides recommended by Orloff et al., (2009) will be used on 1.19 percent of GT alfalfa acres in addition to tillage. The remainder of acres will be managed with tillage only.

Market projections for the acreage of seed were not available from FGI, so APHIS calculated seed acreage at year 10 based on the predicted need for GT seed for hay. The acreage of seed from the USDA 2002 and 2007 survey and the yield in pounds of seed were used to calculate yield (table J-22). The U.S. consumption of seed in pounds was calculated from the FAS database which includes pounds exported and imported.[4] The exported pounds of seed was subtracted from the total U.S. pounds of seeds produced. The imported pounds of seed was added to that to arrive at the pounds of seed consumed domestically. Pounds of seed was translated to acreage using the 2007 yield data. This assumes that the yield for imported seed was the same as the U.S. yield. The acreage of seed fields that support U.S. domestic needs includes both U.S. seed acres as well as fields that produced imported seed, in table J-22 is refered to as "global seed acres." Table J-22 explains how acres of GT seed was calculated starting with global seed acres and subtracting non-hay usages. The percentage of seed that goes to each domestic use includes the assumptions that seed field stock seed is negligible and sprouts (human consumption) are negligible and will not be GT alfalfa. Haylage/greenchop percentage was calculated using USDA survey acreage data.

Table J-22. Alfalfa Seed Production Acreage Estimates

	2007	**2002**	**units**
Domestic seed production	62,115,239	58,020,460	Pounds
Exports	33,652,048	21,896,532	Pounds
Imports	34,427,767	149,28,732	Pounds
Domestic consumption	62,890,958	51,052,660	Pounds
U.S. Yield	511	525	Pounds/acre
Global seed acres that support U.S. seed needs	123,074	97,243	acres (globally)
Assume that acres hay harvest is directly proportional to acres of seed needed			
Assume equilibrium year to year. Even though seed harvested would in reality be used in subsequent years, we assume for simplicity that the system has reached equilibrium so Year 11 hay acres are same as Year 10, so seed grown in Year 10 is used in the calculation.			
Assume GT alfalfa will not be used for haylage/greenchop, so haylage/greenchop acres can be subtracted			
Percentage of haylage/greenchop acres to subtract	14.4	13.5	percent acres
Subtract the % that goes to haylage from the seed acres to convert to acres that support hay	105,351	84,115	acres*
Assume that all GT seed will be grown in United States			
Assume that all imported seed is non-GT			
Assume at Year 10, 51% of the hay acres are GT alfalfa			
Assume 51% of hay seed production acres provides for 51% of hay acres	53,729	42,899	acres**

Source: 2007 Census of Agriculture - http://www.agcensus.usda.gov/Publications/2007/Full_Report/usv1.pdf
*Acres (globally) of seed needed to support U.S. hay production
**Acres needed of GT seed to support 51% of hay acres being GT

[4] http://www.fas.usda.gov/gats/default.aspx

As described above GT alfalfa seed acreage for year 10 was based on an extrapolation from the hay acreage prediction provided by FGI. The same herbicide application schedules and scenarios adapted for use in the herbicide analysis for alfalfa hay crops described above (see section 2.7.3) are used during the alfalfa seed crop analysis.

Assumptions for the total amount of herbicide used on alfalfa for seed are as follows:

- The 51percent of acreage switching to GT alfalfa is solely from those acres that are currently treated with herbicides.
- The remaining acreage that is conventional alfalfa is treated the same way as it was before adoption (approx. 37 percent).
- The remaining acreage is not treated with any herbicides (approx. 22 percent).

2.7.5 Projected herbicide use in alfalfa seed

Based on the baseline data and assumptions described above, APHIS calculated the amount of herbicide projected to be used on alfalfa grown for seed for the various scenarios. Summary results can be found below in tables J-23 and J-24 for years 2007 and 2002, respectively, and detailed results can be found in appendix J-1.

Table J-23: Projected and Baseline Herbicide Use, Alfalfa Grown for Seed for Hay - Compared by Usage Scenario, 2007

	Seed for Hay Herbicide Usage, 2007 Data			
	Scenario 1	Scenario 2	Scenario 3	Baseline Data
Total lbs. AI	129,223.95	236,477.66	282,568.10	480,800
Total lbs. Glyphosate	94,797.53	202,051.23	110,055.13	3,500
Total lbs. non-Glyphosate	34,426.42	34,426.42	172,512.97	477,300

Seed for Hay Herbicide Usage, 2007 Data vs. Baseline.	Scenario 1 Total	Change vs. Baseline, Scenario 1	Scenario 2 Total	Change vs. Baseline, Scenario 2	Scenario 3 Total	Change vs. Baseline, Scenario 2	Baseline Herbicide Usage, Alfalfa Grown for Seed
Total Herbicide Usage (lbs. ai or ae)	129,223.95	-351,576.05	236,477.66	-244,322.34	282,568.10	-198,231.90	480,800.00
Total Glyphosate used in seed for hay prod. (lbs. ae)	94,797.53	91,297.53	202,051.23	198,551.23	110,055.13	106,555.13	3,500.00
% Glyphosate	73.36%	9977.44%*	85.44%	11637.29%*	38.95%	5250.37%*	0.73%
Total non-Glyphosate in seed for hay prod. (lbs. ai or ae)	34,426.42	-442,873.58	34,426.42	-442,873.58	172,512.97	-304,787.03	477,300.00
% non-glyphosate	26.64%	-73.16%*	14.56%	-85.34%*	61.05%	-38.50%*	99.27%

Table J-24: Projected and Baseline Herbicide Use, Alfalfa Grown for Seed for Hay - Compared by usage Scenario, 2002

	Seed Herbicide Usage, 2002 Data			
	Scenario 1	Scenario 2	Scenario 3	Baseline Data
Total lbs. AI	103,176.10	188,810.98	225,611.11	480,800
Total lbs. Glyphosate	75,689.42	161,324.30	87,871.59	3,500
Total lbs. non-Glyphosate	27,486.68	27,486.68	137,739.52	477,300

Seed Herbicide Usage, 2002 Data vs. Baseline.	Scenario 1 Total	Change vs. Baseline, Scenario 1	Scenario 2 Total	Change vs. Baseline, Scenario 2	Scenario 3 Total	Change vs. Baseline, Scenario 2	Baseline Herbicide Usage, Alfalfa Grown for Seed
Total Herbicide Usage (lbs. ai or ae)	103,176.10	-377,623.90	225,611.11	-255,188.89	225,611.11	-255,188.89	480,800.00
Total Glyphosate used in seed for hay prod. (lbs. ae)	75,689.42	72,189.42	161,324.30	157,824.30	87,871.59	84,371.59	3,500.00
% Glyphosate	73.36%	9977.49%*	71.51%	9722.81%*	38.95%	5250.38%*	0.73%
Total non-Glyphosate in seed for hay prod. (lbs. ai or ae)	27,486.68	-449,813.32	27,486.68	-449,813.32	137,739.52	-339,560.48	477,300.00
% non-glyphosate	26.64%	-73.16%*	12.18%	-87.73%*	61.05%	-38.50%*	99.27%

*These percentages are proportional changes. That is, they represent the percent change in the proportion of overall herbicide use, which indicates how much the proportional use of an herbicide would change relative to the baseline, even though the acreage treated or absolute herbicide use could be much different between the projection and baseline.

Based on the data available from Hower (1999) for alfalfa grown for seed, the estimated herbicide usage for GT alfalfa grown for seed would decrease in all usage scenarios. Given the relatively large and diverse usage profile for herbicide use on conventional seed, adoption of GT alfalfa for seed production would both simplify and decrease overall herbicide use. Estimates based on data for 2007 and 2002 both show overall decreases in the amount of herbicides used, as well as decreases in the amount of non-glyphosate herbicides used. A large proportion of the decrease in herbicide use for seed production overall can be explained by the total number of acres in production. The data from Hower et al. (1999) show that 179,100 acres were in seed production, on average, between 1988 and 1992. Data available from the Census of Agriculture for 2002 and 2007 showed 84,115 and 105,351 acres in production, respectively.

Table J-25 shows the herbicide use per acre for seed production based on 2007 and 2002 data for seed production from the Census of Agriculture compared to baseline data, by treatment scenario. The per-acre usage of glyphosate *increases* from baseline, ranging from 1.13 to 2.44 lbs ae/acre (i.e., 3.43 minus 1.57 and minus 3.44), whereas the per-acre usage of non-glyphosate herbicides *decreases* from baseline, with a range of 1.3 to 3.07 lbs. ai/acre. These changes are

driven primarily by the recommended treatment strategies for GT alfalfa, which relies heavily on glyphosate use for weed control.

Table J-25: Projected and Baseline Herbicide Use, Alfalfa Grown for Seed for Hay - Compared by Usage Scenario on lbs a.i./acre basis, 2007 and 2002 Data

	Seed Herbicide Usage, 2007 Data			Seed Herbicide Usage, 2002 Data			
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3	Baseline Data
Total Acres in Seed Production	105,351.00			84,115.00			179,100
Total Acres Treated	82,174.00			65,610.00			140,200
Lbs. a.i. Herbicide/Acre Treated/year	1.57	2.88	3.44	1.57	2.88	3.44	3.43
Lbs. Glyphosate/ Acre Treated/year	1.15	2.46	1.34	1.15	2.46	1.34	0.02
Lbs. non-Glyphosate/ Acre Treated/year	0.33	0.33	2.10	0.42	0.42	2.10	3.40

2.7.6 Summary of Findings

Results from projecting herbicide use in alfalfa hay and seed can range widely depending on many factors, including adoption rate and the selection by individual farmers of any number of combinations of herbicides and other techniques for stand establishment, maintenance, and removal. For example, glyphosate under the conditions of Scenario 2 (i.e., 51 percent adoption, using management schedules 0 and 2) shows that the total glyphosate could increase by about 18.4M lbs., or about five times the baseline at year 10 of GT alfalfa adoption, and proportional usage could increase about six times (table J-26). Total non-glyphosate could increase about 4M lbs., though proportional usage could decrease about 65 percent. Scenario 2 employed the greatest diversity of non-glyphosate herbicides and various conservative assumptions and so can be used to present a high end estimate of total non-glyphosate herbicides that might be used given the recommendations of Orloff et al. (2009).

Table J-26: Herbicide Use Statistics for Baseline Data Compared to 51% Adoption of GT Alfalfa at 10 Years

Projected Herbicide Usage for Seed and Hay Production	Scenario 2: Seed Total	Scenario 2: Hay Total	Total Scenario 2
Total Herbicide Usage (lbs. ai or ae)	236,478	27,558,432	27,794,910
Total Glyphosate used (lbs. ae)	202,051	18,703,011	18,905,062
% Glyphosate	85%	68%	68%
Total non-Glyphosate (lbs. ai or ae)	34,426	8,855,422	8,889,848
% non-glyphosate	15%	32%	32%
Baseline Data for Seed and Hay Production	**Baseline Herbicide Usage, Alfalfa Grown for Seed**	**Baseline Herbicide Usage, Alfalfa Grown for Hay**	**Total Baseline Data**
Total Herbicide Usage (lbs. ai or ae)	480,800	4,442,770	4,923,570
Total Glyphosate Used (lbs. ae)	3,500	446,500	450,000
% Glyphosate	0.7%	10%	9.1%
Total non-Glyphosate (lbs. ai or ae)	477,300	3,996,270	4,473,570
% non-glyphosate	99.3%	90%	90.9%
Projected vs. Baseline Herbicide Usage, 51% GT Alfalfa Adoption	**Projected Herbicide Use, 51% Adoption Rate at Year 10**	**Baseline Herbicide Use Data**	**Change vs. Baseline**
Total Herbicide Usage (lbs. ai or ae)	27,794,910	4,923,570	22,871,340
Total Glyphosate used (lbs. ae)	18,905,062	450,000	18,455,062
% Glyphosate	68%	9%	644%*
Total non-Glyphosate (lbs. ai or ae)	8,889,848	4,473,570	4,416,278
% non-glyphosate	31%	90%	-65%*

*These percentages are proportional changes. That is, they represent the percent change in the proportion of overall herbicide use, which indicates how much the proportional use of an herbicide would change relative to the baseline, even though the acreage treated or absolute herbicide use could be much different between the projection and baseline.

One of the main drivers of the increase in total herbicide use for Scenario 2, as well as the increase in glyphosate use, is the large number of acres treated with herbicides compared to baseline. All GT alfalfa acres would require herbicide treatment; though the herbicide applied the majority of the time would be glyphosate, according to the assumptions of this analysis. However, given the large increase in the number of acres treated, approximately 50 percent more non-glyphosate herbicides would be used overall. It is important to note that the scenario in table J-26 is based on an herbicide treatment schedule that involves a number of tank-mix herbicides and assumes multiple applications of these herbicides throughout the stand life.

A summary of the five scenarios is shown in table J-27. (Given the relatively minor effect of seed described above, this summary only addresses hay.) All show an increase in glyphosate use, with a range of 5.4M to 24M lbs. Non-glyphosate ranges from a decrease of 3.8M to an increase of 4.9M lbs. Overall herbicide use increases across the scenarios, with a range of 1.6M to 23.2M lbs. In contrast, EPA (2009b) estimates that current agricultural use of glyphosate is about 135M lbs/year.

Further analysis is possible, such as a more regional analysis of the data or the development of better assumptions. A regional analysis would be difficult because the baseline data (year 0) does not have the same State-by-State grouping as the regional market adoption predictions (year 10) from FGI. The development of better assumptions would likely only minimally reduce the range of results, especially given the inherent uncertainties regarding predictions of this type. Therefore, APHIS does not believe additional analysis will provide substantially more accurate or precise results at this point.

Table J-27. Summary of Changes in Annual Herbicide Use for Five Scenarios at Year 10 Compared to Baseline (Hay Only)

Scenario	Key Assumptions*	Change (M lbs.)		
		Glyphosate	Non-glyphosate	Total Herbicide
1	• 51% adoption • Schedules 0 and 1	24.0	-3.8	20.2
2	• 51% adoption • Schedules 0 and 2	18.3	4.9	23.2
3	• 16.7% adoption • Schedule 0	5.4	-3.8	1.6
4	• 16.7% adoption • Schedule 1	12.1	-3.8	8.3
5	• 16.7% adoption • Schedule 2	6.4	4.9	11.3

*Summary of schedules:
Schedule 0 = single application of glyphosate at establishment and in the spring of each year, with minimal use of other herbicides. See table J-4A.
Schedule 1 = similar to Schedule 0, but more frequent use of glyphosate. See table J-17.
Schedule 2 = similar to Schedule 0, but more frequent use of other herbicides. See table J-17.

2.8 Summary of Findings

GT crops, which were introduced in 1996, have been widely adopted in the United States and their adoption in the United States and globally is on an upward trend (James, 2007).

Several analyses of pesticide use concluded that herbicide use has been reduced due to the adoption of herbicide-tolerant crops. (Brimner et al., 2005; Fernandez-Cornejo, 2006; Gianessi and Reigner, 2006; Kleter et. al., 2007; Sankula, 2006; Johnson et al., 2008). One analysis of pesticide use concluded that herbicide use has increased due to herbicide-tolerant crops (Benbrook, 2004). All the studies agreed that herbicide use has shifted toward glyphosate. Using standardized methods for ranking environmental impact, researchers have concluded that glyphosate is less harmful to the environment than many other herbicides and that the shift of herbicide use for some crops has resulted in a net lower environmental impact from herbicides (Kleter et al., 2007). Whether this situation applies to the use of glyphosate on GT alfalfa is unclear (see section 2.7).

Glyphosate adsorbs strongly to soil so doesn't generally move vertically below six inches. Glyphosate is rapidly degraded by soil microbes in the environment. The major degradate of glyphosate is AMPA, which degrades in the soil to form carbon dioxide. The half-life of

glyphosate in soil laboratory studies is two days. In agricultural soils, the half-life of glyphosate ranges from 1.7 to 197.3 days, but is typically less than 60 days. Although glyphosate and AMPA have been detected in surface water and groundwater, the concentrations are many times lower than levels where toxic effects might occur. Glyphosate has low volatility and has not been detected in air, other than possibly adhered to dust particles.

Herbicides are used much more often with alfalfa seed fields (78.3 percent of total fields) than with hay fields (16.6 percent of total fields; 22 percent of acreage). Mechanical and cultural methods for weed control (e.g. tillage and companion crops) were used for ~80 percent of the spring planted alfalfa and 18 percent of the fall planted alfalfa (Hower et al., 1999).

Non-GT and GT alfalfa can be treated similarly regarding cultivation techniques and most herbicide applications. The difference between non-GT and GT alfalfa is glyphosate use. Glyphosate can be used to remove non-GT stands, but cannot be used for whole field weed control. Glyphosate can be used for in crop weed control in GT alfalfa but cannot be used for stand removal. Organic farming practices do not permit the use of any herbicides. Cultivation weed control practices are permitted in organic farming.

Herbicides related to alfalfa farming can be divided into two major groups, herbicides that do not kill alfalfa, so can be used to control weeds in alfalfa, and herbicides that kill alfalfa, so are used for stand removal. Adoption of GT alfalfa decreases the number of herbicides used to control weeds in alfalfa because glyphosate is the preferred herbicide for GT alfalfa. Adoption of GT alfalfa might increase use of some herbicides used for stand removal. For stand removal adoption of GT alfalfa might result in a shift from glyphosate to other herbicides. Herbicide shifts due to stand removal would be smaller in magnitude than herbicide shifts due to weeds control.

Overall, glyphosate is expected to increase, with the amount dependant on many factors, including GT alfalfa adoption rate and weed pressure. Non-glyphosate herbicides could either decrease, remain about the same, or increase, again depending on these same factors.

3.0 Alfalfa Farming Practices

Forage production of alfalfa and its associated farming practices are discussed below, along with cultural farming practices related to weed control and removal in alfalfa.

3.1 Forage Production

Alfalfa grown for forage is the third-ranked crop in the United States by value and fourth ranked by total acreage. The number and location of alfalfa forage acres are closely associated with livestock operations, especially dairy. Alfalfa is highly valued for animal feed because of its high protein content, high intake potential, and digestibility. It can provide the sole plant component in many livestock feeding programs when supplemented with the proper minerals.

Alfalfa is a deep-rooted perennial that has many economic, soil, and environmental benefits when used alone or in rotation (Hanson et al., 1988). In the United States more than 22 million acres currently are grown for forage production (figure 9). The alfalfa acreage in the United States has declined gradually over the past 40 years from a high of approximately 30 million acres (Petition table VII-1, page 255).

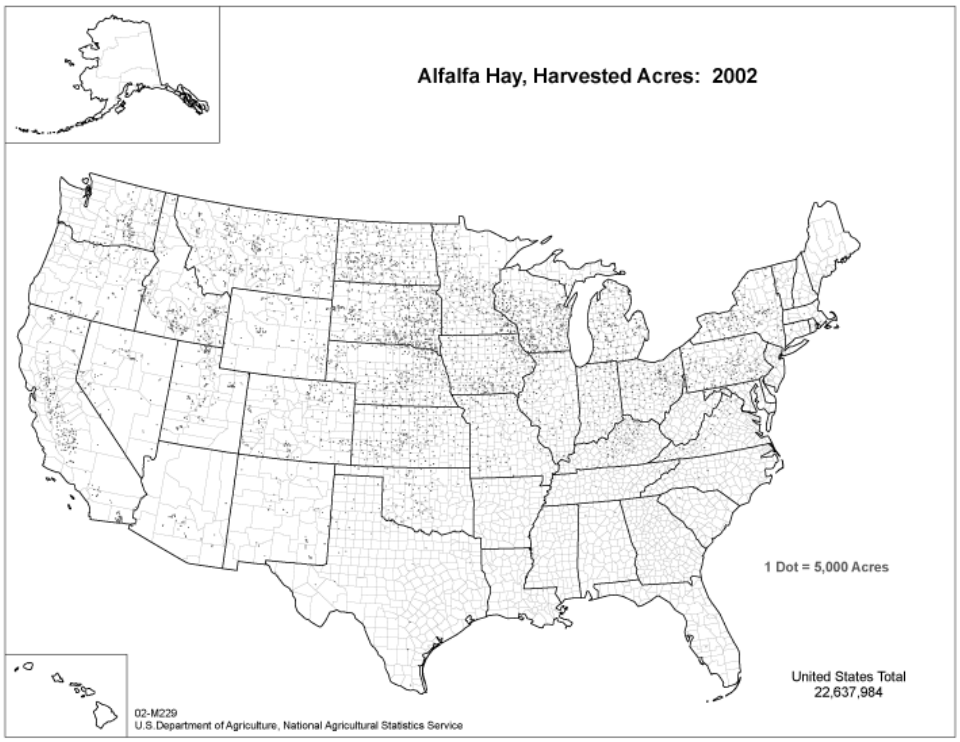

Figure 9: Geographic distribution of alfalfa forage acres, 2002 (USDA FS, 2002)

3.1.1 Stand Establishment

Dependent on climate and grower preference, most alfalfa is sown in the spring, except in the western United States where fall planting is more common (Hower et al., 1999). Alfalfa can be sown anytime there is available moisture and a sufficient growth period for the seedling that is

frost-free (about six to eight weeks). Weeds are the most damaging pest during early stand establishment, especially for spring-sown alfalfa. In order to reduce weed competition, many growers establishing in the spring apply herbicides or co-seed alfalfa with a quick-to-establish companion cereal crop, such as oat or spring wheat. This practice is especially valuable on wind-swept or sloping land that is prone to erosion. The cereal crop can be maintained until grain set, or more commonly it is harvested immature as forage along with the weeds and the first growth of alfalfa. Companion crops, like weeds, compete directly with the alfalfa seedlings for available moisture, light and space and reduce the amount of harvestable alfalfa forage in the establishment year. Competition or other stress during the establishment period has permanent negative consequences on the overall yield potential of the stand. Therefore, many hay producers "direct-seed" or "clear-seed" alfalfa stands without use of a companion crop. Successful alfalfa sowing requires that the seeds be placed at shallow depth (about one-quarter inch) and that the seedbed is uniform, firm and free of competing weeds.

Most pure-stand alfalfa in the United States is established with herbicides, with 52 percent and 66 percent of spring and fall planted acres, respectively, treated with herbicides (Hower et al., 1999). About 1.49 M acres of alfalfa are established annually using herbicides (Hower et al., 1999).

3.1.2 Stand Longevity

Alfalfa forage production fields remain economically viable for approximately five years after planting, although longevity typically ranges from about three to eight years, depending on the region and other factors. Plants become unthrifty and stands become thin as they age due to the accumulated negative impacts of weed competition, diseases, insects and environmental stress (e.g., excessive cold, heat, drought, and flooding). When terminated, very thin alfalfa stands offer less soil nitrogen to the rotational crop (less rotational benefit) compared to those terminated at higher plant density. Stand longevity is affected by climate, soil type, soil tilth and drainage, autotoxicity, fertility, variety (genetics), and pest impacts. Very short forage harvest intervals generally increase the rate of stand depletion and weed encroachment; very long harvest intervals allow more time for weed seed set. Frequently alfalfa stands may be seriously injured, thinned, or weakened by an interaction between unexpected changes in weather and appropriate use of certain labeled herbicides, resulting in unacceptable weed control.

Often, alfalfa stand length is predetermined according to the grower's whole-farm crop rotation schedule; typically alfalfa is grown for three to eight years followed by at least two years of a non-legume crop (e.g., corn, small grain, cotton, safflower, or vegetables). Expensive-to-control weed infestations can be one reason why forage fields are terminated early.

3.1.3 Stand Thinning, Impacts of Weed Encroachment and Stand Termination

Healthy, productive stands of alfalfa require attention to the management of pests (including weeds), fertilizer inputs, irrigation (if applicable), and harvest timing. Several years after sowing when plants weaken and stands become thin, weeds become more highly competitive with the alfalfa and can contribute to a significant decline in alfalfa yield and forage value. Certain weed species found in alfalfa stands are particularly difficult to control (Hower et al., 1999), are poisonous to livestock, negatively affect palatably or livestock performance, impart off flavors to

milk products, and may be noxious to regulated species (e.g., dodder). Alfalfa stands nearly always are terminated using some type of tillage (plowing, disking, roto-tilling, etc.) to help break up roots and crowns, hasten decomposition, relieve soil compaction, and to incorporate this nitrogen-rich plant material as a soil amendment. It is common for many producers to use tillage integrated with herbicides and or other stand take-out practices (e.g., flooding). Stand take-out is discussed in Petition section VII.B.6 (Pages 259-260). Well-established alfalfa fields or fields undergoing stand renovation are sometimes used for the disposal of livestock manures. Weed seeds present in livestock manure can contribute to an accumulation of weed seeds in the soil and weed problems in alfalfa production systems.

3.2 Cultural Farming Practices

Cultural farming practices include all the methods farmers use to control weeds without the application of herbicides. There are usually multiple benefits of cultural practices beyond weed control. Examples include crop rotation, companion crops, mowing, grazing, burning, tillage, and no-tillage.

3.2.1 Crop Rotation

For weed, insect, and disease management, it is recommended that alfalfa be used in rotation with other crops (Orloff et al., 1997; Padgitt et al., 2000). Alfalfa is also used in crop rotation because it provides nitrogen to the soil, which decreases fertilizer inputs in other rotations. It can be economically advantageous to include alfalfa in rotations (Mends and Dobbs, 1991). Perennials and annuals promote and restrict different weeds, so rotating perennials with annuals helps control weeds in general. It is also advisable to rotate alfalfa because mature alfalfa is auto toxic to seedling alfalfa (Xuan et al., 2005). Monsanto recommends that alfalfa can be rotated to grass crops (corn and cereal crops) or broadleaf crops, and that alfalfa should not be rotated with other GT crops (Monsanto, 2008). This limits some options for farmers, as GT corn and GT soybean are both popular rotation crops for alfalfa. Typical rotation crops include wheat, oats, barley, potato (*Solanum tuberosum L.*), sugar beet (*Beta vulgaris L.*), and corn. These are expected to continue as currently practiced because nonglyphosate herbicides are available to manage alfalfa volunteers in each crop. Alfalfa rotation with soybean will remain uncommon because of the lack of nitrogen benefit from alternating between consecutive plantings of legumes. Although the success of rotation with cotton will depend largely on mechanical control of volunteer alfalfa, the number of acres is expected to be low (Rogan and Fitzpatrick, 2004).

The crops that are rotated with alfalfa must have known and available mechanical or herbicidal methods for controlling volunteer alfalfa (Monsanto, 2008). Table J-27 gives an indication of typically recommended crop rotations for alfalfa. These could change as plants and weeds become resistant to glyphosate, or as GT volunteer alfalfa becomes a problem. Crop rotations can help maintain soil fertility, reduce soil erosion, avoid pathogen and pest buildup, adapt to weather changes, avoid allelopathic effects and increase profits (Peel, 1998).

Herbicides that can be used to remove either conventional or GT alfalfa have rotation restrictions. For example, following clopyralid (Curtail® or Stinger®), pea, lentil, potato, and dry bean cannot be planted for 18 months. Picloram (Tordon®) can only be followed by grasses for the year following application. Sunflower, dry bean, and potato should not be planted for

several years following picloram (Miller et al., 2006). Dicamba (Banvel®) should not be used prior to soybean and is also limited seasonally in California (Dillehay and Curran, 2006). Because of these restrictions, alfalfa stand removal and rotation schedules should be closely coordinated. Nonglyphosate herbicides are available to manage alfalfa volunteers in wheat, oats, barley, sugar beet, and corn. Therefore, rotations from GT alfalfa to those crops should be similar to rotations with non-GT alfalfa (Rogan and Fitzpatrick, 2004). However, if a farmer cultivates another GT crop that would impact crop rotations, and might discourage the use of GT alfalfa as glyphosate could not be used in other crop rotations to control for volunteer alfalfa.

Table J-27. Recommended Rotations for Pest Reduction (Goodell, 2006)

Pest	Recommended Rotation
Root knot nematode	1 year rotation with cotton
Stem nematode	3-4 year rotation with small grains, beans, cotton, corn, sorghum, lettuce, carrots, tomatoes, or forage grasses.*
Diseases: Bacterial wilt Anthracnose Spring blackstem Common leafspot Stagonospora	3-4 year rotation with small grains, beans, corn, sorghum, forage grasses.*
Winter weeds	A minimum of 1 year (preferably longer) in crops such as small grains, wheat, oats, winter forage grasses that allow the use of selective herbicides that are not registered in alfalfa.
Summer weeds	A minimum of 1 year (preferably longer) in crops such as small grains, beans, cotton, corn, sorghum, summer forage grasses that allow the use of selective herbicides that are not registered in alfalfa.
Dodder	At least 2 years with cotton or other nonhost crops such as small grains, beans, corn, sorghum, or forage grasses. Avoid rotations with crops such as tomatoes, onions, and carrots that also serve as a host for this weed.
Nutsedge	Two year rotation with corn or sorghum rotation that includes application of herbicide to control nutsedge.

* Three- to four-year rotations give satisfactory results. A rotation for fewer years will provide minimal suppression.

Adoption of GT alfalfa does affect crop rotations because glyphosate cannot be used for stand removal or volunteer alfalfa control. Therefore other herbicides, which might have rotation restrictions, might need to be used along with tillage to remove GT alfalfa stands. However, because glyphosate is not very effective at killing a mature alfalfa plant, adoption of GT alfalfa will likely not significantly change the amount of glyphosate used for these purposes)Endres, 1999; Mayerle, 2002; Manitoba Agriculture and Food, 2002). GT alfalfa stands might also last longer than non-GT alfalfa stands (Rogan and Fitzpatrick, 2004); therefore adoption of GT alfalfa might influence the number of years that alfalfa is in a rotation. No data were found that quantifies actual differences in herbicide use throughout stand life comparing GT alfalfa with non-GT alfalfa. No data were found that indicates if rotation differences are observed with the adoption of GT alfalfa.

3.2.2 Companion Cropping in Alfalfa

Alfalfa grown for hay is sometimes grown with a companion crop. Companion crops planted with alfalfa are crops that act as weed control and prevent soil erosion, such as oats, spring wheat

or peas. They tend to grow much quicker than alfalfa, and out-compete any weeds while alfalfa is becoming established. Once the companion crop begins to compete with the alfalfa for nutrients, water and space, the companion crop can be harvested, and serves as extra profit for the farmer (Smith et al., 1998). At this point, the alfalfa is established enough to compete against any weeds on its own. Oats are the most popular companion crop to alfalfa because they are the least competitive, with alternatives such as peas also in wide use, but exact companion crop habits depend on farmer preference and region (McCordick et al., 2008; Smith et al., 1998). Studies have found that companion cropping in alfalfa can suppress weed growth more than herbicide treatments, but that the crop then competes with the alfalfa, reducing yield (McCordick et al., 2008). As noted in table J-9, companion cropping is more prevalent in the North Central United States (Hower et al., 1999).

Alfalfa-grass forage mixtures are very common in the northeastern United States, and are generally more widespread than pure seeded stands of alfalfa or grass. Alfalfa-grass mixtures tend to provide similar or increased yield while providing a more desirable nutrient balance than monocultures of either crop. Alfalfa-grass mixtures might also help the crop withstand insect damage, improve soil and water conservation, as well as increase stand life (Dillehay, 2007).

Companion crops are different from nurse crops in that nurse crops are a specific type of companion crop. Nurse crops do not compete with alfalfa for nutrients, but rather are removed or killed with herbicide early in development. This can result in both effective weed control and little impact on alfalfa yield (McCordick et al., 2008). Nurse crops can also help reduce wind, water and soil erosion and provide early groundcover like other companion crops (Hall et al., 2004). Other types of companion cropping include using a cover crop, used during dormant seasons to protect the soil, or a barrier crop, used as pest control by serving as a refuge and distraction for pests.

With the development of GT alfalfa, companion cropping options and methods have the opportunity to change. A study by McCordick et al. (2008) looked at the effect of establishment method (companion crops and herbicide interactions) on GT alfalfa establishment. The study found that the highest alfalfa yield came from plots treated with glyphosate, either with or without a companion crop, and that the treatment without herbicide and with a companion crop had the lowest yield, but the system did reduce weed biomass. Also, plots without a companion crop experienced higher dry matter yields than that of plots seeded with a companion crop, indicating that establishing GT alfalfa without a companion crop can maximize production. They also studied the effect of imazamox, another herbicide, on the crops, and found more damage to the alfalfa and lower first harvest yields with use of this herbicide, indicating that the weed control used before the first harvest can significantly impact the crop. Because glyphosate is less damaging to the GT alfalfa, but normal herbicides are still toxic, the results suggest that farmers who grow GT alfalfa can move away from companion cropping and solely use glyphosate for weed control. This would not only reduce potential herbicide damage to the alfalfa, but it could also decrease costs by removing harvesting of the companion crop and increase profits by having more pure alfalfa hay. Exact establishment methods would depend on the goal of the farmer as well as weed presence. Companion crops can decrease weed biomass, but can also decrease yield, and the study concludes that companion crops are not needed with GT alfalfa (McCordick et al., 2008).

Dillehay et al.(2009) compared traditional alfalfa-orchardgrass seeding with a delayed seeding system where orchardgrass is seeded into an existing GT alfalfa seedling stand and glyphosate was used for weed control. Weed species present included common lambsquarters (*Chenopodium album* L.), common ragweed (*Ambrosia artemisiifolia* L.), giant foxtail (*Setaria faberi* Herrm.), and velvetleaf (*Abutilon theophrasti* Medik.), with common lambsquarters and giant foxtail being predominant at both locations and years. The results suggest that GT alfalfa mixed with orchardgrass and the use of glyphosate for weed control during the establishment year can be an effective combination. Seeding the alfalfa alone and applying glyphosate at or just before orchardgrass seeding 4 to 5 weeks after the alfalfa was planted successfully established the mixture with reduced weeds. Glyphosate had the greatest effect in reducing weed biomass and increasing orchardgrass content during the first harvest of the seeding year and the first harvests in subsequent years.

3.2.3 Tillage

Tillage fits into the broader context of soil conservation practices. Some soil conservation practices include, chiseling and subsoiling, conservation cover, conservation tillage (no-till, ridge-till, mulch till), contour farming, cover or green manure (legumes), critical area planting (erosion zones), crop residue use, filter strips, grade-stabilization structures, grass and legume in rotation, grassed waterways, strip cropping, and terracing (Caswell et al., 2001).

Tillage practices during cultivation of crops impact the soil and water, and can influence such factors as weed control, crop rotations and yields. Tillage is most often used between crops in order to remove the traces of the previous crop and as weed control in preparation for the next crop. Excessive tillage causes soil erosion. For example, in 100 years half of Iowa's original topsoil eroded (Fawcett and Towery, 2002). Soil degradation has been cited as the most frequent cause of historical cultural decline and civilization collapse (Ragnarsdottir, 2006). Conventional till agriculture fields average one to two orders of magnitude greater soil erosion than natural rates, which is considered unsustainable (Montgomery, 2007). There are multiple types of tillage methods, including conventional tillage, reduced tillage and no tillage. These types of tillage, their uses and their effects are elaborated in table J-11.

Conservation tillage benefits the environment in the following ways (Fawcett and Towery, 2002):

- Reduced soil erosion
- Improved moisture content in soil
- Healthier, more nutrient-enriched soil
- More earthworms and beneficial soil microbes
- Reduced consumption of fuel to operate equipment
- Return of beneficial insects, birds, and other wildlife in and around fields
- Less sediment and chemical runoff entering streams
- Reduced potential for flooding
- Less dust and smoke to pollute the air
- Less carbon dioxide released into the atmosphere

No-till agriculture requires less fossil fuels than conventional agriculture due to decreased use of fertilizers, pesticides, and fuel (Gregory et al., 2005). Both fossil fuel energy consumption and soil compaction (at 15 cm) can be half as much with no-till compared to conventional (Gregory et al., 2005).

Tillage affects cone index, which is a measure of soil strength and soil moisture. Higher cone indexes can lead to reduced crop growth, although cone index effects have not been determined for alfalfa. Preparation of alfalfa seed bed commonly includes deep tillage. Huhnke et al. (1993) measured the effects of different primary tillage practices in alfalfa stand establishment, light disking had the highest cone index and deep primary tillage had the lowest cone index. After the first year cone indexes were not related to primary tillage type. The researchers also concluded that tillage treatment did not significantly affect initial alfalfa population or first year yield. Tillage treatments did have a significant effect on cool-season grass emergence (weeds) within the first month after planting (Huhnke et al., 1993). In another study, forage yield was greater the first year after no-tillage compared to conventional tillage, but there were no differences in yield in the following two years (Malhi et al., 2007). In experimental fields rotated from corn to alfalfa, simulated rainfall and tillage treatments did not strongly affect soil properties, presumably due to a sable soil structure (Karunatilake and van Es, 2002). Forney et al. (1985) found that in experimental sites no-till alfalfa establishment was compromised by factors other than weeds, which is consistent with the concept that reduced-tillage systems generally require more careful management than conventional systems.

No-till farming has grown in popularity since 1996, specifically in crops that since then have had herbicide-tolerant crops introduced. Because the primary purpose of tillage is weed control, farmers can now use and trust herbicide to serve as weed control in its place. Farmers will choose to reduce tillage if they are assured of weed control without disturbing the fields, such as in the case of GT alfalfa where over-the-top glyphosate application is effective (Fawcett and Towery, 2002). Application of glyphosate will also be effective in specific farming situations like contour farming, where the weeds appearing between strips of GT crops can be effectively managed with glyphosate use. APHIS recognizes the benefits as well as contrary evidence of no-tillage management, including soil organic carbon sequestration, retention of crop residues on soil surface, reduction in soil erosion risk, reduction of fuel use for tillage, increase in nitrogen use, chemical fertilizer runoff risks, and delayed greenhouse gas emission reductions (Karlen et. al., 1994; Reicosky, 2007; Bull et. al., 1993; Warnemuende et. al., 2007). The practice of intensive tillage as a method of combating volunteer alfalfa persistence, however, is concerned with the deep-rooted nature of alfalfa (Bagavathiannan and Van Acker, 2009). As this particular characteristic (discussed in appendix H) is not affected by herbicide resistance, introduction of GT alfalfa is unlikely to adversely alter current tillage practices. Fifty-two percent of GT soybean farmers increased no-till acres after adopting GT soybeans, between 1996 and 2002, while only 21 percent of non-GT soybean farmers increased no-till acres, indicating a correlation between GT soybeans and decreasing tillage (Fawcett and Towery, 2002). A USDA survey showed that in 1997, 60 percent of GT soybean acres were under conservation tillage while only 40 percent of conventional soybeans were under conservation tillage (Wiebe and Gollehon, 2006). See figure J-10 for the change in tillage practices from 1990-2002, before and after adoption of GT crops (Fawcett and Towery, 2002). GT crops came on the market in 1996. While use of GT crops encourage reduced tillage, reduced tillage, in turn, encourages increased

reliance on herbicide use as weed control. Farmers need methods to manage weeds, and when using GT crops, they will be encouraged to use herbicides (glyphosate) in conjunction with the GT crops. A USDA ERS study from 1994 examined pesticide use based on tillage practices in corn and soybeans, and determined that while herbicide use did increase slightly when tillage was decreased, the biggest difference between tillage methods was the type of herbicides used, not the amount of herbicides total.

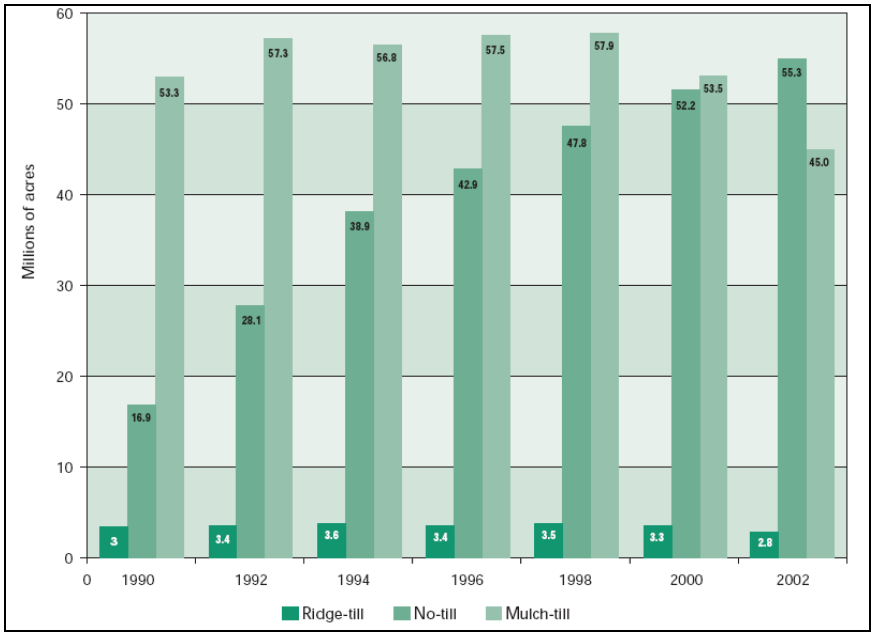

Figure J-10: Conservation tillage adoption in the U.S., 1990-2002 (Fawcett and Towery, 2002)

Studies have been performed that look at the impact of GT crops on tillage practices, and also the impact of tillage practices on glyphosate residues in soil and water. The American Soybean Association examined changes in tillage practices once farmers began using GT soybeans, and they found that farmers increasingly used conservation tillage as opposed to conventional tillage (ASA, 2001; Cerdeira and Duke, 2006). When asked why this was the case, 63 percent of responders stated the GT technology was responsible, as it made cultivation with conservation tillage as effective as conventional tillage. Their reasons included that it reduced weeds, lowered production costs related to fuel and maintenance, decreased the number of labor hours needed for a given field, extended equipment life, and increased yield. The same amount of labor can cover more area elsewhere, leading to increased income. The decreased costs in production might be offset by the increased crop protection costs and the amount of fertilizers needed (Wiebe and Gollehon, 2006).

Tillage can be used in conjunction with GT crops as a form of weed control prior to establishing a stand or for stand removal. If used prior to establishing a stand of alfalfa in order to prepare the land, then this would reduce the amount of herbicide needed for stand establishment (Shukla, 2003).

Sankula (2006) evaluated the impact of biotechnology-derived crops planted in the United States in 2005. A summary of the tillage analysis follows:

- As of 2004 no-till acreage in corn has increased 20 percent compared to 1996.
- No-till cotton acres increased 371 percent in 2004 (the most recent year for which information is available) compared to 1996.
- In 2004 about 36 percent of the total soybean acreage was planted using no-tillage, which represents a 64 percent increase since 1996.

One study examined the levels of AMPA, a glyphosate residue, in the soil after either low or normal tillage, and found that residues were at higher levels in the low tillage treatment than in the normal tillage treatment, due to increased leaching in the low till treatment (Fomsgaard, 2003). No-till practices can lead to nutrient stratification in the soil because the soil is never mechanically disturbed, and repeated applications of herbicides are made to the surface (Wiebe and Gollehon, 2006). Herbicides that adsorb strongly, such as glyphosate, will be protected from degradation and volatilization, and will not readily leach to groundwater. They will only be found in surface water runoff when erosion conditions lead to the loss of surface particles, like in conventional tillage when the soil is highly prone to erosion. Switching to a conservation tillage system, and thus increasing herbicide use, does not increase the likelihood of degradation of water quality through chemical contamination. In general, tillage systems that incorporate low mobility and short persistence herbicides will be better for water-quality standards, with less chance of entering nearby water (Wiebe and Gollehon, 2006). Adopting GT crops would indirectly benefit the environment through the soil conservation practices of conservation tillage, which would increase in popularity (Wiebe and Gollehon, 2006).

Locke et al. (2008) conducted a 6 year conservation tillage field study from 2000 to 2005 at the USDA-ARS Southern Weeds Science Research Unit farm in Stoneville, Mississippi. GT crop rotations were only done from 2003 to 2005. Rotations included continuous GT cotton, continuous non-GT cotton, continuous GT maize, continuous non-GT maize, GT rotation 1 (cotton-maize-cotton), non-GT rotation 1 (cotton-maize-cotton), GT rotation 2 (maize-cotton-maize), and non-GT rotation 2 (maize-cotton-maize). Under continuous GT maize, soils maintained greater soil organic carbon and nitrogen as compared with continuous non-GT maize, but no differences were measured in continuous cotton or in cotton rotated with maize. Soil organisms also showed differences based on fatty acid methyl ester analysis. Locke et al. (2008) concluded that glyphosate use can result in minor effects on soil biological/chemical properties. However, enhanced organic carbon and plant residues in surface soils under conservation practices can buffer potential effects of glyphosate.

3.4 Summary of Findings

Cultural practices such as crop rotation, companion crops, mowing, grazing, burning, tillage, and no-tillage provide multiple benefits to crop production.

Alfalfa is used in crop rotation because it provides nitrogen to the soil, which decreases fertilizer inputs in other rotations. Perennials and annuals promote and restrict different weeds, so rotating perennials with annuals helps control weeds in general.

Adoption of GT alfalfa will likely affect crop rotations because glyphosate cannot be used for stand removal or volunteer alfalfa control. Therefore other herbicides, which might have

rotation restrictions, might need to be used along with tillage to remove GT alfalfa stands. GT alfalfa stands might also last longer than non-GT alfalfa stands, therefore adoption of GT alfalfa might influence the number of years that alfalfa is in a rotation. It is recommended that rotations not consist of all GT crops. Because several of the crops that are popular in rotation with alfalfa (corn, soybeans) have GT varieties farmers might have to decide which GT crop provides the most benefit to the rotation plan and overall farm production.

There are several types of companion cropping practices. These include crops that are interseeded with alfalfa to provide protection from wind and harsh weather or outcompete weeds in the stand establishment year, crops that are planted to cover the soil and prevent erosion between growing seasons, and barrier crops that are planted alongside fields that serve as a refuge for beneficial insects and distract pests. Interseeded companion crops are not likely to be used with GT alfalfa.

Soil conservation practices include, chiseling and subsoiling, conservation cover, conservation tillage (no-till, ridge-till, mulch till), contour farming, cover or green manure (legumes), critical area planting (erosion zones), crop residue use, filter strips, grade-stabilization structures, grass and legume in rotation, grassed waterways, strip cropping, and terracing. GT alfalfa is compatible with all soil conservation practices. GT crops are known to enhance the adoption of conservation tillage.

The cultural practices associated with GT crops and GT alfalfa have a net benefit on soil conservation and quality.

Appendix J-1. Additional Tables and Information from the Herbicide Use Analysis, Section 2.7.

Table J-1A: Use Patterns and EPA Maximum Application Rate for Herbicides Used in Glyphosate-Tolerant Alfalfa

Active Ingredient	Use Pattern	EPA Maximum Application Rate	Notes/Sources for Use Rate
2,4-D	Stand Removal	1.5 lbs. a.e./acre*	EPA RED 1993
Dicamba	Stand Removal	1.0 lbs. a.e./acre*	EPA RED changed application rate to 1.0 lbs. a.e./acre with most recent revisions (2009a)
Diuron	Maintenance (Schedule 2)	2.4 lbs. a.i./acre	EPA RED changed application rate per acre per year from 3.2 lbs. ai to 2.4 lbs. ai with 1 application per year allowed (2003)
Glyphosate	Establishment & Maintenance for GT Alfalfa, Stand Removal for Conventional Alfalfa	1.5 lbs. a.e./acre*	Recommended rate from Monsanto, Draft FEIS, pg. U-9
Hexazinone	Maintenance (Schedule 2)	1.5 lbs. a.i./acre	EPA RED (2002)
Metribuzin	Maintenance (Schedule 2)	0.6 lbs. a.i./acre	EPA RED (1998)
Pendimethalin	Maintenance (Schedule 2)	4.0 lbs. a.i./acre	EPA RED (1997)
Trifluralin	Maintenance (Schedule 2)	2.0 lbs. a.i./acre	EPA RED (1996)

*lbs. a.e./acre represent acid equivalents. In this and the following tables, values of glyphosate, 2,4-D and Dicamba are presented as lbs. a.e. EPA RED=EPA Reregistration Eligibility Decision.

Table J-2A: Herbicide Use Rates and Pounds Per Acre for GT Alfalfa Hay, Maintenance Schedule 1

		Schedule 1 - Hay	
Active Ingredient	**Maximum Application Rate (lbs. a.i./acre, lbs. a.e./acre)**	**# Of Applications, Schedule 1* (Assuming 5.26 year stand life)**	**Total a.e. (lbs.) per acre, per year**
2,4-D	1.50	0.19	0.29
dicamba	1.00	0.19	0.19
glyphosate	1.50	2.47	3.71
		Glyphosate (lbs./acre/year)	3.71
		non-Glyphosate (lbs./acre/year)	0.48

Table J-3A: Herbicide Use Rates and Pounds Per Acre for GT Alfalfa Hay, Maintenance Schedule 2

		Schedule 2 - Hay	
Active Ingredient	**Maximum Application Rate (lbs. ai/acre, lbs. ae/acre)**	**# Of Applications, Scenario 2*† (Assuming 5.26 year stand life)**	**Total a.i./a.e. (lbs.) per acre, per year**
2,4-D	1.50	0.19	0.29
dicamba	1.00	0.19	0.19
diuron	2.40	0.19	0.46
glyphosate	1.50	1.33	2.00
hexazinone	1.50	0.19	0.29
metribuzin	0.60	0.19	0.11
pendimethalin	4.00	0.29	1.14
trifluralin	2.00	0.29	0.57
		Total Glyphosate (lbs./acre/year)	2.00
		Total non-Glyphosate (lbs./acre/year)	3.04

Table J-4A: Herbicide Use Rates and Pounds Per Acre for GT Alfalfa Hay, Maintenance Schedule 0

		Schedule 0 - Hay	
Active Ingredient	**Maximum Application Rate (lbs. ai/acre, lbs. ae/acre, or lbs. cation/acre)**	**# Of Applications, Scenario 1* (Assuming 5.26 year stand life)**	**Total a.e. (lbs.) per acre, per year**
2,4-D	1.50	0.19	0.29
dicamba	1.00	0.19	0.19
glyphosate	1.50	1.14	1.71
		Total Glyphosate (lbs./acre/year)	1.71
		Total non-Glyph (lbs./acre/year)	0.48

The amount of herbicide projected to be used on alfalfa hay for the various scenarios can be found below.

Table J-5A: Total Amount of Herbicide Used on Alfalfa for Hay, Scenario 1

Scenario 1					
		Schedule 0			
Active Ingredient	**Maximum Application Rate (lbs. ai/acre, lbs. ae/acre)**	**# Of Applications, Schedule 0 (Assuming 5.26 year stand life)**	**Pounds a.i./a.e. per acre, per year**	**# of Acres Treated**	**Total Pounds a.e.**
2,4-D	1.50	0.19	0.29	139,355	39,739.94
dicamba	1.00	0.19	0.19	139,355	26,493.29
glyphosate	1.50	1.14	1.71	6,967,736	11,921,981.75
		Schedule 1			
Active Ingredient	**Maximum Application Rate (lbs. ai/acre, lbs. ae/acre)**	**# Of Applications, Schedule 1 (Assuming 5.26 year stand life)**	**Pounds a.i./a.e. per acre, per year**	**# of Acres Treated**	**Total Pounds a.e.**
2,4-D	1.50	0.19	0.29	67,414	19,213.04
dicamba	1.00	0.19	0.19	67,414	12,808.69
glyphosate	1.50	2.47	3.71	3,370,709	12,495,974.43
		Conventional Alfalfa*			
Active Ingredient	**Maximum Application Rate (lbs. ai/acre, lbs. ae/acre)**	**# Of Applications, Conventional (Assuming 5.26 year stand life)**	**Pounds a.i./a.e. per acre, per year**	**# of Acres Treated (stand removal only)**	**Total Pounds a.e.**
2,4-D	1.50	0.19	0.29	198,121	56,464.50
dicamba	1.00	0.19	0.19	198,121	37,643.00
glyphosate	1.50	0.19	0.29	198,121	56,464.50
*The total acreage treated in conventional alfalfa represents 1.97% of the total acreage in conventional alfalfa production. This number is based on the average number of acres that received stand removal herbicides between 1988 and 1992, divided by the total number of acres in hay production from the herbicide survey, as reported by Hower (1999).			**Total lbs. a.i./a.e.**		24,666,783.14
			Total lbs. Glyphosate		24,474,420.68
			Total lbs. non-Glyphosate		192,362.46

Table J-6A: Total Amount of Herbicide Used on Alfalfa for Hay, Scenario 2

Scenario 2					
		Schedule 0			
Active Ingredient	**Maximum Application Rate (lbs. ai/acre, lbs. ae/acre)**	**# of Applications, Schedule 0 (Assuming 5.26 year stand life)**	**Pounds a.i./a.e. per acre, per year**	**# of Acres Treated**	**Total Pounds a.e.**
2,4-D	1.50	0.19	0.29	139,355	39,739.94
dicamba	1.00	0.19	0.19	139,355	26,493.29
glyphosate	1.50	1.14	1.71	6,967,736	11,921,981.75
		Schedule 2			
Active Ingredient	**Maximum Application Rate (lbs. ai/acre, lbs. ae/acre, or lbs. cation/acre)**	**# of Applications, Schedule 2 (Assuming 5.26 year stand life)**	**Total a.i. (lbs.)per acre, per year**	**# of Acres Treated**	**Total Pounds a.i./a.e.**
2,4-D	1.50	0.19	0.29	67,414	19,550.11
dicamba	1.00	0.19	0.19	67,414	12,808.69
diuron	2.40	0.19	0.46	3,370,709	1,550,526.14
glyphosate	1.50	1.33	2.00	3,370,709	6,741,418.00
hexazinone	1.50	0.19	0.29	3,370,709	977,505.61
metribuzin	0.60	0.19	0.11	3,370,709	370,777.99
pendimethalin	4.00	0.29	1.14	3,370,709	3,842,608.26
trifluralin	2.00	0.29	0.57	3,370,709	1,921,304.13
		Conventional Alfalfa*			
Active Ingredient	**Maximum Application Rate (lbs. ai/acre, lbs. ae/acre)**	**# of Applications, Schedule 0 (Assuming 5.26 year stand life)**	**Pounds a.i./a.e. per acre, per year**	**# of Acres Treated (stand removal only)**	**Total Pounds a.i./a.e.**
2,4-D	1.50	0.19	0.29	198,121	56,464.50
dicamba	1.00	0.19	0.19	198,121	37,643.00
glyphosate	1.50	0.19	0.29	198,121	56,464.50
*The total acreage treated in conventional alfalfa represents 1.97% of the total acreage in conventional alfalfa production. This number is based on the average number of acres that received stand removal herbicides between 1988 and 1992, divided by the total number of acres in hay production from the herbicide survey, as reported by Hower (1999).			**Total lbs. AI**		27,575,285.91
			Total lbs. Glyphosate		18,719,864.25
			Total lbs. non-Glyphosate		8,855,421.66

Table J-7A: Total Amount of Herbicide Used on Alfalfa for Hay, Scenario 3

Scenario 3					
		Schedule 0			
Active Ingredient	Maximum Application Rate (lbs. ai/acre, lbs. ae/acre)	# of Applications, Schedule 0 (Assuming 5.26 year stand life)	Pounds a.i./a.e. per acre, per year	# of Acres Treated	Total Pounds a.i./a.e.
2,4-D	1.50	0.19	0.29	67,414	19,224.58
dicamba	1.00	0.19	0.19	67,414	12,816.38
glyphosate	1.50	1.14	1.71	3,370,709	5,767,372.81
		Conventional Alfalfa*			
Active Ingredient	Maximum Application Rate (lbs. ai/acre, lbs. ae/acre)	# Of Applications, Schedule 0 (Assuming 5.26 year stand life)	Pounds a.i./a.e. per acre, per year	# of Acres Treated	Total Pounds a.i./a.e.
2,4-D	1.50	0.19	0.29	337,476	96,180.59
dicamba	1.00	0.19	0.19	337,476	64,120.39
glyphosate	1.50	0.19	0.29	337,476	96,180.59
*The total acreage treated in conventional alfalfa represents 1.97% of the total acreage in conventional alfalfa production. This number is based on the average number of acres that received stand removal herbicides between 1988 and 1992, divided by the total number of acres in hay production from the herbicide survey, as reported by Hower (1999).			**Total lbs. AI**		6,055,895.35
			Total lbs. Glyphosate		5,863,553.41
			Total lbs. non-Glyphosate		192,341.95

Table J-8A: Total Amount of Herbicide Used on Alfalfa for Hay, Scenario 4

Scenario 4					
		Schedule 1			
Active Ingredient	Maximum Application Rate (lbs. ai/acre, lbs. ae/acre)	# of Applications, Schedule 1 (Assuming 5.26 year stand life)	Pounds a.i./a.e. per acre, per year	# of Acres Treated	Total Pounds a.i./a.e.
2,4-D	1.50	0.19	0.29	67,414	19,213.04
dicamba	1.00	0.19	0.19	67,414	12,808.69
glyphosate	1.50	2.47	3.71	3,370,709	12,495,974.43
		Conventional Alfalfa*			
Active Ingredient	Maximum Application Rate (lbs. ai/acre, lbs. ae/acre)	# of Applications, Schedule 0 (Assuming 5.26 year stand life)	Pounds a.i./a.e. per acre, per year	# of Acres Treated	Total Pounds a.i./a.e.
2,4-D	1.50	0.19	0.29	337,476	96,180.59
dicamba	1.00	0.19	0.19	337,476	64,120.39
glyphosate	1.50	0.19	0.29	337,476	96,180.59
*The total acreage treated in conventional alfalfa represents 1.97% of the total acreage in conventional alfalfa production. This number is based on the average number of acres that received stand removal herbicides between 1988 and 1992, divided by the total number of acres in hay production from the herbicide survey, as reported by Hower (1999).			**Total lbs. AI**		12,784,477.74
			Total lbs. Glyphosate		12,592,155.02
			Total lbs. non-Glyphosate		192,322.72

Table J-9A: Total Amount of Herbicide Used on Alfalfa for Hay, Scenario 5

Scenario 5					
		Schedule 2			
Active Ingredient	Maximum Application Rate (lbs. ai/acre, lbs. ae/acre, or lbs. cation/acre)	# Of Applications, Schedule 2 (Assuming 5.26 year stand life)	Total a.i. (lbs.)per acre, per year	# of Acres Treated	Total Pounds a.i./a.e.
2,4-D	1.50	0.19	0.29	67,414	19,550.11
dicamba	1.00	0.19	0.19	67,414	12,808.69
diuron	2.40	0.19	0.46	3,370,709	1,550,526.14
glyphosate	1.50	1.33	2.00	3,370,709	6,724,564.46
hexazinone	1.50	0.19	0.29	3,370,709	977,505.61
metribuzin	0.60	0.19	0.11	3,370,709	370,777.99
pendimethalin	4.00	0.29	1.14	3,370,709	3,842,608.26
trifluralin	2.00	0.29	0.57	3,370,709	1,921,304.13
		Conventional Alfalfa*			
Active Ingredient	Maximum Application Rate (lbs. ai/acre, lbs. ae/acre)	# Of Applications, Schedule 0 (Assuming 5.26 year stand life)	Pounds a.i./a.e. per acre, per year	# of Acres Treated	Total Pounds a.i./a.e.
2,4-D	1.50	0.19	0.29	337,476	96,180.59
dicamba	1.00	0.19	0.19	337,476	64,120.39
glyphosate	1.50	0.19	0.29	337,476	96,180.59
*The total acreage treated in conventional alfalfa represents 1.97% of the total acreage in conventional alfalfa production. This number is based on the average number of acres that received stand removal herbicides between 1988 and 1992, divided by the total number of acres in hay production from the herbicide survey, as reported by Hower (1999).			**Total lbs. AI**		15,676,126.97
			Total lbs. Glyphosate		6,820,745.05
			Total lbs. non-Glyphosate		8,855,381.92

Table J-10A: Total Amount of Herbicide Used on Alfalfa for Seed, Scenario 1, 2007 Acreage

Scenario 1 Seed - 51% Adoption, 2007 Acreage					
		Schedule 0			
Active Ingredient	Maximum Application Rate (lbs. ai/acre, lbs. ae/acre)	# of Applications, Schedule 0 (Assuming 5.26 year stand life)	Pounds a.i./a.e. per acre, per year	# of Acres Treated (equal to 51% of total acreage in seed production)	Total Pounds a.i./a.e.
2,4-D	1.50	0.19	0.29	639	182.33
dicamba	1.00	0.19	0.19	639	121.55
glyphosate	1.50	1.14	1.71	53,729	91,931.75
		Conventional			
Active Ingredient	Average Annual Application Rate (lbs. ai/acre, lbs. ae/acre) based on Hower (1999)	Total Acres in Conventional Production (37% of total acreage farmed)	Relative % of Acres Treated	# of Acres Treated (Relative % of Acres multiplied by 37% of total acreage)	Total Pounds a.i./a.e.
2,4-DB	1.15	28,445	3.31%	942	1,082.76
Benefin	1.42	28,445	2.93%	833	1,183.48
Bentazon	1	28,445	0.10%	28	28.45
Bromoxynil	0.33	28,445	2.44%	694	229.04
DCPA	2.75	28,445	0.12%	34	93.87
Diclobenil	1.9	28,445	0.02%	6	10.81
Diuron	1.7	28,445	22.59%	6,426	10,923.73
EPTC	3.08	28,445	13.30%	3,783	11,652.21
Ethalfluralin	0.65	28,445	8.51%	2,421	1,573.44
Fluazifop	0.14	28,445	2.42%	688	96.37
Hexazinone	0.73	28,445	13.52%	3,846	2,807.41
Imazethapyr	0.06	28,445	0.48%	137	8.19
Paraquat	0.5	28,445	3.70%	1,052	526.23
Pendimethalin	1.25	28,445	1.74%	495	618.68
Pronamide	1.46	28,445	3.63%	1,033	1,507.53
Sethoxydim	0.27	28,445	0.63%	179	48.38
Simazine	0.8	28,445	3.68%	1,047	837.42
Terbacil	0.54	28,445	1.23%	350	188.93
Trifluralin	0.79	28,445	3.14%	893	705.61
Glyphosate	0.89	28,445	11.32%	3,220	2,865.78
			Total lbs. AI		129,223.95
			Total lbs. Glyphosate		94,797.53
			Total lbs. non-Glyphosate		34,426.42

Table J-11A: Total Amount of Herbicide Used on Alfalfa for Seed, Scenario 1, 2002 Acreage

Scenario 1 Seed - 51% Adoption, 2002 Acreage					
		Schedule 0			
Active Ingredient	**Maximum Application Rate (lbs. ai/acre, lbs. ae/acre)**	**# of Applications, Schedule 0 (Assuming 5.26 year stand life)**	**Pounds a.i./a.e. per acre, per year**	**# of Acres Treated (equal to 51% of total acreage in seed production)**	**Total Pounds a.i./a.e.**
2,4-D	1.50	0.19	0.29	510	145.58
dicamba	1.00	0.19	0.19	510	97.05
glyphosate	1.50	1.14	1.71	42,899	73,401.33
		Conventional			
Active Ingredient	**Average Annual Application Rate (lbs. ai/acre, lbs. ae/acre) based on Hower (1999)**	**Total Acres in Conventional Production (37% of total acreage farmed)**	**Relative % of Acres Treated**	**# of Acres Treated (Relative % of Acres multiplied by 37% of total acreage)**	**Total Pounds a.i./a.e.**
2,4-DB	1.15	22,711	3.31%	752	864.49
Benefin	1.42	22,711	2.93%	665	944.91
Bentazon	1	22,711	0.10%	23	22.71
Bromoxynil	0.33	22,711	2.44%	554	182.87
DCPA	2.75	22,711	0.12%	27	74.95
Diclobenil	1.9	22,711	0.02%	5	8.63
Diuron	1.7	22,711	22.59%	5,130	8,721.71
EPTC	3.08	22,711	13.30%	3,021	9,303.33
Ethalfluralin	0.65	22,711	8.51%	1,933	1,256.26
Fluazifop	0.14	22,711	2.42%	550	76.94
Hexazinone	0.73	22,711	13.52%	3,071	2,241.48
Imazethapyr	0.06	22,711	0.48%	109	6.54
Paraquat	0.5	22,711	3.70%	840	420.15
Pendimethalin	1.25	22,711	1.74%	395	493.96
Pronamide	1.46	22,711	3.63%	824	1,203.64
Sethoxydim	0.27	22,711	0.63%	143	38.63
Simazine	0.8	22,711	3.68%	836	668.61
Terbacil	0.54	22,711	1.23%	279	150.85
Trifluralin	0.79	22,711	3.14%	713	563.37
Glyphosate	0.89	22,711	11.32%	2,571	2,288.09
			Total lbs. AI		103,176.10
			Total lbs. Glyphosate		75,689.42
			Total lbs. non-Glyphosate		27,486.68

Table J-12A: Total Amount of Herbicide Used on Alfalfa for Seed, Scenario 2, 2007 Acreage

Scenario 2 Seed - 51% Adoption, 2007 Acreage					
		Schedule 1			
Active Ingredient	**Maximum Application Rate (lbs. ai/acre, lbs. ae/acre)**	**# of Applications, Schedule 1 (Assuming 5.26 year stand life)**	**Pounds a.i./a.e. per acre, per year**	**# of Acres Treated**	**Total Pounds a.i./a.e.**
2,4-D	1.50	0.19	0.29	639	182.33
dicamba	1.00	0.19	0.19	639	121.55
glyphosate	1.50	2.47	3.71	53,729	199,185.46
		Conventional			
Active Ingredient	**Average Annual Application Rate (lbs. ai/acre, lbs. ae/acre) based on Hower (1999)**	**Total Acres in Conventional Production (37% of total acreage farmed)**	**Relative % of Acres Treated**	**# of Acres Treated (Relative % of Acres multiplied by 37% of total acreage)**	**Total Pounds a.i./a.e.**
2,4-DB	1.15	28,445	3.31%	942	1,082.76
Benefin	1.42	28,445	2.93%	833	1,183.48
Bentazon	1	28,445	0.10%	28	28.45
Bromoxynil	0.33	28,445	2.44%	694	229.04
DCPA	2.75	28,445	0.12%	34	93.87
Diclobenil	1.9	28,445	0.02%	6	10.81
Diuron	1.7	28,445	22.59%	6,426	10,923.73
EPTC	3.08	28,445	13.30%	3,783	11,652.21
Ethalfluralin	0.65	28,445	8.51%	2,421	1,573.44
Fluazifop	0.14	28,445	2.42%	688	96.37
Hexazinone	0.73	28,445	13.52%	3,846	2,807.41
Imazethapyr	0.06	28,445	0.48%	137	8.19
Paraquat	0.5	28,445	3.70%	1,052	526.23
Pendimethalin	1.25	28,445	1.74%	495	618.68
Pronamide	1.46	28,445	3.63%	1,033	1,507.53
Sethoxydim	0.27	28,445	0.63%	179	48.38
Simazine	0.8	28,445	3.68%	1,047	837.42
Terbacil	0.54	28,445	1.23%	350	188.93
Trifluralin	0.79	28,445	3.14%	893	705.61
Glyphosate	0.89	28,445	11.32%	3,220	2,865.78
			Total lbs. AI		236,477.66
			Total lbs. Glyphosate		202,051.23
			Total lbs. non-Glyphosate		34,426.42

Table J-13A: Total Amount of Herbicide Used on Alfalfa for Seed, Scenario 2, 2002 Acreage

Scenario 2 Seed - 51% Adoption, 2002 Acreage					
		Schedule 1			
Active Ingredient	Maximum Application Rate (lbs. ai/acre, lbs. ae/acre)	# of Applications, Schedule 1 (Assuming 5.26 year stand life)	Pounds a.i./a.e. per acre, per year	# of Acres Treated	Total Pounds a.i./a.e.
2,4-D	1.50	0.19	0.29	510	145.58
dicamba	1.00	0.19	0.19	510	97.05
glyphosate	1.50	2.47	3.71	42,899	159,036.22
		Conventional			
Active Ingredient	Average Annual Application Rate (lbs. ai/acre, lbs. ae/acre) based on Hower (1999)	Total Acres in Conventional Production (37% of total acreage farmed)	Relative % of Acres Treated	# of Acres Treated (Relative % of Acres multiplied by 37% of total acreage)	Total Pounds a.i./a.e.
2,4-DB	1.15	22,711	3.31%	752	864.49
Benefin	1.42	22,711	2.93%	665	944.91
Bentazon	1	22,711	0.10%	23	22.71
Bromoxynil	0.33	22,711	2.44%	554	182.87
DCPA	2.75	22,711	0.12%	27	74.95
Diclobenil	1.9	22,711	0.02%	5	8.63
Diuron	1.7	22,711	22.59%	5,130	8,721.71
EPTC	3.08	22,711	13.30%	3,021	9,303.33
Ethalfluralin	0.65	22,711	8.51%	1,933	1,256.26
Fluazifop	0.14	22,711	2.42%	550	76.94
Hexazinone	0.73	22,711	13.52%	3,071	2,241.48
Imazethapyr	0.06	22,711	0.48%	109	6.54
Paraquat	0.5	22,711	3.70%	840	420.15
Pendimethalin	1.25	22,711	1.74%	395	493.96
Pronamide	1.46	22,711	3.63%	824	1,203.64
Sethoxydim	0.27	22,711	0.63%	143	38.63
Simazine	0.8	22,711	3.68%	836	668.61
Terbacil	0.54	22,711	1.23%	279	150.85
Trifluralin	0.79	22,711	3.14%	713	563.37
Glyphosate	0.89	22,711	11.32%	2,571	2,288.09
			Total lbs. AI		188,810.98
			Total lbs. Glyphosate		161,324.30
			Total lbs. non-Glyphosate		27,486.68

Table J-14A: Total Amount of Herbicide Used on Alfalfa for Seed, Scenario 3, 2007 Acreage

Scenario 3 Seed - 51% Adoption, 2007 Acreage					
		Schedule 2			
Active Ingredient	**Maximum Application Rate (lbs. ai/acre, lbs. ae/acre)**	**# of Applications, Schedule 1 (Assuming 5.26 year stand life)**	**Pounds a.i./a.e. per acre, per year**	**# of Acres Treated**	**Total Pounds a.i./a.e.**
2,4-D	1.50	0.19	0.29	639	185.42
dicamba	1.00	0.19	0.19	639	121.48
diuron	2.40	0.19	0.46	53,729	24,715.34
glyphosate	1.50	1.33	2.00	53,729	107,189.36
hexazinone	1.50	0.19	0.29	53,729	15,581.41
metribuzin	0.60	0.19	0.11	53,729	5,910.19
pendimethalin	4.00	0.29	1.14	53,729	61,251.06
trifluralin	2.00	0.29	0.57	53,729	30,625.53
		Conventional			
Active Ingredient	**Average Annual Application Rate (lbs. ai/acre, lbs. ae/acre) based on Hower (1999)**	**Total Acres in Conventional Production (37% of total acreage farmed)**	**Relative % of Acres Treated**	**# of Acres Treated (Relative % of Acres multiplied by 37% of total acreage)**	**Total Pounds a.i./a.e.**
2,4-DB	1.15	28,445	3.31%	942	1,082.76
Benefin	1.42	28,445	2.93%	833	1,183.48
Bentazon	1	28,445	0.10%	28	28.45
Bromoxynil	0.33	28,445	2.44%	694	229.04
DCPA	2.75	28,445	0.12%	34	93.87
Diclobenil	1.9	28,445	0.02%	6	10.81
Diuron	1.7	28,445	22.59%	6,426	10,923.73
EPTC	3.08	28,445	13.30%	3,783	11,652.21
Ethalfluralin	0.65	28,445	8.51%	2,421	1,573.44
Fluazifop	0.14	28,445	2.42%	688	96.37
Hexazinone	0.73	28,445	13.52%	3,846	2,807.41
Imazethapyr	0.06	28,445	0.48%	137	8.19
Paraquat	0.5	28,445	3.70%	1,052	526.23
Pendimethalin	1.25	28,445	1.74%	495	618.68
Pronamide	1.46	28,445	3.63%	1,033	1,507.53
Sethoxydim	0.27	28,445	0.63%	179	48.38
Simazine	0.8	28,445	3.68%	1,047	837.42
Terbacil	0.54	28,445	1.23%	350	188.93
Trifluralin	0.79	28,445	3.14%	893	705.61
Glyphosate	0.89	28,445	11.32%	3,220	2,865.78
			Total lbs. AI		282,568.10
			Total lbs. Glyphosate		110,055.13
			Total lbs. non-Glyphosate		172,512.97

Table J-15A: Total Amount of Herbicide Used on Alfalfa for Seed, Scenario 3, 2002 Acreage

Scenario 3 Seed - 51% Adoption, 2002 Acreage					
		Schedule 2			
Active Ingredient	Maximum Application Rate (lbs. ai/acre, lbs. ae/acre)	# of Applications, Schedule 1 (Assuming 5.26 year stand life)	Pounds a.i./a.e. per acre, per year	# of Acres Treated	Total Pounds a.i./a.e.
2,4-D	1.50	0.19	0.29	510	148.04
dicamba	1.00	0.19	0.19	510	96.99
diuron	2.40	0.19	0.46	42,899	19,733.54
glyphosate	1.50	1.33	2.00	42,899	85,583.51
hexazinone	1.50	0.19	0.29	42,899	12,440.71
metribuzin	0.60	0.19	0.11	42,899	4,718.89
pendimethalin	4.00	0.29	1.14	42,899	48,904.86
trifluralin	2.00	0.29	0.57	42,899	24,452.43
		Conventional			
Active Ingredient	Average Annual Application Rate (lbs. ai/acre, lbs. ae/acre) based on Hower (1999)	Total Acres in Conventional Production (37% of total acreage farmed)	Relative % of Acres Treated	# of Acres Treated (Relative % of Acres multiplied by 37% of total acreage)	Total Pounds a.i./a.e.
2,4-DB	1.15	22,711	3.31%	752	864.49
Benefin	1.42	22,711	2.93%	665	944.91
Bentazon	1	22,711	0.10%	23	22.71
Bromoxynil	0.33	22,711	2.44%	554	182.87
DCPA	2.75	22,711	0.12%	27	74.95
Diclobenil	1.9	22,711	0.02%	5	8.63
Diuron	1.7	22,711	22.59%	5,130	8,721.71
EPTC	3.08	22,711	13.30%	3,021	9,303.33
Ethalfluralin	0.65	22,711	8.51%	1,933	1,256.26
Fluazifop	0.14	22,711	2.42%	550	76.94
Hexazinone	0.73	22,711	13.52%	3,071	2,241.48
Imazethapyr	0.06	22,711	0.48%	109	6.54
Paraquat	0.5	22,711	3.70%	840	420.15
Pendimethalin	1.25	22,711	1.74%	395	493.96
Pronamide	1.46	22,711	3.63%	824	1,203.64
Sethoxydim	0.27	22,711	0.63%	143	38.63
Simazine	0.8	22,711	3.68%	836	668.61
Terbacil	0.54	22,711	1.23%	279	150.85
Trifluralin	0.79	22,711	3.14%	713	563.37
Glyphosate	0.89	22,711	11.32%	2,571	2,288.09
			Total lbs. AI		225,611.11
			Total lbs. Glyphosate		87,871.59
			Total lbs. non-Glyphosate		137,739.52

Appendix J-2. References

ASA (2001) American Soybean Association Conservation Tillage Study. http://www.soygrowers.com/ctstudy/ctstudy_files/frame.htm.

Bagavathiannan, M.V., and R.C. Van Acker. 2009. The Biology and Ecology of Feral Alfalfa (*Medicago sativa* L.) and Its Implications for Novel Trait Confinement in North America. *Critical Reviews in Plant Sciences*. 28(1):69-87.

Benbrook, C. M. (2004), Genetically Engineered Crops and Pesticide Use in the United States: The First Nine Years, Technical report, BioTech InfoNet, Technical Paper Number 7.

Benbrook, C. 2009. Impacts of Genetically Engineered Crops on Pesticide Use in the United States: The First Thirteen Years. The Organic Center Critical Issue Report. November, 2009. http://www.organic-center.org/reportfiles/13Years20091126_FullReport.pdf (accessed 3/3/10). pp. 1–69.

Borggaard, O.K. & Gimsing, A.L. (2007) Fate of glyphosate in soil and the possibility of leaching to ground and surface waters: a review. *Pest Management Science.* 64:441-456.

Bohm, G.M.B., Alves, B.J.R., Urquiaga, S., Boddey, R.M., Xavier, G.R., Hax, F., and Rombaldi, C.V. 2009. Glyphosate- and imazethapyr-induced effects on yield, nodule mass and biological nitrogen fixation in field-grown glyphosate-resistant soybean. *Soil Biology and Biochemistry* 41(2):420–422.

Brimner, T. A.; Gallivan, G. J. & Stephenson, G. R. (2005), Influence of herbicide-resistant canola on the environmental impact of weed management., *Pest Manag Sci* 61(1), 47--52. http://dx.doi.org/10.1002/ps.967.

Brothers, B.A. & Hesterman, O.B. (1991) Are herbicides necessary for alfalfa establishment?: Results from studies with conventional and no-till alfalfa. Proceedings of the Forage and Grassland Conference p.157-161.

Brookes, G. & Barfoot, P. (2006), Global Impact of Biotech Crops: Socio-Economic and Environmental Effects in the First Ten Years of Commercial Use, *AgBioForum* 9(3), 139-151.

Bull, L., H. Delvo, C. Sandretto, and B. Lindamood. 1993. Analysis of pesticide use by tillage system in 1990, 1991, and 1992 corn and soybeans. Agricultural Resource Situation and Outlook Report 32. Economic Research Service. United States Department of Agriculture.

Canevari, M., Vargas, R.N., and Orloff, S.B. 2007. Weed Management in Alfalfa, Technical report, University of California, Division of Agriculture and Natural Resources.

Proceedings, 37th California Alfalfa & Forage Symposium, Monterey, CA, 17-19 December, 2007. UC Cooperative Extension, Agronomy Research and Information Center, Plant Sciences Department, One Shields Ave., University of California, Davis 95616. http://alfalfa.ucdavis.edu.

Carpenter, J.E., and L.P. Gianessi. 2003. Trends in pesticide use since the introduction of genetically engineered crops. In Cerdeira, AL and SO Duke. 2006. The current status and environmental impacts of GT crops: a review. J. Environ. Qual. 35:1633:1658.

Caswell, M.; Fuglie, K.; Ingram, C.; Jans, S. & Kascak, C. (2001), Adoption of Agricultural Production Practices: Lessons Learned from the U.S. Department of Agriculture Area Studies Project, Technical report, USDA Agricultural Economic Report No. (AER792). http://www.ers.usda.gov/publications/aer792/aer792e.pdf.

Cerdeira, A. L. & Duke, S. O. (2006), The current status and environmental impacts of glyphosate-resistant crops: a review., *J Environ Qual* 35(5), 1633--1658. http://etmd.nal.usda.gov/bitstream/10113/7373/1/IND43835166.pdf

Conservation for Agricultures Future (No Year), Conservation Tillage, Purdue University. http://www2.ctic.purdue.edu/Core4/CT/CT.html.

Devos, Y.; Cougnon, M.; Vergucht, S.; Bulcke, R.; Haesaert, G.; Steurbaut, W.; Reheul, D. (2008) Environmental impact of herbicide regimes used with genetically modified herbicide-resistant maize. *Transgenic Res* (in press).

Dill, G. M.; CaJacob, C. A. & Padgette, S. R. (2008), Glyphosate-resistant crops: adoption, use and future considerations, *Pest Management Science* 64, 326-331.

Dillehay, B. L. & Curran, W. S. (2006), Guidelines for Weed Management in Roundup Ready® Alfalfa, *Weed Control Agronomy Facts* 65. http://cropsoil.psu.edu/extension/facts/agfact65.pdf.

Dillehay, BL (2007) Incorporating Glyphosate-Resistant Alfalfa into Field Crop Integrated Pest Management Programs of Pennsylvania. A Thesis in Agronomy.

Dillehay,B.L., Curran,W.S., Hall, M.H. (2009) Potential for Delayed Orchardgrass Seeding during Glyphosate-Resistant Alfalfa Establishment. Agronomy Journal, Volume 101, Issue 5, p1108-1112.

Dow AgroSciences. 2007. “Tordon 202C: Liquid Herbicide”. Dow AgroSciences Canada Inc. Document 2007-6961: pp 1-10.

Endres, G. 1999. “Control of Established Alfalfa, Fargo, 1993.” North Dakota State University Extension Service Pro Crop Database.

Fawcett, R. & Towery, D. (2002), Conservation Tillage and Plant Biotechnology: How New

Technologies Can Improve the Environment By Reducing the Need to Plow, Technical report, Conservation Technology Information Center.

Fernandez-Cornejo, J. (2006), Agricultural Resources and Environmental Indicators (AREI) Chapter 3.3: Biotechnology and Agriculture, USDA Economic Research Service. http://www.ers.usda.gov/publications/arei/eib16/Chapter3/3.3/.

Fomsgaard, I. S.; Spliid, N. H. & Felding, G. (2003), Leaching of pesticides through normal-tillage and low-tillage soil--a lysimeter study. II. Glyphosate., *J Environ Sci Health B* 38(1), 19--35.

Forage Genetics, Inc. (FGI). 2010. Trait Adoption Request. Personal Communication, July 30, 2010.

Forney, D. R.; Foy, C. L. & Wolf, D. D. (1985), Weed Suppression in No-Till Alfalfa (*Medicago sativa*) by Prior Cropping of Summer-Annual Forage Grasses, *Weed Science* 33, 490-497.

Getenga, Z. M. & Kengara, F. O. (2004), Mineralization of glyphosate in compost-amended soil under controlled conditions., *Bull Environ Contam Toxicol* 72(2), 266--275. http://dx.doi.org/10.1007/s00128-003-9004-9.

Gianessi, L. & Reigner, N. (2006), Pesticide Use in U.S. Crop Production: 2002, Insecticides & Other Pesticides, Technical report, CropLife Foundation, Crop Protection Research Institute. http://www.croplifefoundation.org/Documents/PUD/NPUD%202002/Fung%20&%20Herb%202002%20Data%20Report.pdf.

Gianessi, L. P. (2005), Economic and herbicide use impacts of glyphosate-resistant crops., *Pest Manag Sci* 61(3), 241--245. http://dx.doi.org/10.1002/ps.1013.

Gianessi, L. P.; Silvers, C. S.; Sankula, S. & Carpenter, J. E. (2002), Plant Biotechnology: Current and Potential Impact For Improving Pest Management In U.S. Agriculture An Analysis of 40 Case Studies Herbicide Tolerant Alfalfa, *National Center for Food and Agricultural Policy*, Technical report, National Center for Food and Agricultural Policy, 1-13. http://www.ncfap.org/40CaseStudies/CaseStudies/AlfalfaHT.pdf.

Giesy, J.P., S. Dobson and K.R. Solomon. 2000. Ecotoxicological Risk Assessment for Roundup® Herbicide., *Reviews of Environmental Contamination and Toxicology* 167, 35-120. http://www.monsanto.com/monsanto/content/products/productivity/roundup/ecotoxicological_risk.pdf.

Gimsing, A.; Borggaard, O. K.; Jacobsen, O. S.; Aamand, J. & Sørensen, J. (2004), Chemical and microbiological soil characteristics controlling glyphosate mineralisation in Danish surface soils, *Applied Soil Ecology* 27, 233-242.

Goldsborough, L. G. & Beck, A. E. (1989), Rapid Dissipation of Glyphosate in Small Forest Ponds, *Arch. Environ. Contam. Toxicol.* 18, 537-544.

Goldsborough, L. G. & Brown, D. (1993), Dissipation of Glyphosate and Anminomethylphosphonic Acid in Water and Sediments of Boreal Forest Ponds, *Environmental Toxicology and Chemistry* 12, 1139-1147.

Goodell, P. B. (2006), UC IPM Pest Management Guidelines: Alfalfa, Technical report, University of California. http://www.ipm.ucdavis.edu/PMG/r1900811.html?printpage.

Gregory, M.M., Shea, K.L., Bakko, E.B. (2005) Comparing agroecosystems: Effects of cropping and tillage patterns on soil, water, energy use, and productivity. *Renewable Agriculture and Food Systems*. 20(2):81-90.

Grunewald, K.; Schmidt, W.; Unger, C.; Hanschmann, G. (2001) Behavior of glyphosate and aminomethlyphosphonic acid (AMPA) in soils and water of reservoir Radeburg II catchment (Saxony/Germany). *J. Plant Nutr. Soil Sci.* vol 164, pp65-70.

Guerena, M. & Sullivan, P. (2003), Organic Alfalfa Production: Agronomic Production Guide, Technical report, Appropriate Technology Transfer for Rural Areas. http://attra.ncat.org/attra-pub/PDF/alfalfa.pdf.

Hall, M. H.; Jennings, J. A. & Shewmaker, G. E. (2004), Alfalfa Establishment Guide, *Forage and Grazelands Online*. Plant Management Network International. (GF-2004-0723-01-MG). http://www.plantmanagementnetwork.org/pub/fg/management/2004/alfalfa/.

Hanson, A.A., Barnes, D.K., and Hill, Jr., R.R. (eds.). 1988. Alfalfa and Alfalfa Improvement, Agronomy Monograph no. 29. ASA-CSSA-SSSA, Madison, Wisconsin. 1084 pp.

Harker, K. N.; Clayton, G.; Blackshaw, R.; ODonovan, J.; Lupwayi, N.; Johnson, E.; Gan, Y.; Zentner, R.; Lafond, G. & Irvine, R. (2005), Glyphosate-resistant spring wheat production system effects on weed communities, *Weed Science* 53, 451-464.

Heimlich, R.E., J. Fernandez–Cornejo,W. McBride, J.S. Klotz–Ingram, S. Jans, and N. Brooks. 2000. Genetically engineered crops: Has adoption reduced pesticide use? In Cerdeira, AL and SO Duke. 2006. The current status and environmental impacts of GT crops: a review. J. Environ. Qual. 35:1633:1658.

Hower, A.A., Harper, J.K., Harvey, R.G. (1999) The importance of pesticides and other pest management practices in U.S. alfalfa production. National Agricultural Pesticide Impact Assessment Program, USDA. (NAPIAP document number 2-CA-99).

Huhnke, R.L., Stritzke, J.F., Solie, J.B. (1993) Primary tillage effects on alfalfa establishment and yield. *American Society of Agricultural Engineers.* 9(6):495-499.

James, C. (2007) Global Status of Commercialized Biotech/GM Crops: 2007. International

Service for the Acquisition of Agi-biotech Applications (ISAAA). Brief 37. Executive Summary: http://www.isaaa.org/resources/publications/briefs/37/executivesummary/default.html.

Johnson, R. (2005), Type of tillage greatly affects soil quality, *Farm and Ranch Guide.* October 26. http://www.farmandranchguide.com/articles/2005/10/26/ag_news/production_news/prod17.txt.

Johnson, S. R.; Strom, S. & Grillo, K. (2008), Quantification of the Impacts on US Agriculture of Biotechnology-Derived Crops Planted in 2006, Technical report, National Center for Food and Agricultural Policy. http://www.ncfap.org/documents/Quantification%20of%20the%20Impacts%20on%20US%20Agriculture%20of%20Biotechnology.pdf.

Karlen, D.L., N.C. Wollenhaupt, D.C. Erbach, E.C. Berry, J.B. Swan, N.S. Eash, and J.L. Jordahl. 1994. Long-term tillage effects on soil quality. *Soil Tillage Research*. 32:313-327.

Karunatilake, U.P. & van Es, H.M. (2002) Rainfall and tillage effects on soil structure after alfalfa conversion to maize on a clay loam soil in New York. *Soil & Tillage Research* 67, pp. 135-146.

Kjaer, J.; Olsen, P.; Ullum, M. & Grant, R. (2005), Leaching of glyphosate and amino-methylphosphonic acid from Danish agricultural field sites. *J Environ Qual* 34(2), 608--620.

Kleter, G. A.; Bhula, R.; Bodnaruk, K.; Carazo, E.; Felsot, A. S.; Harris, C. A.; Katayama, A.; Kuiper, H. A.; Racke, K. D.; Rubin, B.; Shevah, Y.; Stephenson, G. R.; Tanaka, K.; Unsworth, J.; Wauchope, R. D. & Wong, S. (2007), Altered pesticide use on transgenic crops and the associated general impact from an environmental perspective, *Pest Manag Sci* 63, 1107-1115.

Kolpin, D. W.; Thurman, E. M.; Lee, E. A.; Meyer, M. T.; Furlong, E. T. & Glassmeyer, S. T. (2006), Urban contributions of glyphosate and its degradate AMPA to streams in the United States., *Sci Total Environ* 354(2-3), 191--197. http://dx.doi.org/10.1016/j.scitotenv.2005.01.028.

Kolpin, D. W.; Thurman, E. M. & Linhart, S. M. (1998), The environmental occurrence of herbicides: the importance of degradates in ground water., *Arch Environ Contam Toxicol* 35(3), 385—390.

Kovach, A. J.; Petzoldt, C.; Degni, J. & Tette, J. (2010), A Method to Measure the Environmental Impact of Pesticides, Technical report, Cornell University. Accessed October 17, 2010 at http://www.nysipm.cornell.edu/publications/eiq/.

Kovach, A. J.; Petzoldt, C.; Degni, J. & Tette, J. (2007), A Method to Measure the Environmental Impact of Pesticides, Technical report, Cornell University. http://nysipm.cornell.edu/publications/eiq/files/EIQ_values07.pdf.

Kovach, J.; Petzoldt, C.; Degni, J. & Tette, J. (1992), A Method to Measure the Environmental Impact of Pesticides, Technical report, Cornell University New York State Integrated Management Program. http://www.nysipm.cornell.edu/publications/eiq/.

Kremer, R.J., and Means, N.E. 2009. Glyphosate and glyphosate-resistant crop interactions with rhizosphere microorganisms. *European Journal of Agronomy* 31(3):153–161.

Laitinan, P. ; Ramo, S. ; Siimes, K. (2007) Glyphosate translocation from plants to soil – does this constitute a significant proportion of residues in soil? *Plant Soil*. Vol 300. pp. 51-60.

Lee, J.; Hundal, L. S.; Horton, R. & Thompson, M. L. (2001), Vadose Zone Processes and Chemical Transport, Sorption and Transport Behavior of Naphthalene in an Aggregated Soil, *Journal of Environmental Quality* **31**, 1716-1721. http://jeq.scijournals.org/cgi/reprint/31/5/1716.

Locke, M. A.; Zablotowicz, R. M. & Reddy, K. N. (2008), Integrating soil conservation practices and glyphosate-resistant crops: impacts on soil, *Pest Management Science* **64**, 457-469. http://www.ars.usda.gov/SP2UserFiles/Place/64022000/Publications/Zablotowicz/Locke%20et%20al.%2008%20PMS%2064-457-469.pdf.

Loux, M. M.; Stachler, J. M.; Johnson, W. G.; Nice, G. R. & Bauman, T. T. (2007), Weed Control Guide for Ohio Field Crops, Ohio State University. http://ohioline.osu.edu/b789/index.html.

Major, W. W.; Grue, C. E.; Gardner, S. C. & Grassley, J. M. (2003), Concentrations of Glyphosate and AMPA in Sediment Following Operational Applications of Rodeo to Control Smooth Cordgrass in Willapa Bay, Washington, USA, *Bulletin of Environmental Contamination and Toxicology* 71, 912-918.

Malhi, S.S., Johnston, A.M., Loeppky, H., Bandera, P.M.S. (2007) Tillage system and seeding time effects on forage and seed yield in alfalfa and bromegrass. *Communications in Soil Science and Plant Analysis.* 38, pp. 1897-1910.

Malone, R. W.; Shipitalo, M. J.; Wauchope, R. D. & Sumner, H. (2004), Residual and contact herbicide transport through field lysimeters via preferential flow., *J Environ Qual* 33(6), 2141—2148.

Manitoba Agriculture and Food. 2002. “Getting out Alfalfa with Herbicides.” University of Manitoba Faculty of Agriculture and Food Sciences. http://www.gov.mb.ca/agriculture/crops/forages/bjb00s12.html.

Mamy, L.; Barriuso, E. & Gabrielle, B. (2005), Environmental fate of herbicides trifluralin, metazachlor, metamitron and sulcotrione compared with that of glyphosate, a substitute broad spectrum herbicide for different glyphosate-resistant crops., *Pest Manag Sci* 61(9), 905--916. http://dx.doi.org/10.1002/ps.1108.

Mayerle, G. 2002. "Eradicating Alfalfa for Direct Seeding." The Newsletter of the Saskatchewan Soil Conservation Association. 33.

McCordick, S. A.; Hillger, D. E.; Leep, R. H. & Kells, J. J. (2008), Establishment Systems for Glyphosate-Resistant Alfalfa, *Weed Technology* 22, 22-29.

Mends, C. & Dobbs, T. (1991), Effect of Including Alfalfa in Whole-Farm Plans: Comparison of Conventional, Ridge Till, and Alternative Farming Systems, Technical report, Department of Economics South Dakota State University, Brookings, South Dakota. Economics Staff Paper No. 91-1.

Miller, J.; Hill, B. D.; Chang, C. & Lindwall, C. (1995), Residue detections in soil and shallow groundwater after long-term herbicide applications in southern Alberta, *Canadian Journal of Soil Science*, 349-356.

Miller, S. D.; Wilson, R. G.; Kniss, A. R. & Alford, C. M. (2006), Roundup Ready® Alfalfa: A new technology for high plains hay producers, Technical report, University of Wyoming Cooperative Extension Service.

Monsanto (2008), Technology Use Guide, Technical report, Monsanto. http://www.monsanto.com/monsanto/ag_products/pdf/stewardship/2008tug.pdf.

Montgomery, D.R. (2007) Soil erosion and agricultural sustainability. *PNAS*. 104(33)13268-13272. http://www.pnas.org/content/104/33/13268.full.pdf+html.

OMAFRA (2008), Guide to Weed Control, Technical report, Ontario Ministry of Agriculture, Food and Rural Affairs. http://www.omafra.gov.on.ca/english/crops/pub75/1use.htm.

Orloff, S. B.; Carlson, H. L. & Teuber, L. R. (1997) *Intermountain Alfalfa Management*, Vol. 3366, University of California, Division of Agriculture and Natural Resources. http://ucce.ucdavis.edu/files/filelibrary/2129/18336.pdf.

Orloff, S.B., Daniel H. Putnam, Mick Canevari, and W. Thomas Lanini. (2009) Avoiding Weed Shifts and Weed Resistance in Roundup Ready® Alfalfa Systems. University of California Agriculture and Natural Resources, Publication 8362. www.anrcatalog.ucdavis.edu.

Owen, M. (1998), Pesticide drift complaints in 1998 on a record pace, *Iowa State University Weed Science*. http://www.weeds.iastate.edu/weednews/drift.htm.

Padgitt, M.; Newton, D.; Penn, R. & Sandretto, C. (2000), Production Practices for Major Crops

in U.S. Agriculture, 1990-97, Technical report, USDA Statistical Bulletin No. (SB969). http://www.ers.usda.gov/publications/sb969/sb969e.pdf.

Peel, M. D. (1998), Crop Rotations for Increased Productivity, Technical report, North Dakota State University College of Agriculture, Food Systems, and Natural Resources. http://www.ag.ndsu.edu/pubs/plantsci/crops/eb48-1.htm.

Peterson, R. & Hulting, A. (2004), A comparative ecological risk assessment for herbicides used on spring wheat: the effect of glyphosate when used within a glyphosate-tolerant wheat system, *Weed Science* 52, 834-844.

Pierson, P. and Reyes, C. 2006. Roundup Ready® Alfalfa – Summary of Third-Party Data for Yield, Forage Quality and Crop Safety. Proceedings of the 40th North American Alfalfa Improvement Conference and 19th Trifolium Conference, July 16-19, 2006, Bloomington, MN. http://www.naaic.org/Meetings/National/2006meeting/procedings/Pierson.PDF.

Powell, J.R., and Swanton, C.J. 2008. A critique of studies evaluating glyphosate effects on diseases associated with *Fusarium* spp. *Weed Research* 48(4): 307–318.

Putnam, D.; Russelle, M.; Orloff, S.; Kuhn, J.; Fitzhugh, L.; Godfrey, L.; Kiess, A. & Long, R. (2001), Alfalfa, Wildlife, and the Environment: The Importance and Benefits of Alfalfa in the 21st Century, Technical report, California Alfalfa and Forage Association. http://alfalfa.ucdavis.edu/-files/pdf/Alf_Wild_Env_BrochureFINAL.pdf.

Ragnarsdottir, V. (2006) The state we are in – understanding the life-cycle of soils. Worldwide Universities Network Research Review. March 2006. pp 16-17. http://www.wun.ac.uk/wsc/documents/soilspaperVR.pdf.

Reicosky, D.C. 2007. Environmental benefits of reduced tillage and soil carbon management in water-limited areas of Central Asia. p. 199-209. In R. Lal et al. (eds.), Climate Change and Terrestrial Carbon Sequestration in Central Asia. Taylor & Francis, London; New York.

Renz, M. (2007), Fall Alfalfa Removal Using Herbicides, University of Wisconsin. http://ipcm.wisc.edu/WCMNews/tabid/53/EntryID/387/Default.aspx.

Rogan, G. & Fitzpatrick, S. (2004), Petition for Determination of Nonregulated Status: Roundup Ready® Alfalfa (*Medicago sativa* L.) Events J101 and J163, Technical report, Monsanto. http://www.aphis.usda.gov/brs/aphisdocs/04_11001p.pdf.

Sankula, S. (2006), Quantification of the impacts on US Agriculture of Biotechnology-Derived Crops Planted in 2005, Technical report, National Center for Food and Agricultural Policy. http://www.ncfap.org/documents/Quantification%20of%20the%20Impacts%20on%20US%20Agriculture%20of%20Biotechnology.pdf.

Sankula, S.; Marmon, G. & Blumenthal, E. (2005), Biotechnology-Derived Crops Planted in 2004 - Impacts on US Agriculture, Technical report, National Center for Food and Agricultural Policy. http://www.whybiotech.com/resources/tps/BiotechnologyDerivedCropsPlantedin2004.pdf.

Scribner, E. A.; Battaglin, W. A.; Gilliom, R. & Meyer, M. (2007), Concentrations of Glyphosate, Its Degradation Product, Aminomethylphosphonic Acid, and Glufosinate in Ground-and-Surface-Water, Rainfall, and Soil Samples Collected in the United States, 2001-06, Technical report, U.S. Department of the Interior, USGS. http://pubs.usgs.gov/sir/2007/5122/.

SDSU. 2010. *Weed Control: SDSU Cooperative Extension Service*. Retrieved from http://plantsci.sdstate.edu/weeds/weed_description.cfm?weed=Leafy%20spurge.

Shukla, M.; Lal, R. & Ebinger, M. (2003), Tillage Effects on Physical and Hydrological Properties of a Typic Argiaquoll in Central Ohio, *Soil Science* 168, 802-811.

Speth, T.F. (1994) Glyphosate removal from drinking water. *J of Environmental Engineering.* Vol 199, pp. 1139-1157.

Smith, D.; Beck, K.; Peairs, F. & Brown, W. (1998), Alfalfa: Production and Management, Colorado State University Extension, Technical report, Colorado State University. http://www.ext.colostate.edu/Pubs/crops/00703.html.

Tickes, B. (2002), Evaluation of Stinger (Clopyralid) for Weed Control in Broccoli, Technical report, University of Arizona Cooperative Extension. http://cals.arizona.edu/pubs/crops/az1292/az1292_5d.pdf.

Torstensson, L.; Borjesson, E. & Stenstrom, J. (2005), Efficacy and fate of glyphosate on Swedish railway embankments, *Pest Management Science* 61, 881-886.

Trewavas, A. and C. Leaver. 2001. Is opposition to GM crops science or politics? An investigation into the arguments that GMcrops pose a particular threat to the environment. In Cerdeira, AL and SO Duke. 2006. The current status and environmental impacts of GT crops: a review. J. Environ. Qual. 35:1633:1658.

University of Illinois. 2010. *The Bulletin*. http://bulletin.ipm.illinois.edu/contents.php.

USDA FS (United States Department of Agriculture Forest Service). 2002. U.S. Forest service requires the use of noxious weed-free hay. Aug. 5, 2002.

USDA FS (United States Department of Agriculture Forest Service). 2003. Glyphosate -Human Health and Ecological Risk Assessment Final Report, Technical report, USDA, Forest Service. http://teamarundo.org/control_manage/docs/04a03_glyphosate.pdf.

U.S. EPA (United States Environmental Protection Agency). 1993. Reregistration Eligibility Decision (RED): Glyphosate, Technical report, Office of Prevention, Pesticides and Toxic Substances. EPA 738-R-93-014, September 1993.

U.S. EPA (United States Environmental Protection Agency). 1996. Reregistration Eligibility Decision for Trifluralin. EPA-738-F-95-035, April 1996.

U.S. EPA (United States Environmental Protection Agency). 1997. Reregistration Eligibility Decision (R.E.D.) Facts, Paraquat Dichloride. EPA-738-F-96-028, August 1997.

U.S. EPA (United States Environmental Protection Agency). 1998. Reregistration Eligibility Decision for Alachlor. EPA-738-R-98-020, December 1998.

U.S. EPA (United States Environmental Protection Agency). 2002. Reregistration Eligibility Decision for Benomyl. EPA-738-R-02-011, July 31, 2002.

U.S. EPA (United States Environmental Protection Agency). 2003. Reregistration Eligibility Decision for Diuron, Case Number 0046, September 30, 2003.

U.S. EPA (United States Environmental Protection Agency). 2006. Glyphosate New Use (bent-grass): Environmental Fate and Effects Risk Assessment. Office of Prevention, Pesticides, And Toxic Substances/ Environmental Fate and Effects Division. May 2006. Authored by Silvia Termes and Daniel Rieder.

U.S. EPA (United States Environmental Protection Agency). 2009a. Corrections to the Amendments to the Dicamba Reregistration Eligibility Decision (RED). EPA-HQ-OPP-206-0479, June 17, 2009.

U.S. EPA (United States Environmental Protection Agency). 2009b. Glyphosate Summary Document and Registration Review Document for Glyphosate, Case Number 0178. June. http://www.regulations.gov/search/Regs/home.html#docketDetail?R=EPA-HQ-OPP-2009-0361.

USHHS (U.S. Department of Health and Human Services), Public Health Service. 1997. Agency for Toxic Substances and Disease Registry (ATSDR). Hazardous Substances Emergency Events Surveillance (HSEES) 1997 Annual Report. Division of Health Studies Epidemiology and Surveillance Branch.

Vereecken, H. (2005), Mobility and leaching of glyphosate: a review, *Pest Management Science* 61, 1139-1151.

Vogue, P.; Kerle, E. & Jenkins., J. (1994), OSU Extension Pesticide Properties Database, National Pesticide Information Center. http://npic.orst.edu/ppdmove.htm.

Wang, N.; Besser, J.M.; Buckler, D.R.; Honegger, J.L.; Ingersoll, C.G.; Johnson, B.T.,

Kurtzweil, M.L.; MacGregor, J.; McKee, M.J. (2005) Influence of sediment on the fate and toxicity of a polyethoxylate tallowamine surfactant system (MON 0818) in aquatic microcosms. *Chemosphere*. 59 pp.545-551.

Warnemuende, E.A., J.P. Patterson, D.R. Smith, and C. Huang. 2007. Effects of tilling no-till soil on losses of atrazine and glyphosate to runoff water under variable intensity simulated rainfall. *Soil & Tillage Research*. 95:19-26.

Wauchope, R. D.; Estes, T. L.; Allen, R.; Baker, J. L.; Hornsby, A. G.; Jones, R. L.; Richards, R. P. & Gustafson, D. I. (2001), Predicted impact of transgenic, herbicide tolerant corn on drinking water quality in vulnerable watersheds of the mid-western USA., *Pest Manag Sci* 58(2), 146--160. http://dx.doi.org/10.1002/ps.433.

Wiebe, K. & Gollehon, N. (2006), Information Bulletin 16 Agricultural Resources and Environmental Indicators 2006 Edition, Technical report, USDA. http://www.ers.usda.gov/publications/arei/eib16/eib16.pdf.

Xuan, T. D.; Tawata, S.; Khanh, T. D. & Chung I. M (2005) Cropping and Forage Systems/ Crop Ecology/ Organic Farming: Decomposition of Allelopathic Plants in Soil. J. Agronomy & Crop Science 191, 162-171.

Zollinger, R. K. (2008), 2008 North Dakota Weed Control Guide, Technical report, North Dakota State University College of Agriculture, Food Systems, and Natural Resources. http://www.ag.ndsu.edu/weeds/w253/w253-3f.htm.

Appendix J-3. Literature Search

1.0 Literature Search Strategy

1.1 Purpose

The purpose of this literature search is to locate references about the potential impacts of glyphosate-tolerant alfalfa cultivation practices on water, soil, and air.

1.2 Retrieval criteria

Titles were used to indicate the subject of the paper. If the paper was not in English or indicated a geographic region outside of the United States, it was not retrieved. Over 90 pages of titles were generated by the searches (see Results below). All titles were reviewed and approximately 50 titles were deemed relevant to provide information on cultivation practices in alfalfa (highlighted in gray in the Results below). The selected titles were searched for online by a professional librarian. Titles that were obtained for free and were cited include the URL in the citation. Titles that were not free access were obtained through online purchase or the use of a copy vendor, who regularly visits National Institutes of Health and National Agricultural Library to obtain references. Not all of the articles were retrieved due to availability. Books that were of marginal interest were not purchased.

1.3 Databases

File 10:AGRICOLA 70-2008/Jun
(c) format only 2008 Dialog
File 156:ToxFile 1965-2008/Jun W2
(c) format only 2008 Dialog
File 266:FEDRIP 2008/Feb
Comp & dist by NTIS, Intl Copyright All Rights Res
File 245:WATERNET(TM) 1971-2008Apr
(c) 2008 American Water Works Association
File 5:Biosis Previews(R) 1926-2008/Jun W2
(c) 2008 The Thomson Corporation
File 6:NTIS 1964-2008/Jun W4
(c) 2008 NTIS, Intl Cpyrght All Rights Res
File 41:Pollution Abstracts 1966-2008/May
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(c) 2008 Congressional Information Service
File 76:Environmental Sciences 1966-2008/Jun
(c) 2008 CSA.
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(c) 2008 CSA.

File 117:Water Resources Abstracts 1966-2008/Mar
(c) 2008 CSA.
File 144:Pascal 1973-2008/Jun W2
(c) 2008 INIST/CNRS
File 50:CAB Abstracts 1973-2008/May W4
(c) 2008 CAB International
File 44:Aquatic Science & Fisheries Abstracts 1966-2008/Mar
(c) 2008 CSA.
File 71:ELSEVIER BIOBASE 1994-2008/Jun W2
(c) 2008 Elsevier B.V.
File 143:Biol. & Agric. Index 1983-2008/Apr
(c) 2008 The HW Wilson Co
File 203:AGRIS 1974-2008/Feb
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1.4 Scope of Search

The search focused on any published references between 1990 and the present. A list of titles (below) was screened followed by screening of abstracts for relevant titles. There were no limits on language for titles but only English language publications were retrieved for evaluation.

1.5 Key word combinations

Alfalfa OR Medicago AND "organic farm*"

Alfalfa OR Medicago AND cultivation

Alfalfa OR Medicago AND till*

Glyphosate AND water AND contamination

Glyphosate AND air AND contamination

Glyphosate AND soil AND contamination

1.6 Key Questions

(numbering from original APHIS scope document)

5. What differences are there in weediness traits of conventional alfalfa versus glyphosate-tolerant alfalfa under managed crop production systems as well as in unmanaged ecosystems?

6. What is the occurrence of common and serious weeds found in organic alfalfa systems, in conventional alfalfa systems, and in glyphosate-tolerant alfalfa systems?

What are the current impacts of weeds, herbicide-tolerant weeds, weed management practices, and unmet weed management needs for organic and conventional alfalfa cultivation?
How may the weed impacts change with the use of glyphosate-tolerant alfalfa?

7. What are the particular management practices for controlling weeds in organic alfalfa systems, in conventional alfalfa systems, and in glyphosate-tolerant alfalfa systems?
What are the potential changes in crop rotation practices and weed management practices for control of volunteer alfalfa or herbicide-tolerant weeds in rotational crops that may occur with the use of glyphosate-tolerant alfalfa?
What are the potential effects on alfalfa stand termination and renovation practices that may occur with the use of glyphosate-tolerant alfalfa?
What is the potential weediness of glyphosate-tolerant alfalfa?

8. What is the potential cumulative impact of glyphosate-resistant weeds, especially with the increase in acreage of glyphosate-tolerant crops?
Are there glyphosate-resistant weeds and what is their prevalence in crops and in noncrop ecosystems?
Will the release of glyphosate-tolerant alfalfa cause an increase in glyphosate-resistant weeds in alfalfa and in other crops?
Which weeds are the most likely to gain glyphosate resistance with the use of glyphosate-tolerant alfalfa?
What are the alternatives for management of glyphosate-tolerant or other herbicide-tolerant weeds in glyphosate-tolerant alfalfa stands or in subsequent crops?
What are the potential changes that may occur in glyphosate-tolerant alfalfa as to susceptibility or tolerance to other herbicides?

9. What are current or prospective herbicide-tolerant weed mitigation options, including those addressed by the Environmental Protection Agency-approved label for glyphosate herbicides?

1.7 Results

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      S1  147012  ALFALFA OR MEDICAGO
      S2  873388  ORGANIC()FARM? OR CULTIVAT? OR TILL OR TILLED OR TILLS OR
                  TILLING OR TILLAGE
      S628645322  PY=1926:1989 [faster to take out older than keep newer]
      S7   72469  S1 NOT S6
      S8    5994  S7 AND S2
      S9    3010  S7 (S) S2
     S10     444  S9/TI
     S11     171  RD S10  (unique items)

 12/6/1     (Item 1 from file: 203)
 01571304
   Adaptablity and *cultivation* methods of Xinjiang broad leaf *alfalfa*
   1990

 12/6/2     (Item 2 from file: 50)
0008462009   CAB Accession Number: 20033094659
   Agronomic and energy evaluation of clover [ Trifolium sp.] and lucerne [
```

Medicago sativa] mixed *cultivation* in forest steppe of the cis-Urals.
Publication Year: 2003

12/6/3 (Item 3 from file: 203)
02090131
Alfalfa (*Medicago* sativa L.) samples *cultivated* in vitro and evaluated as selection resourse (Selektsionna otsenka na obraztsi lyutserna (Medicago sativa L.), polucheni chrez in vitro metoda)
1995

12/6/4 (Item 4 from file: 10)
4528411 43826342 Holding Library: AGL
Alfalfa management in no-*tillage* corn
2006

12/6/5 (Item 5 from file: 10)
3151543 92012874 Holding Library: AGL
Alfalfa and orchardgrass control in no-*till* corn
1991

12/6/6 (Item 6 from file: 50)
0006456718 CAB Accession Number: 19912312898
Alfalfa and orchardgrass control in no-*till* corn.
Proceedings, 45th annual meeting of the Northeastern Weed Science Society.
Publication Year: 1991

12/6/7 (Item 7 from file: 5)
10787694 BIOSIS NO.: 199192033465
ANTAGONISTIC POTENTIAL OF SOIL MICROFLORA TO VERTICILLIUM-DAHLIAE KLEB. IN COTTON-*ALFALFA* CROP ROTATION FIELDS AS A FUNCTION OF THE DEPTH AND TECHNIQUES OF *CULTIVATION*
1990

12/6/8 (Item 8 from file: 50)
0009012128 CAB Accession Number: 20063044893
Assessing inter and intra-population genetic diversity and structure in Iranian *cultivated* *alfalfa* (*Medicago* sativa L.) using microsatellite markers.
Publication Year: 2005

12/6/9 (Item 9 from file: 203)
02673757
2006
[Breeding value of *alfalfa* wild species and species of limited occurrence as *cultivated* plants] (Selektsionnaya tsennost' dikorastushchikh i malo rasprostranennykh v kul'ture vidov lyutserny)

12/6/10 (Item 10 from file: 5)
0019803970 BIOSIS NO.: 200700463711
Basic technological criteria for *alfalfa* *cultivation*
ORIGINAL LANGUAGE TITLE: A Lucernatermesztes Technologiaialapjai
2007

12/6/11 (Item 11 from file: 50)
0006540291 CAB Accession Number: 19921966293

Copper fractions in the soil-plant system influenced during *alfalfa* *cultivation*. Proceedings - Congress of the European Society of Agronomy.
Publication Year: 1990

12/6/12 (Item 12 from file: 203)
02212551
Chemical composition and quality of the forage of *alfalfa* varieties *cultivated* under different water supply and fertilization (Khimichen s"stav i kachestvo na furaza ot sortove lyutserna, otglezhdani pri razlichna vodoosigurenost i torene)
1996

12/6/13 (Item 13 from file: 203)
02017956
1995
[Chemical control of broad-leaved weeds in *alfalfa* *cultivation*] (Control quimico de malezas latifoliadas en implantacion del cultivo de alfalfa)

12/6/14 (Item 14 from file: 50)
0008402962 CAB Accession Number: 20033036095
Chemical control of weeds in winter wheats *cultivated* with *alfalfa* as a companion crop.
Original Title: Chemiczne zwalczanie chwastow w zbozach ozimych z wsiewka, koniczyny akowej.
Publication Year: 2002

12/6/15 (Item 15 from file: 5)
10509480 BIOSIS NO.: 199141022106
CHANGES IN THE BIOCHEMICAL INDICES OF *ALFALFA* CULTIVARS *CULTIVATED* IN THE CENTRAL ASIAN REGION USSR INDUCED BY INOCULATION WITH NODULE BACTERIA
1990

12/6/16 (Item 16 from file: 10)
2127848 83786077 Holding Library: AGL; AGL
Alfalfa *cultivation.*
Cultivo de la alfalfa / por Ramon Garcia Oses. -
1921

12/6/17 (Item 17 from file: 50)
0008640724 CAB Accession Number: 20043052199
Cultivation of Galega orientalis and *Medicago* varia as a resource-saving measure.
Publication Year: 2001

12/6/18 (Item 18 from file: 50)
0007442035 CAB Accession Number: 19970709723
Cultivation of lucerne [*Medicago* sativa] in Zemaitija, Lithuania.
Original Title: Liucernu auginamas Zemaitijoje.
Publication Year: 1995

12/6/19 (Item 19 from file: 50)
0008065480 CAB Accession Number: 20013086523
Cultivating *alfalfa* mixed with timothy: changes in harvest and nutritive value.
Original Title: Saagi ja toitevaartuse muutused lutserni kasvatamisel

segus poldtimutiga.
Publication Year: 2001

12/6/20 (Item 20 from file: 203)
01962509
1993
[The *cultivation* of the *alfalfa* in the half zone of San Luis Potosi State] (El cultivo de la alfalfa en la zona media de San Luis Potosi)

12/6/21 (Item 21 from file: 203)
01552318
1990
[Cultivation of roughage [grasses, whole crop, *alfalfa*, beets, maize, textbook]] (Dyrkning af grovfoder)

12/6/22 (Item 22 from file: 203)
01856014
Cultivation technique for high yield of Xinjiang big leaf *alfalfa*
1993

12/6/23 (Item 23 from file: 10)
3771212 22002348 Holding Library: AGL
Cultivation of established *alfalfa* stands
1996

12/6/24 (Item 24 from file: 50)
0008931181 CAB Accession Number: 20053196860
Calcium and magnesium ratio in the fertility of a dystrophic dark red latosol *cultivated* with *alfalfa*.
Original Title: Relacao calcio e magnesio na fertilidade de um latossolo vermelho escuro distrofico cultivado com alfafa.
Publication Year: 2005

12/6/25 (Item 25 from file: 5)
15805592 BIOSIS NO.: 200000523905
[Study comparing the morphological features and productivity of *alfalfa* (*Medicago* media Pers.) *cultivated* in pure sowing and in mixtures with plants of the Papilionaceae family and grasses. Part I: Morphological features of the plants and the structure of the field in relation to the *cultivation* method]
ORIGINAL LANGUAGE TITLE: Studium porownawcze cech morfologicznych i produktywnosci lucerny mieszancowej (Medicago media Pers.) uprawianej w czystym siewie i w mieszankach z roslinami motylkowatymi i trawami
1998

12/6/26 (Item 26 from file: 50)
0007919170 CAB Accession Number: 20000710029
Comparative study of morphological traits and productivity of *alfalfa* (*Medicago* media Pers) *cultivated* in pure stands and in mixture with legumes and grasses. Part II. Relationship between morphological traits of legumes at the 1st cut.
Original Title: Studium porownawcze cech morfologicznych i produktywnosci lucerny mieszanscowej (Medicago media Pers) uprawianej w czystym siewie i w mieszankach z roslinami motylkowatymi i trawami. Cz. II. Wspozaleznoscs cech morfologicznych roslin motylkowatych w I pokosie.
Publication Year: 1999

12/6/27 (Item 27 from file: 5)
15897459 BIOSIS NO.: 200100069298
[Comparative study of morphological traits and productivity of *alfalfa* (*Medicago* media Pers) *cultivated* in pure sowing and in mixture with papilionaceous plants and grasses. Part II. Relationship between morphological traits of papilionaceous in 1-st cutting]
ORIGINAL LANGUAGE TITLE: Studium porownawcze cech morfologicznych i produktywnosci lucerny mieszancowej (Medicago media Pers) uprawianej w czystym siewie i w mieszankach z roslinami motylkowatymi i trawami
1999

12/6/28 (Item 28 from file: 10)
3427693 20445776 Holding Library: AGL
A comparison of irrigated corn production in no-*till* and plowed *alfalfa* sod
1995 Jan

12/6/29 (Item 29 from file: 10)
3305068 93047263 Holding Library: AGL
Comparison of slug Mollusca: Pulmonata) trapping in no-*till* *alfalfa*
1993 Jun

12/6/30 (Item 30 from file: 203)
02520808
[The content of heavy metals in *cultivated* *alfalfa*] (Continutul metalelor grele in lucerna cultivata)
2001
[Breeding and technologies of cultivation of leguminous and forage crops] (Ameliorarea si tehnologiile de cultivare a culturilor leguminoase si furajere)

12/6/31 (Item 31 from file: 50)
0007606289 CAB Accession Number: 19982303279
Control of Johnson grass (Sorghum halepense (L.) Pers.) in *alfalfa* stands *cultivated* for forage and seeds.
Publication Year: 1997

12/6/32 (Item 32 from file: 10)
3700197 21806066 Holding Library: AGL
Control of established *alfalfa* (*Medicago* sativa L.) and red clover (Trifolium pratense L.) in a no-*till* corn (Zea mays L.) cropping sequence
1998

12/6/33 (Item 33 from file: 144)
13970916 PASCAL No.: 99-0153354
Contrasting patterns of genetic diversity in neutral markers and agromorphological traits in wild and *cultivated* populations of *Medicago* sativa L. from Spain
Methodologies de gestion et de conservation des ressources genetiques (Methodologies of genetic resources management and conservation) 1998

12/6/35 (Item 35 from file: 10)
3486532 20488449 Holding Library: AGL
Conventional vs. no-*till* corn following *alfalfa*/grass: timing of vegetation kill
1992 Sep

12/6/36 (Item 36 from file: 50)
0008151196 CAB Accession Number: 20013097991
Conservation *tillage* using organic fertilizer mulch in *alfalfa*.
Original Title: Labranza de conservacion usando coberturas de abono organico en alfalfa.
Publication Year: 2000

12/6/37 (Item 37 from file: 5)
0019523483 BIOSIS NO.: 200700183224
Construction of two genetic linkage maps in *cultivated* tetraploid *alfalfa* (*Medicago* sativa) using microsatellite and AFLP markers
2003

12/6/38 (Item 38 from file: 10)
3814170 22036904 Holding Library: AGL
Differentiation between natural and *cultivated* populations of *Medicago* sativa (Leguminosae) from Spain: analysis with random amplified polymorphic DNA (RAPD) markers and comparison to allozymes
1999

12/6/39 (Item 39 from file: 144)
09268349 PASCAL No.: 91-0058724
Les divers pratiques de la culture de la luzerne
(Different practices of *alfalfa* *cultivation*)
1990

12/6/40 (Item 40 from file: 50)
0008742538 CAB Accession Number: 20043161675
Study of daily water consumption by the species *Medicago* sativa *cultivated* in the Chinteni experimental field, Cluj county.
Original Title: Cercetari privind consumul diurn de apa al speciei *Medicago* sativa , *cultivata* in campul experimental chinteni - jud. cluj.
Publication Year: 2001

12/6/41 (Item 41 from file: 203)
02307377
Dry matter production and seasonal distribution and chemical composition of alfafa *cultivates* (*Medicago* sativa L.) (Producao e distribuicao de materia seca e composicao bromatologica de cultivares de alfafa (Medicago sativa L.))
1998

12/6/42 (Item 42 from file: 5)
14750697 BIOSIS NO.: 199900010357
Dry matter production and seasonal distribution and chemical composition of *alfalfa* *cultivates* (*Medicago* sativa L.)
1998

12/6/43 (Item 43 from file: 50)
0008340690 CAB Accession Number: 20023168644
Efficiency of phosphorus sources and rates for *alfalfa* and centrosema *cultivated* in an Yellow Latosol (Oxisol).
Original Title: Eficiencia de fontes e doses de fosforo na alfafa e centrosema cultivadas em Latossolo Amarelo.
Publication Year: 2002

12/6/44 (Item 44 from file: 50)
0008393650 CAB Accession Number: 20033018750
Effect of *cultivation* of *Medicago* sativa on soil fertility in Tabarian and Tavacolbagh rangelands of Khorasan Province.
Publication Year: 2002

12/6/45 (Item 45 from file: 10)
3170991 92027340 Holding Library: AGL
Effects of coated seed on *alfalfa* stand density and yield in reduced *tillage* systems
1991

12/6/46 (Item 46 from file: 50)
0008018862 CAB Accession Number: 20013038660
The influence of different ways of *alfalfa* (*Medicago* sativa L.) stands *cultivation* on its yield capacity.
Publication Year: 2001

12/6/47 (Item 47 from file: 10)
3871266 22085890 Holding Library: AGL
Effect of field inoculation with Sinorhizobium meliloti L33 on the composition of bacterial communities in rhizospheres of a target plant (*Medicago* sativa) and a non-target plant (Chenopodium album)--linking of 16S rRNA gene-based single-strand conformation polymorphism community profiles to the diversity of *cultivated* bacteria
2000

12/6/48 (Item 48 from file: 143)
1248332 H.W. WILSON RECORD NUMBER: BBAI00048200
Effect of field inoculation with Sinorhizobium meliloti L33 on the composition of bacterial communities in rhizospheres of a target plant (*Medicago* sativa) and a non-target plant (Chenopodium album)--linking of 16S rRNA polymorphism community profiles to the diversity of *cultivated* bacteria
20000800

12/6/49 (Item 49 from file: 50)
0008843019 CAB Accession Number: 20053095618
Effects of growing system, soil *cultivation* and stage of development on crude protein and fibre content in *alfalfa* (*Medicago* sativa , L.).
Publication Year: 2004

12/6/50 (Item 50 from file: 71)
03729864 2007148475
Effect of lucerne seed bacterization (*Medicago* sativa L.) on yield components in ecological *cultivation*
ISSUE TITLE: Proceedings of the VI.ALPS-ADRIA Scientific Workshop

12/6/51 (Item 51 from file: 5)
0019740899 BIOSIS NO.: 200700400640
Effect of lucerne seed bacterization (*Medicago* sativa L.) on yield components in ecological *cultivation*
2007

12/6/52 (Item 52 from file: 203)

02168404
Influence of the intensive factors on the yield of *alfalfa* *cultivated* on calcareous chernozem (Vliyanie na intenzivnite faktori v"rkhu dobiva ot lyutserna, otglezhdana na karbonaten chernozem)
1996

12/6/53 (Item 53 from file: 10)
3394370 20418661 Holding Library: AGL
Effect of plant genotype on the transformation of *cultivated* *alfalfa* (*Medicago* sativa) by Agrobacterium tumefaciens
1994

12/6/54 (Item 54 from file: 144)
11444615 PASCAL No.: 94-0278975
Effect of plant genotype on the transformation of *cultivated* *alfalfa* (*Medicago* sativa) by Agrobacterium tumefaciens
1994

12/6/55 (Item 55 from file: 10)
3411103 20432820 Holding Library: AGL
Effects of *tillage* on *alfalfa* establishment and production
1992

12/6/56 (Item 56 from file: 10)
3302369 93044457 Holding Library: AGL
Effect of *tillage* on nitrogen response in corn (Zea mays L.) after established *alfalfa* (*Medicago* sativa L.)
1993 Jan

12/6/58 (Item 58 from file: 10)
3037938 90056775 Holding Library: AGL
Effect of *tillage* on soil water and *alfalfa* establishment in corn stubble
1990

12/6/59 (Item 59 from file: 10)
3372335 20398036 Holding Library: AGL
Effect of *tillage* system on the spontaneous regeneration of two annual medics (*Medicago* spp.) after wheat in north Syria
1994 Apr

12/6/60 (Item 60 from file: 10)
3035972 90057355 Holding Library: AGL
Effect of atrizine and *tillage* on *alfalfa* (*Medicago* sativa) establishment in corn (Zea mays)-*alfalfa* rotation
1990 Apr

12/6/61 (Item 61 from file: 50)
0008564470 CAB Accession Number: 20033213695
The influence of stands *cultivation* on persistency of different cultivars of *Medicago* sativa L.
Publication Year: 2003

12/6/62 (Item 62 from file: 5)
11790180 BIOSIS NO.: 199395092446
The effect of C 360 tractor traffic over the soil in the third year of

alfalfa (*Medicago* varia Martin) *cultivation*
1993

12/6/63 (Item 63 from file: 50)
0007250070 CAB Accession Number: 19961608176
Early screening for drought tolerance in *cultivated* *alfalfa*.
Publication Year: 1995

12/6/64 (Item 64 from file: 10)
3452772 20465300 Holding Library: AGL
Erosion from *alfalfa* established with oat under conservation *tillage*
1995 Mar

12/6/65 (Item 65 from file: 144)
14249409 PASCAL No.: 99-0452382
Etude des populations naturelles en contact avec un compartiment cultive apparente. Le cas de Medicago sativa L. en Espagne
(The study of natural populations in contact with related *cultivated* forms. The case of *Medicago* sativa L. from Spain) 1998-04; 1998

12/6/66 (Item 66 from file: 10)
3790409 22017001 Holding Library: AGL
Evidence for gene flow between wild and *cultivated* *Medicago* sativa (Leguminosae) based on allozyme markers and quantitative traits
1999

12/6/67 (Item 67 from file: 5)
16680662 BIOSIS NO.: 200200274173
Evaluation of *cultivates* of *alfalfa* (*Medicago* sativa L.) by in situ degradability technique
2001

12/6/68 (Item 68 from file: 50)
0009253280 CAB Accession Number: 20073084627
Evaluation and recommendations for the use and management of soil, irrigation system and *alfalfa* *cultivation* on a farm in Zapala Department (Neuquen).
Original Title: Evaluacion y recomendaciones para el uso y manejo de los suelos, el riego y el cultivo de alfalfa en un establecimiento del departamento Zapala (Neuquen).
Publication Year: 2006

12/6/69 (Item 69 from file: 10)
3009760 90037353 Holding Library: AGL
The evolution of hemolytic saponin content in wild and *cultivated* *alfalfa* (*Medicago* sativa, Fabaceae)
1990 Apr

12/6/70 (Item 70 from file: 50)
0006540285 CAB Accession Number: 19921966287
Evolution of plant Zn concentration and chemical fractions of Zn in soil during *alfalfa* *cultivation*.
Proceedings - Congress of the European Society of Agronomy.
Publication Year: 1990

12/6/71 (Item 71 from file: 50)

0008304437 CAB Accession Number: 20023003982
Evaluation of soil chemical properties in 'suka kollus' *cultivated* with association of fodder plants and *alfalfa*, locality of Batallas, Department of La Paz [Bolivia].
Original Title: Evaluacion de propiedades quimicas en suelos de suka kollus cultivados con asociaciones de forrajeras y alfa-alfa, localidad Batallas, Departamento de La Paz.
Publication Year: 2001

12/6/73 (Item 73 from file: 5)
14873730 BIOSIS NO.: 199900133390
Establishment of corn in rotation and *alfalfa* and rye: Influence of grazing, *tillage*, and herbicides
1998

12/6/74 (Item 74 from file: 10)
3762070 21990427 Holding Library: AGL
Establishment of corn in rotation with *alfalfa* and rye: influence of grazing, *tillage*, and herbicides
1998

12/6/75 (Item 75 from file: 10)
3128195 91053684 Holding Library: AGL
Establishing *alfalfa* in corn ground with various *tillage* and weed control treatments
1990

12/6/76 (Item 76 from file: 10)
3785417 22011750 Holding Library: AGL
The establishment of *alfalfa* into different maize residues by conservation-*tillage* and its effect on insect infestation
1999

12/6/77 (Item 77 from file: 203)
02520264
[The influence of chemical fertilizers on *cultivated* *alfalfa* productivity] (Influenta ingrasamintelor chimice asupra productivitatii lucernei cultivate)
2001
[Breeding and technologies of cultivation of leguminous and forage crops] (Ameliorarea si tehnologiile de cultivare a culturilor leguminoase si furagere)

12/6/78 (Item 78 from file: 50)
0007661422 CAB Accession Number: 19990700103
Forage yield, *cultivation*, management and utilization of *Medicago* sativa and Onobrychis viciifolia in different sowing methods in forage-grain crop rotation.
Publication Year: 1997

12/6/79 (Item 79 from file: 203)
01903532
(US farmers are enthusiastic - *alfalfa* *cultivation* without regrets?) (US-Farmer sind begeistert: Luzerne: Anbau ohne Reue?)
1994

12/6/80 (Item 80 from file: 5)
10468764 BIOSIS NO.: 199140111655
FERTILIZER NITROGEN BALANCE IN TYPICAL SIEROZEM SOILS IN THE *CULTIVATION* OF COTTON FOLLOWING THE *CULTIVATION* OF *ALFALFA*
1990

12/6/81 (Item 81 from file: 10)

3900178 22438416 Holding Library: AGL
Genetic diversity of Sinorhizobium populations recovered from different *Medicago* varieties *cultivated* in Tunisian soils
2001

12/6/82 (Item 82 from file: 10)
3194999 92044498 Holding Library: AGL
Genetic segregation of random amplified polymorphic DNA in diploid *cultivated* *alfalfa*
1992 Feb

12/6/83 (Item 83 from file: 5)
12604583 BIOSIS NO.: 199598072416
Germplasm transfer to *cultivated* *alfalfa* mediated by 2n gametes
1994

12/6/84 (Item 84 from file: 10)
3239862 92074549 Holding Library: AGL
Habitat and food preferences of Allonemobius allardi (Orthoptera: Gryllidae) and potential damage to *alfalfa* in conservation-*tillage* systems
1992 Oct

12/6/85 (Item 85 from file: 10)
3170989 92027338 Holding Library: AGL
Are herbicides necessary for *alfalfa* establishment?: Results from studies with conventional and no-*till* *alfalfa*
1991

12/6/86 (Item 86 from file: 10)
3967276 23253325 Holding Library: AGL
How mitochondrial DNA diversity can help to understand the dynamics of wild-*cultivated* complexes. The case of *Medicago* sativa in Spain
2001

12/6/87 (Item 87 from file: 5)
18559785 BIOSIS NO.: 200510254285
Study of hypocholesterolemic and antiatherosclerotic properties of *Medicago* sativa L. *cultivated* in Egypt
2005

12/6/88 (Item 88 from file: 5)
0019504159 BIOSIS NO.: 200700163900
Improvement of *tillage* practices after *alfalfa* growing on leached black earth in central Pre-Caucasus
2006

12/6/89 (Item 89 from file: 10)

3213307 92056911 Holding Library: AGL
Inbreeding *cultivated* *alfalfa* at the diploid level by selfing and sib-mating
1992 Mar

12/6/91 (Item 91 from file: 5)
0019879658 BIOSIS NO.: 200700539399
Increase in *alfalfa* *cultivation* effectiveness based upon intensification of symbiotic nitrogen fixation
2007

12/6/92 (Item 92 from file: 76)
0000975969 IP ACCESSION NO: 3672797
Increased yields of *alfalfa* (*Medicago* sativa) inoculated with N sub(2)-fixing bacteria and *cultivated* in a calcareous soil of northwestern Egypt
PUBLICATION DATE: 1994

12/6/93 (Item 93 from file: 10)
3428134 20446227 Holding Library: AGL
Increased yields of *alfalfa* (*Medicago* sativa) inoculated with N2-fixing bacteria and *cultivated* in a calcareous soil of northwestern Egypt
1994 Oct

12/6/94 (Item 94 from file: 10)
3008763 90036313 Holding Library: AGL
Infiltration rate as affected by an *alfalfa* and no-*till* cotton cropping system
1990 Mar

12/6/95 (Item 95 from file: 10)
3379233 20406432 Holding Library: AGL
Interrow *cultivation* to reduce herbicide use in corn following *alfalfa* without *tillage*
1994 Jan

12/6/96 (Item 96 from file: 203)
02252740
[Alfalfa: *cultivation*, transformation and consumption] (Alfalfa: cultivo, transformacion y consumo)
1998

12/6/97 (Item 97 from file: 203)
01916109
[Alfalfa: a good *cultivation*] (Luzerne: la bonne conduite)
1995

12/6/98 (Item 98 from file: 203)
02149478
[Alfalfa sowing under the cover of *tilled* crops] (Posev lutserny pod pokrovom propashnykh kul'tur)
1997

12/6/99 (Item 99 from file: 10)

4872307 23227205 Holding Library: AGL
  Leaf spot diseases on winter wheat influenced by nitrogen, *tillage*, and haying after a grass-*alfalfa* mixture in the Conservation Reserve Program
  2001
  URL: http://hdl.handle.net/10113/14876

 12/6/100 (Item 100 from file: 144)
  09890023 PASCAL No.: 92-0092514
  La luzerne. Culture-Utilisation
  (*Alfalfa*. *Cultivation*-Utilization) s.d.

 12/6/101 (Item 101 from file: 10)
2997351 90029703 Holding Library: AGL
  Late-winter no-*till* seeding of *alfalfa* into autumn-suppressed tall fescue
  1990 Mar

 12/6/102 (Item 102 from file: 10)
3702381 21804154 Holding Library: AGL
  Medicagenic acid content in foliage of ten varieties of *alfalfa* (*Medicago* sativa L.) *cultivated* in Mexico
  1997

 12/6/103 (Item 103 from file: 203)
 02088863
  [Medicago sativa *cultivation* in the Western Cape, South Africa] (Verbouing van lusern in die Wes-kaap [Suid-Afrika])
  1996
  [Information Day Lectures] (Inligtingsdag Lesings)

 12/6/104 (Item 104 from file: 50)
0009406962 CAB Accession Number: 20073241497
  Mielga (*Medicago* sativa L.): origin, characteristics and value for *cultivation* and use.
  Original Title: La mielga (Medicago sativa L.): origen, caracterizacion y valor agronomico.
  Publication Year: 2005

 12/6/105 (Item 105 from file: 203)
 01584127
  1990
  [Impact of *alfalfa* *cultivation* for more than 5 years on some biological, chemical and physical characters and on nitrogeneous content for sandy soil under coastal region conditions] ('at"ar zira:3at> al-fis*at> li'akt"ar min h*ams/i sanawa:t 3ala> ba3d*/i al-s*ifa:t al-fi:zi:a:'iyt> wa-l-ki:mi:a:'iyat> liturbat> ramli:at> fi: al-sa:h"il)

 12/6/106 (Item 106 from file: 5)
16523762 BIOSIS NO.: 200200117273
Mitochondrial DNA diversity and phenotypic variation in wild and *cultivated* populations of *Medicago* sativa: Insights into the dynamics of contact zones between the two related forms
2001

 12/6/107 (Item 107 from file: 203)
 01826594
  [Methods for *cultivation* of isolated cells, tissues and organs in

alfalfa breeding] (Priemy kul'tivirovaniya izolirovannykh kletok,tkanej i organov v selektsii lyutserny)
1992
[Breeding and seed production of field crops under conditions of irrigation] (Selektsiya i semenovodstvo polevykh kul'tur v usloviyakh orosheniya)

12/6/108 (Item 108 from file: 50)
0006978754 CAB Accession Number: 19952302617
Mycobiota of *Medicago* L. species seeds in Lithuania. 1. Composition and distribution of micromycete species of *cultivated* and wild *alfalfa* seeds.
Publication Year: 1993

12/6/109 (Item 109 from file: 10)
3331674 20361850 Holding Library: AGL
Nitrogen fertilization of wheat no-*till* planted in *alfalfa* stubble
1993 Jul

12/6/110 (Item 110 from file: 10)
3603762 20588737 Holding Library: AGL
No *till* corn in living *alfalfa* sod
1990

12/6/111 (Item 111 from file: 10)
3474525 20481626 Holding Library: AGL
No-*tillage* corn production in an *alfalfa*-grass sod
1990 Jan

12/6/112 (Item 112 from file: 10)
3415666 20436362 Holding Library: AGL
No-*till* *alfalfa* production: limestone amendment for acid soil
1994 Oct

12/6/113 (Item 113 from file: 10)
3367867 20393497 Holding Library: AGL
No-*till* *alfalfa* establishment after small-grain cereals
1993 Mar

12/6/115 (Item 115 from file: 10)
3805408 22029807 Holding Library: AGL
No-*till* *alfalfa* stand termination strategies: *alfalfa* control and wheat and barley production
1999

12/6/116 (Item 116 from file: 10)
3550140 20545270 Holding Library: AGL
No-*till* seeding of grazing-tolerant *alfalfa* as influenced by grass suppression, fungicide, and insecticide
1996 Jul

12/6/117 (Item 117 from file: 10)
3003461 90033185 Holding Library: AGL
No-*till* seeding of ladino clover and *alfalfa* into grass sod as affected by insects, grass competition, and time of planting
1990 Feb

12/6/118 (Item 118 from file: 10)
3538298 20536230 Holding Library: AGL
No-*till* establishment of ladino clover, and *alfalfa* as influenced by time of seeding, time of grass suppression, and insects
1993

12/6/119 (Item 119 from file: 10)
3806896 22031604 Holding Library: AGL
The nutritive value and yield of *alfalfa* *cultivated* on sulphur postmining lands
1999

12/6/120 (Item 120 from file: 10)
3613400 20597399 Holding Library: AGL
Nitrous oxide emission as affected by *tillage*, corn-soybean-*alfalfa* rotations and nitrogen fertilization
1997

12/6/121 (Item 121 from file: 10)
3729702 21968507 Holding Library: AGL
Nitrous oxide emission in three years as affected by *tillage*, corn-soybean-*alfalfa* rotations, and nitrogen fertilization
1998

12/6/122 (Item 122 from file: 10)
3245287 92078024 Holding Library: AGL
Nitrogen availability from *alfalfa* suppressed or killed for no-*till* production
1991

12/6/123 (Item 123 from file: 203)
02506090

A new lucerne variety for *organic* *farming* [*Medicago* sativa L. - Umbria (Italy)] (Costituzione di una varieta' di erba medica per l'agricoltura biologica [Medicago sativa L. - Umbria])
2001

12/6/124 (Item 124 from file: 5)
11801519 BIOSIS NO.: 199395103785
Study on the *cultivation* of *alfalfa* (*Medicago* sativa L.) on hill land: 1. Effect of Rhizobium inoculation method on the early growth of *alfalfa* (*Medicago* sativa L.)
1992

12/6/125 (Item 125 from file: 5)
12468965 BIOSIS NO.: 199497490250
Study on the *cultivation* of *alfalfa* on hill land: 2. Effect of rhizobium inoculation method on the DM yield and nutritive value of *alfalfa*
1994

12/6/126 (Item 126 from file: 50)
0008187355 CAB Accession Number: 20023039442
Study on high-yield and high-quality *cultivation* techniques of *Medicago* sativa in Minqin Desert Oasis, China.
Publication Year: 2001

12/6/127 (Item 127 from file: 203)
01867145
Studies on establishing a standard for *cultivation* of *alfalfa*
1990

12/6/128 (Item 128 from file: 10)
4872361 23291624 Holding Library: AGL
Organelle based molecular analyses of the genetic relatedness of *cultivated* *alfalfa* (*Medicago* sativa L) to *Medicago* edgeworthii Sirjaev, and *Medicago* ruthenica (L.) Ledebour
2002
URL: http://hdl.handle.net/10113/14367

12/6/129 (Item 129 from file: 10)
3511018 10748381 Holding Library: AGL
Plant *cultivation* studies on red clover and *alfalfa* grass green fallow in the modified crop rotation sugarbeets-winter wheat-winter barley
Pflanzenbauliche Untersuchungen zu Rotklee- und Luzernegras-Grunbrachen in der modifizierten Fruchtfolge zuckerruben-Winterweizen-Wintergerste / vorgelegt von Stefan Dreesmann
1994

12/6/130 (Item 130 from file: 10)
3213516 92057122 Holding Library: AGL
Producing no-*till* cereal or corn following *alfalfa* on furrow-irrigated land
1991 Apr

12/6/131 (Item 131 from file: 203)
02520031
[The productivity of *cultivated* *alfalfa* on green mass and seeds] (Productivitatea lucernei cultivata la masa verde si seminte)
2001
[Breeding and technologies of cultivation of leguminous and forage crops] (Ameliorarea si tehnologiile de cultivare a culturilor leguminoase si furajere)

12/6/132 (Item 132 from file: 50)
0008302726 CAB Accession Number: 20023128213
Productivity of lucerne [*Medicago* L.] *cultivated* in the forest-steppe of the Northern Trans-Urals.
Publication Year: 2002

12/6/133 (Item 133 from file: 5)
11894400 BIOSIS NO.: 199396058816
Production and nutrient levels in *alfalfa* (*Medicago* sativa) in the first year of *cultivation* in the Zona da Mata of Minas Gerais
1993

12/6/134 (Item 134 from file: 10)
3359745 20386446 Holding Library: AGL
Primary *tillage* effects on *alfalfa* establishment and yield
1993 Nov

12/6/135 (Item 135 from file: 5)
11976733 BIOSIS NO.: 199396141149

Peroxidase in *cultivated* *alfalfa* cells
1992

12/6/136 (Item 136 from file: 5)
13985457 BIOSIS NO.: 199799619517
The persistence of bioluminescent Rhizobium meliloti strains L1 (RecA-) and L33 (RecA+) in non-sterile microcosms depends on the soil type, on the co-*cultivation* of the host legume *alfalfa* and on the presence of an indigenous R. meliloti population
1997

12/6/140 (Item 140 from file: 203)
02056567
[Optimal estimation of function response of the area *cultivated* with *alfalfa*]
1990

12/6/141 (Item 141 from file: 203)
01601240
Quality of *alfalfa* *cultivated* in Mediterranean climates (Rapport sur la qualite de la luzerne cultivee en climat mediterraneen)
1991
Mediterranean Forages and By Products, Montpellier (France), 5-6 Jul 1990 (Fourrages et Sous-produits Mediterraneens)

12/6/142 (Item 142 from file: 203)
02225699
1996
[Recommendations for *alfalfa* *cultivation* in Asturias [Spain]] (Recomendaciones para el cultivo de la alfalfa en Asturias)

12/6/143 (Item 143 from file: 203)
02669726
2006
[Irrigation and fertilization of *alfalfa* *cultivated* under pivot] (Riego y abonado en alfalfa cultivada bajo pivot)

12/6/144 (Item 144 from file: 5)
15615263 BIOSIS NO.: 200000333576
Regeneration of F1 hybrids derived from crosses between *cultivated* *alfalfa* and a highly regenerable Regen SY line
2000

12/6/145 (Item 145 from file: 203)
01613245
[Irrigation regime, methods and rates of *alfalfa* sowing during *cultivation* for seeds under conditions of the central black-earth zone] (Rezhim orosheniya, sposoby i normy vyseva lyutserny pri vyrashchivanii na semena v usloviyakh Tsentral'no-Chernozemnoj zony)
1990
[Irrigated chernozems and their rational use] (Oroshaemye chernozemy i ikh ratsional'noe ispol'zovanie)

12/6/146 (Item 146 from file: 203)
01682957
Rhizobium meliloti populations and *alfalfa* yields due to nitrogen

fertilization and inoculation methods at *cultivated* upland soil
1992

12/6/147 (Item 147 from file: 10)
4018684 23293612 Holding Library: AGL
Rainfall and *tillage* effects on soil structure after *alfalfa* conversion to maize on a clay loam soil in New York
2002

12/6/148 (Item 148 from file: 203)
02209400
1990
[Response to the inoculation with Rhizobium sp. in the *cultivation* of *alfalfa* (*Medicago* sativa L.) in the zone of Tunja, Boyaca [Colombia]] (Respuesta a la inoculacion con Rhizobium sp. en el cultivo de la alfalfa Medicago sativa L. en la zona de Tunja, Boyaca)

12/6/149 (Item 149 from file: 203)
01650149
Research on *cultivation* techniques of *alfalfa* in Weibei rainfed highlands, Shaanxi Province [China]
1992

12/6/150 (Item 150 from file: 50)
0007188832 CAB Accession Number: 19960703606
Selection of strains of Rhizobium meliloti tolerant to soil acidity for *cultivation* of *Medicago* spp.
Original Title: Selection de souches de Rhizobium meliloti tolerantes a l'acidite des sols pour la culture de Medicago spp.
Publication Year: 1994

12/6/151 (Item 151 from file: 203)
01969587
Soil pH is a major determinant of the numbers of naturally occurring Rhizobium meliloti in non-*cultivated* soils in central New South Wales [*Medicago* species]
1991

12/6/152 (Item 152 from file: 10)
3878150 22088464 Holding Library: AGL
Soil and maize response to plow and no-*tillage* after *alfalfa*-to-maize conversion on a clay loam soil in New York
2000

12/6/153 (Item 153 from file: 203)
02104203
The soil *tillage* and *alfalfa* sowing machines (Masine za pripremu zemljista i setvu lucerke)
1996

12/6/154 (Item 154 from file: 10)
3631894 20610751 Holding Library: AGL
Surface *alfalfa* residue removal by earthworms Lumbricus terrestris L. in a no-*till* agroecosystem
1997

12/6/155 (Item 155 from file: 50)

0007147192 CAB Accession Number: 19951913686
Survey, selection and testing of acid-tolerant Rhizobium meliloti strains for the *cultivation* of annual *Medicago* species on acid and slightly acid soils in Morocco.
Original Title: Prospektion, Selektion sowie Prufung auf Effektivitat von sauretoleranten Rhizobium meliloti -Stammen fur den Anbau von annuellen Medicago -Arten auf sauren und schwach sauren Boden in Marokko.
Publication Year: 1994

12/6/156 (Item 156 from file: 50)
0006786809 CAB Accession Number: 19932461063
Theoretical and experimental comparison of an agricultural drainage system beneath two *cultivated* soils: *alfalfa*.
Original Title: Comparacion teorica-experimental de un sistema de drenaje agricola bajo dos suelos cultivados: alfalfa.
Memoria del III congreso nacional [Proceedings of the III national congress]. Held in Queretaro, Mexico, 13-15 October, 1993.
Publication Year: 1993

12/6/157 (Item 157 from file: 10)
3601589 20584735 Holding Library: AGL
Tall fescue response to clipping and competition with no-*till* seeded *alfalfa* as affected by fungal endophyte
1997

12/6/158 (Item 158 from file: 10)
3079717 91018440 Holding Library: AGL
Tillage and canopy cover effects on interrill erosion from first-year *alfalfa*
1990 Nov

12/6/159 (Item 159 from file: 10)
3610786 20594298 Holding Library: AGL
Tillage effects on nitrogen management for corn after *alfalfa* on irrigated sandy soils
1995

12/6/160 (Item 160 from file: 10)
3793908 22016853 Holding Library: AGL
Tillage effects on soil nitrogen and plant biomass in a corn-*alfalfa* rotation
1999

12/6/161 (Item 161 from file: 10)
4678696 43939284 Holding Library: AGL
Tillage System and Seeding Time Effects on Forage and Seed Yield of *Alfalfa* and Bromegrass
2007

12/6/162 (Item 162 from file: 5)
17149484 BIOSIS NO.: 200300108203
Temporal pattern of arthropod community on *cultivated* *alfalfa* grassland.
2002

12/6/163 (Item 163 from file: 50)

0006209709 CAB Accession Number: 19900732228

Utilization of selected Rhizobium meliloti strains in *Medicago* rigidula L. and *Medicago* noeana Boiss. *cultivation*.
Original Title: Utilizzazione di ceppi selezionati di Rhizobium meliloti nella coltivazione di Medicago rigidula L. e Medicago noeana Boiss.
Publication Year: 1987, publ. 1989

12/6/164 (Item 164 from file: 10)
3537352 20535100 Holding Library: AGL
Vegetation management and interrill erosion in no-*till* corn following *alfalfa*
1996 Jul

12/6/165 (Item 165 from file: 50)
0006969322 CAB Accession Number: 19950702351
Yield of lucerne (*Medicago* sativa L.) in its first year of *cultivation* in relation to the management strategy in the Tadla area of Morocco.
Original Title: Production de la luzerne (Medicago sativa L.) en 1 SUP ere annee en relation avec le rythme d'exploitation dans le Tadla.
Publication Year: 1992

12/6/166 (Item 166 from file: 50)
0007069015 CAB Accession Number: 19950709286
Yields and nutrient contents in *alfalfa* (*Medicago* sativa L.) in the first year of *cultivation* in the Zona da Mata, Minais Gerais.
Original Title: Producao e niveis de nutrientes em alfafa (Medicago sativa L.) no primeiro ano de cultivo, na Zona da Mata de MG.
Publication Year: 1993

12/6/167 (Item 167 from file: 10)
3550157 20545288 Holding Library: AGL
Yield response to *cultivation* of established *alfalfa*
1995 Nov

12/6/168 (Item 168 from file: 5)
16433183 BIOSIS NO.: 200200026694
[Saponins and tannins in twenty-eight *alfalfa* (*Medicago* sativa L.) *cultivates* grown in Botucatu - SP.]
ORIGINAL LANGUAGE TITLE: Porcentagens de Saponinas e Taninos em Vinte e Oito Cultivares de Alfafa (Medicago sativa L.) em Duas Epocas de Corte - Botucatu - SP
2001

12/6/169 (Item 169 from file: 5)
12422212 BIOSIS NO.: 199497443497
Zero-*tillage* establishment of *alfalfa* and meadow bromegrass as influenced by previous annual grain crop
1994

12/6/170 (Item 170 from file: 203)
02584622
[Strategy in the herbicides use on *alfalfa* *cultivation*] (Estrategia del empleo de los herbicidas en el cultivo de la alfalfa)
2004

12/6/171 (Item 171 from file: 203)

02408117

[The sowing machines for common sowing of *alfalfa* under the protection of *tilled* crops] (Semanatoare pentru insamintarea comuna a lucernei sub protectia culturilor prasitoare)

1999

[Results and perspectives of scientific researches in the field of plant breeding and crop technologies of cereals] (Rezultatele si perspectivele cercetarilor stiintifice in domeniul ameliorarii si tehnologiilor de cultura a cerealelor)

SETS IN SAME PARAGRAPH/FIELD AND ONE TERM OF EITHER SET IN TITLE

S9 3010 S7 (S) S2
S10 444 S9/TI
S13 2566 S9 NOT S10
S14 1323 RD S13 (unique items)
S15 559 S14 AND (S7 OR S2)/TI

16/6/1 (Item 1 from file: 10)
3913741 23211258 Holding Library: AGL
Abundance of cereal aphids (Homoptera: Aphididae) and their predators in spring wheat-*alfalfa* intercrops under different crop management intensities
2000

16/6/2 (Item 2 from file: 143)
1794824 H.W. WILSON RECORD NUMBER: BBAI04158344
Above- and below-ground effects from *alfalfa* and marsh reedgrass on aspen seedlings
20041011

16/6/3 (Item 3 from file: 50)
0009317870 CAB Accession Number: 20073169348
Acacia nilotica and *Medicago* sativa , suitable plants for agro-forestry in southern coasts of Iran.
Publication Year: 2007

16/6/4 (Item 4 from file: 5)
11776574 BIOSIS NO.: 199395078840
The action of chloride salinization on the formation and activity of symbiotic *alfalfa* system
1992

16/6/5 (Item 5 from file: 5)
17878566 BIOSIS NO.: 200400247513
Acyrthosiphon (A.) loti (Hemiptera: Aphididae) founded on Lucerne in Argentina.
ORIGINAL LANGUAGE TITLE: Acyrthosiphon (A.) loti (Hemiptera: Aphididae) hallado sobre *alfalfa* en la Argentina.
2003

16/6/6 (Item 6 from file: 5)
10861220 BIOSIS NO.: 199192106991
ADAPTIVE RESPONSES OF ROOT SYSTEMS OF SOME NATIVE AND *CULTIVATED* SPECIES TO DESERT CONDITIONS
1991

16/6/7 (Item 7 from file: 10)
3937933 23230842 Holding Library: AGL
Adopting zero *tillage* management: impact on soil C and N under long-term crop rotations in a thin Black chernozem
2001

16/6/8 (Item 8 from file: 10)
3793379 22012950 Holding Library: AGL
AFLP fingerprinting in *Medicago* spp.: its development and application in linkage mapping
1999

16/6/9 (Item 9 from file: 5)
17144555 BIOSIS NO.: 200300103274
Agrobacterium-mediated transformation of lucerne (*Medicago* sativa Linn.): Optimizing biological and physical parameters.
2002

16/6/10 (Item 10 from file: 50)
0007879902 CAB Accession Number: 20001909205
Agrophysical properties of the soil under *cultivation* of fodder and cereals crops in crop rotation.
Publication Year: 1999

16/6/11 (Item 11 from file: 203)
02377142
Agronomic effects and economic results of *alfalfa* sod-seeding with cocksfoot (Agronomiczno-ekonomiczne efekty podsiewu lucerny kupkowka pospolita)
1999

16/6/12 (Item 12 from file: 10)
3627085 20606976 Holding Library: AGL
Agronomic evaluation of *Medicago* ruthenica collected in Inner Mongolia
1997

16/6/13 (Item 13 from file: 40)
00603958 ENVIROLINE NUMBER: 01-09738
Alfalfa
May-Jun 01

16/6/14 (Item 14 from file: 266)
00576456
IDENTIFYING NO.: 0209978 AGENCY CODE: AGRIC
Alfalfa Breeding and ManagementSDTDPXAT

16/6/15 (Item 15 from file: 50)
0006658103 CAB Accession Number: 19931636157
Alfalfa cytogenetics.
Book Title: Chromosome engineering in plants: genetics, breeding, evolution. Part B.
Publication Year: 1991

16/6/16 (Item 16 from file: 143)
0405091 H.W. WILSON RECORD NUMBER: BBAI93003915
Alfalfa development after simulated *alfalfa* weevil injury
19921100

16/6/17 (Item 17 from file: 143)
1990914 H.W. WILSON RECORD NUMBER: BBAI07100081
Alfalfa Fiber Estimation in Mixed Stands and Its Relationship to Plant Morphology
20061100

16/6/18 (Item 18 from file: 71)
02077802 2002157874
Alfalfa growth promotion by bacteria grown under iron limiting conditions

16/6/19 (Item 19 from file: 143)
2131127 H.W. WILSON RECORD NUMBER: BBAI06129707
Alfalfa as an Alternative to Bermudagrass for Pastured Stocker Cattle Systems in the Southern USA
20060500

16/6/20 (Item 20 from file: 5)
10861148 BIOSIS NO.: 199192106919
ALFALFA *MEDICAGO*-SATIVA L. WATER USE EFFICIENCY AS AFFECTED BY HARVEST TRAFFIC AND SOIL COMPACTION IN A SANDY LOAM SOIL
1991

16/6/21 (Item 21 from file: 143)
0326900 H.W. WILSON RECORD NUMBER: BBAI91030987
Alfalfa and the nitrogen cycle in the corn belt
19910500

16/6/22 (Item 22 from file: 50)
0006299574 CAB Accession Number: 19900738191
Alfalfa production manual.
Original Title: Manual de producao de *alfalfa*.
Publication Year: 1990

16/6/23 (Item 23 from file: 5)
10651788 BIOSIS NO.: 199191034679
ALFALFA RESPONSE TO LIME PHOSPHORUS POTASSIUM MAGNESIUM AND MOLYBDENUM ON ACID ULTISOLS
1990

16/6/24 (Item 24 from file: 143)
1799799 H.W. WILSON RECORD NUMBER: BBAI03111355
Alfalfa Autotoxicity: Effects of Reseeding Delay, Original Stand Age, and Cultivar
20020700

16/6/25 (Item 25 from file: 5)
10849172 BIOSIS NO.: 199192094943
ALFALFA YIELD AS AFFECTED BY HARVEST TRAFFIC AND SOIL COMPACTION IN A SANDY LOAM SOIL
1991

16/6/26 (Item 26 from file: 143)
0481400 H.W. WILSON RECORD NUMBER: BBAI94031861
Alfalfa yield and quality are affected by soil hydrologic conditions
19940500

16/6/27 (Item 27 from file: 10)
4378426 43757416 Holding Library: AGL
Alfalfa yield and nutrient uptake as affected by pH and applied K
2005

16/6/28 (Item 28 from file: 5)
12062721 BIOSIS NO.: 199497084006
Alfalfa yield programming under irrigation
1993

16/6/29 (Item 29 from file: 143)

0628433 H.W. WILSON RECORD NUMBER: BBAI95023472
Alfalfa establishment with barley and oat companion crops differing in stature
19950300

16/6/30 (Item 30 from file: 10)
3415667 20436363 Holding Library: AGL
Alfalfa establishment with and without spring-applied herbicides
1994 Oct

16/6/31 (Item 31 from file: 10)
3353825 20381296 Holding Library: AGL
Alfalfa stand establishment
1993 Feb

16/6/32 (Item 32 from file: 266)
00572992
IDENTIFYING NO.: 0205738 AGENCY CODE: AGRIC
Alternative Crop, Rotation, and *Tillage* Practices

16/6/33 (Item 33 from file: 143)
0545865 H.W. WILSON RECORD NUMBER: BBAI95042192
Alternating strips of grass and legume, and nitrogen fertilization strategy, for long-term herbage production from a brome-*alfalfa* stand
19950700

16/6/34 (Item 34 from file: 5)
17244495 BIOSIS NO.: 200300203214
Annual *Medicago* as a smother crop in soybean.
2002

16/6/35 (Item 35 from file: 50)
0007912594 CAB Accession Number: 20000709552
Use of annual medics in sustainable agriculture systems.
Lucerne and medics for the XXI century. Proceedings XIII EUCARPIA *Medicago* spp. Group Meeting, Perugia, Italy, 13-16 September 1999.
Publication Year: 2000

16/6/36 (Item 36 from file: 5)
17687382 BIOSIS NO.: 200400054912
Analysis of different types of competitive capacity in the *alfalfa* rhizobia (Sinorhizobium meliloti) Tn5 mutants.
2001

16/6/37 (Item 37 from file: 10)
4700748 43952530 Holding Library: AGL
Analyses of a multi-parent population derived from two diverse *alfalfa* germplasms: testcross evaluations and phenotype-DNA associations
2007
URL: http://dx.doi.org/10.1007/s00122-007-0614-1

16/6/38 (Item 38 from file: 76)
0001816566 IP ACCESSION NO: 5990250
Analysis on Water-saving Irrigation and Water Effectiveness of *Medicago* sativa in Arid Desert Oasis --An Example of Minqin County
PUBLICATION DATE: 2004

16/6/40 (Item 40 from file: 156)
4196992 NLM Doc No: 17157359
The arbuscular mycorrhizal fungus Glomus mosseae gives contradictory effects on phosphorus and arsenic acquisition by *Medicago* sativa Linn.
Jul 1 2007

16/6/41 (Item 41 from file: 24)
0002281571 IP ACCESSION NO: 5297102
Arbuscular mycorrhiza in mini-mycorrhizotrons: first contact of *Medicago* truncatula roots with Glomus intraradices induces chalcone synthase
PUBLICATION DATE: 2001

16/6/42 (Item 42 from file: 71)
03639809 2007056546
Availability and contributions of soil phosphorus to forage production of seeded *alfalfa* in semiarid Loess Plateau

16/6/43 (Item 43 from file: 50)
0008364590 CAB Accession Number: 20033004750
Aspects regarding the crop technology of *alfalfa* and Alexandria clover mixture under Burnas plain conditions.
Original Title: Aspecte privind tehnologia de cultura a lucernei in amestec cu trifoiul de Alexandria in campia Burnasului.
Publication Year: 2001

16/6/44 (Item 44 from file: 5)
14661538 BIOSIS NO.: 199800455785
Assessing *tillage*- and cropping-induced changes in relative conductivity
1998

16/6/45 (Item 45 from file: 5)
11180275 BIOSIS NO.: 199293023166
BIOCHEMICAL ACTIVITY OF IRRIGATED SIEROZEMS AS IT DEPENDS ON THE METHOD OF PLANT *CULTIVATION*
1991

16/6/46 (Item 46 from file: 10)
3066779 91009532 Holding Library: AGL
Backcrossing tetraploidy into diploid *Medicago* falcata L. using 2n eggs
1990 Nov

16/6/47 (Item 47 from file: 50)
0008471114 CAB Accession Number: 20033083621
Biodiversity on *organic* *farms*.
Original Title: La biodiversita nell'azienda biologica.
Publication Year: 2001

16/6/48 (Item 48 from file: 50)
0006642355 CAB Accession Number: 19931974266
Biological activity of irrigated serozems under cotton as depending on the technology of cotton *cultivation*.
Publication Year: 1991

16/6/49 (Item 49 from file: 50)
0007840803 CAB Accession Number: 20001906122
The biological fundamentals of water-saving irrigation conditions for two- to three-year-old *alfalfa* in the semidesert of Kalmykia.

Publication Year: 1998, publ. 1999

16/6/50 (Item 50 from file: 266)
00572611
IDENTIFYING NO.: 0205214 AGENCY CODE: AGRIC
Biology and Management of Vegetable and Field Crop Insects and Diseases and the Effects of Conservation *Tillage* on Corn Insects

16/6/51 (Item 51 from file: 10)
4827810 43637521 Holding Library: AGL
Bulk density as a soil quality indicator during conversion to no-*tillage*
2004
URL: http://hdl.handle.net/10113/10542

16/6/52 (Item 52 from file: 50)
0007202951 CAB Accession Number: 19960704799
Biomass production in two crop rotation at different fertilization and soil *tillage*.
Original Title: Produkcia biomasy v dvoch osevnych postupoch pri roznom hnojeni a obrabani pody.
Publication Year: 1995

16/6/53 (Item 53 from file: 203)
02181414
Breeding of "Hisawakaba" *alfalfa* [*Medicago* sativa] and its characteristics
1995

16/6/54 (Item 54 from file: 5)
0001413839 BIOSIS NO.: 19644500035030
Breeding of *alfalfa* varieties resistant to diseases
ORIGINAL LANGUAGE TITLE: Vyvedenie sortov lyutserny, ustoichivykh k boleznyam

16/6/55 (Item 55 from file: 24)
0002207538 IP ACCESSION NO: 5111824
Brief communication. Physical mapping of rRNA genes in *Medicago* sativa and M. glomerata by fluorescent in situ hybridization
PUBLICATION DATE: 2000

16/6/56 (Item 56 from file: 41)
0000254257 IP ACCESSION NO: 6469076
Bioremediation of Copper and Benzo[a]pyrene-Contaminated Soil by *Alfalfa*
PUBLICATION DATE: 2005

16/6/57 (Item 57 from file: 5)
13377831 BIOSIS NO.: 199699011891
Betaines as methyl group donors in *alfalfa* seedlings exposed to salt
1995

16/6/58 (Item 58 from file: 143)
1141332 H.W. WILSON RECORD NUMBER: BBAI91019222
Changes in the baseline of the crop water stress index for lucerne (*Medicago* sativa) over 3 years
19910200

16/6/59 (Item 59 from file: 5)

11952126 BIOSIS NO.: 199396116542
Changes in pattern of phenolic acids induced by culture filtrate of Fusarium oxysporum in *alfalfa* plants differing in susceptibility to the pathogen
1993

16/6/60 (Item 60 from file: 203)
01653082
[Characteristics of *alfalfa* mosaic virus pathogens of bean in Emilia Romagna] (Caratteristiche del virus del mosaico dell'erba medica patogeno del fagiolo in Emilia Romagna)
1991

16/6/61 (Item 61 from file: 50)
0009268216 CAB Accession Number: 20073122636
Chromatographic (GC-MS) and virological evaluations of Lavandula hybrida "Alardi" infected by *Alfalfa* mosaic virus.
Publication Year: 2006

16/6/62 (Item 62 from file: 10)
3674192 21234542 Holding Library: AGL
Chromosomal and molecular rearrangements in somatic hybrids between tetraploid *Medicago* sativa and diploid *Medicago* falcata
1997

16/6/63 (Item 63 from file: 50)
0007913653 CAB Accession Number: 20001612633
Collecting and breeding *Medicago* perennial species in Greece.
Lucerne and medics for the XXI Century. Proceedings XIII Eucarpia *Medicago* spp. Group Meeting, Perugia, Italy, 13-16 September 1999.
Publication Year: 2000

16/6/64 (Item 64 from file: 5)
15597040 BIOSIS NO.: 200000315353
Clones of pea aphid, Acyrthosiphon pisum (Hemiptera: Aphididae) distinguished using genetic markers, differ in their damaging effect on a resistant *alfalfa* cultivar
2000

16/6/65 (Item 65 from file: 10)
4740844 43981807 Holding Library: AGL
The *cultivation* bias: different communities of arbuscular mycorrhizal fungi detected in roots from the field, from bait plants transplanted to the field, and from a greenhouse trap experiment
2007
URL: http://dx.doi.org/10.1007/s00572-007-0147-0

16/6/67 (Item 67 from file: 5)
15603415 BIOSIS NO.: 200000321728
Cultivation effects on phosphate forms and sorption in loess-soils of Argentina
2000

16/6/68 (Item 68 from file: 50)
0006593716 CAB Accession Number: 19920757564
Cultivation of grasses for land improvement transforms solonetz soils.
Publication Year: 1992

16/6/69 (Item 69 from file: 5)
17394117 BIOSIS NO.: 200300352836
Cultivation and grassland type effects on light fraction and total organic C and N in a Dark Brown Chernozemic soil.
2003

16/6/70 (Item 70 from file: 50)
0006468657 CAB Accession Number: 19910749145
Cultivation of millet and related crops in irrigated fields.
Publication Year: 1990

16/6/71 (Item 71 from file: 50)
0007354687 CAB Accession Number: 19970603981
Cultivation methods for controlling erosion in the semiarid zone of Chile. Preliminary results.
Original Title: Tecnicas de cultivo para el control de la erosion en la zona semiarida. Resultados preliminares.
Publication Year: 1995

16/6/72 (Item 72 from file: 50)
0006441849 CAB Accession Number: 19910747640
Cultivation techniques and [lucerne] yield.
Publication Year: 1990

16/6/73 (Item 73 from file: 50)
0009231970 CAB Accession Number: 20073056859
Combined influence of *tillage* and herbicide application on weed dynamics and yield of wheat under rice - wheat system.
Publication Year: 2006

16/6/74 (Item 74 from file: 10)
3848699 22056478 Holding Library: AGL
Completion of the agronomic evaluations of *Medicago* ruthenica [(L.) Ledebour] germplasm collected in Inner Mongolia
1999

16/6/75 (Item 75 from file: 76)
0001998256 IP ACCESSION NO: 6458603
Comparing agroecosystems: Effects of cropping and *tillage* patterns on soil, water, energy use and productivity
PUBLICATION DATE: 2005

16/6/76 (Item 76 from file: 10)
3972073 23252580 Holding Library: AGL
Comparing pocket gopher (Thomomys bottae) density in *alfalfa* stands to assess management and conservation goals in northern California
2001

16/6/77 (Item 77 from file: 40)
00682492 ENVIROLINE NUMBER: 05-10605
A Comparison of Conventional and Alternative Agroecosystems Using *Alfalfa* (*Medicago* sativa) and Winter Wheat (Triticum aestivum)
Mar 05

16/6/78 (Item 78 from file: 50)
0007484716 CAB Accession Number: 19980701485

Comparisons of new *Medicago* spp. in South Australia.
Proceedings of the 8th Australian Agronomy Conference, Toowoomba, Queensland, Australia, 30 January-2 February, 1996.
Publication Year: 1996

16/6/79 (Item 79 from file: 143)
0836483 H.W. WILSON RECORD NUMBER: BBAI98008470
Comparison of sodseeding versus slotseeding of *alfalfa* into established crested wheatgrass in southwestern Saskatchewan
19971000

16/6/80 (Item 80 from file: 10)
4435561 43658596 Holding Library: AGL
Competition and facilitation in mixtures of aspen seedlings, *alfalfa*, and marsh reedgrass Summary in French.
2004

16/6/81 (Item 81 from file: 5)
19361619 BIOSIS NO.: 200700021360
Composition diversity of lactic acid bacteria (LAB) community A12 used for *alfalfa* silage
2006

16/6/82 (Item 82 from file: 203)
01747465
[Economic analysis on non traditional forage *cultivation* and effects on management of cattle husbandry [Umbria]] (Analisi economica di colture foraggere non tradizionali e riflessi sulla gestione di allevamenti bovini [Umbria])
1992

16/6/83 (Item 83 from file: 50)
0008730244 CAB Accession Number: 20043182078
A contribution to the study of the distribution of *Medicago* -Sinorhizobium symbiosis in Sardinia (Italy).
Publication Year: 2004

16/6/84 (Item 84 from file: 203)
01925849
Contribution to the knowledge of the Heteroptera fauna in seed *alfalfa* crops (Contributii la cunoasterea faunei de heteroptere din lucernierele semincere)
1994

16/6/85 (Item 85 from file: 10)
3363123 20389893 Holding Library: AGL
Conservation *tillage* crop yields in relation to grey garden slug [Deroceras reticulatum (Muller)] (Mollusca: Agriolimacidae) density during establishment
1994 Feb

16/6/86 (Item 86 from file: 10)
3472868 20479616 Holding Library: AGL
Conservation-*tillage* grain drill for furrow-irrigated cropping systems
1994 Nov

16/6/87 (Item 87 from file: 143)

1446419 H.W. WILSON RECORD NUMBER: BBAI96053343
Conserving water and increasing *alfalfa* production using a tall wheatgrass windbreak system
19960900

16/6/88 (Item 88 from file: 5)
17806124 BIOSIS NO.: 200400176881
Construction and validation of cDNA-based Mt6k-RIT macro- and microarrays to explore root endosymbioses in the model legume *Medicago* truncatula.
2004

16/6/89 (Item 89 from file: 10)
3828932 22040864 Holding Library: AGL
Constitutive heterochromatin DNA polymorphisms in diploid *Medicago* sativa ssp. falcata
1999

16/6/90 (Item 90 from file: 10)
4870149 44061843 Holding Library: AGL
Capacity of high milk yielding goats for utilizing *cultivated* pasture
2008
URL: http://dx.doi.org/10.1016/j.smallrumres.2008.03.011

16/6/91 (Item 91 from file: 10)
3238271 92072917 Holding Library: AGL
Corn growth and yield in an *alfalfa* living mulch system
1992 Jul

16/6/92 (Item 92 from file: 10)
3383614 20411504 Holding Library: AGL
Crop management systems for corn (Zea mays L.) following established *alfalfa* (*Medicago* sativa L.)
1994 Apr

16/6/93 (Item 93 from file: 10)
4049771 23319640 Holding Library: AGL
Crop rotation, *tillage* and crop residue management for wheat and maize in the sub-humid tropical highlands. I. Wheat and legume performance
2002

16/6/94 (Item 94 from file: 10)
4049772 23319644 Holding Library: AGL
Crop rotation, *tillage* and crop residue management for wheat and maize in the sub-humid tropical highlands. II. Maize and system performance
2002

16/6/95 (Item 95 from file: 10)
3151032 92012362 Holding Library: AGL
Crop rotation and *tillage* effects on corn growth and soil structural stability
1991 Nov

16/6/96 (Item 96 from file: 10)
4044856 23308688 Holding Library: AGL
Crop rotation and *tillage* system effects on weed seedbanks
2002

16/6/97 (Item 97 from file: 50)
0006697243 CAB Accession Number: 19931977825
Crop and *tillage* induced changes in macropore geometry.
Preferential flow: proceedings of the National Symposium, Chicago, Illinois, USA, 16-17 December 1991.
Publication Year: 1991

16/6/98 (Item 98 from file: 40)
00387018 ENVIROLINE NUMBER: 91-06123
Cropping and *Tillage* Options to Achieve Erosion Control Goals and Maximum Profit on Irregular Slopes
Nov-Dec 90

16/6/99 (Item 99 from file: 5)
11275733 BIOSIS NO.: 199293118624
CROP SEQUENCE AND *TILLAGE* EFFECTS ON WINTER WHEAT DEVELOPMENT AND YIELD
1991

16/6/100 (Item 100 from file: 10)
3111515 91041770 Holding Library: AGL
Crop sequences and *tillage* practices in relation to diseases of winter wheat in Ontario
1990 Dec

16/6/102 (Item 102 from file: 50)
0006474740 CAB Accession Number: 19910749089
Cropping systems using living mulches for no-*till* corn (Zea mays) production.
Publication Year: 1991

16/6/103 (Item 103 from file: 203)
02524837
Cirsium arvense - problematic weed in *organic* *farming*
2002
International Scientific Conference "Scientific Aspects of *Organic* *Farming*". Proceedings of the conference held in Jelgava, Latvia, March 21-22, 2002 (Biologiskas lauksaimniecibas zinatniskie aspekti. Konferences materiali, Latvija, Jelgava, 21.-22.marts, 2002)

16/6/104 (Item 104 from file: 50)
0008952682 CAB Accession Number: 20053211499
Cutting effects on persistence and sustainability of an *alfalfa*-tall fescue mixture.
Book Title: Integrating efficient grassland farming and biodiversity. Proceedings of the 13th International Occasional Symposium of the European Grassland Federation, Tartu, Estonia, 29-31 August 2005
Publication Year: 2005

16/6/105 (Item 105 from file: 143)
1252569 H.W. WILSON RECORD NUMBER: BBAI91034437
Cutting interval and irrigation timing in *alfalfa*: yellow foxtail invasion and economic analysis
19910500

16/6/106 (Item 106 from file: 10)
3895152 22301308 Holding Library: AGL
Use of cover crop mulches in a no-*till* furrow-irrigated processing

tomato production system
2001

16/6/107 (Item 107 from file: 10)
3530087 20528932 Holding Library: AGL
Cover crops in reduced *tillage* systems
1995

16/6/108 (Item 108 from file: 5)
15458689 BIOSIS NO.: 200000177002
Cover crops and interrow *tillage* for weed control in short season maize (Zea mays)
2000

16/6/109 (Item 109 from file: 50)
0008220303 CAB Accession Number: 20023059359
Cynoglossum officinale , a new natural host of *Alfalfa* mosaic virus .
Publication Year: 2002

16/6/110 (Item 110 from file: 50)
0008032669 CAB Accession Number: 20003034912
Cytogenetics in *alfalfa* (*Medicago* sativa L.) breeding.
Original Title: Citogenetica no melhoramento de alfafa (*Medicago* sativa L.).
Publication Year: 2000

16/6/111 (Item 111 from file: 5)
10825019 BIOSIS NO.: 199192070790
DIFFERENTIAL GIEMSA STAINING IN *MEDICAGO*-SPP
1990

16/6/112 (Item 112 from file: 50)
0008639807 CAB Accession Number: 20043078091
Different nutritive values of *alfalfa* silages based on mixed and unmixed sowings.
Original Title: Puhas- ja segukulvi lutsernisilo toitevaartuse erinevusi.
Publication Year: 2003

16/6/113 (Item 113 from file: 5)
19264232 BIOSIS NO.: 200600609627
Differences in syntenic complexity between *Medicago* truncatula with Lens culinaris and Lupinus albus
2006

16/6/114 (Item 114 from file: 10)
3327253 20358561 Holding Library: AGL
Delayed seeding of *alfalfa* avoids autotoxicity after plowing or glyphosate treatment of established stands
1993 Mar

16/6/115 (Item 115 from file: 10)
3641935 20619637 Holding Library: AGL
Denitrification estimates in monoculture and rotation corn as influenced by *tillage* and nitrogen fertilizer
1997

16/6/116 (Item 116 from file: 24)
0001714043 IP ACCESSION NO: 4039418
The density of Bombus lucorum (L.) required to effect maximum pollination of *alfalfa* in Estonia
PUBLICATION DATE: 1996

16/6/117 (Item 117 from file: 6)
2040334 NTIS Accession Number: MIC-97-07002/XAB
Direct seeding of *alfalfa* and meadow bromegrass for hay and seed production: Final report
c1997

16/6/118 (Item 118 from file: 10)
3484516 20492225 Holding Library: AGL
Direct seeding of *alfalfa* in grain stubble and bromegrass sod
1994 Oct

16/6/119 (Item 119 from file: 143)
1701017 H.W. WILSON RECORD NUMBER: BBAI94042871
Direct seeding of *alfalfa* into established Russian wildrye pasture in southwest Saskatchewan
19940700

16/6/120 (Item 120 from file: 5)
11788125 BIOSIS NO.: 199395090391
Dark-induced changes in the content of phenolic acids in callus culture of *alfalfa* (*Medicago* sativa)
1990

16/6/121 (Item 121 from file: 143)
1128286 H.W. WILSON RECORD NUMBER: BBAI95006483
Dairy manure applications to *alfalfa*: crop response, soil nitrate, and nitrate in soil water
19941100

16/6/122 (Item 122 from file: 143)
1629764 H.W. WILSON RECORD NUMBER: BBAI03109904
Dry Matter Yields of Cool-Season Grass Monocultures and Grass-*Alfalfa* Binary Mixtures
20010300

16/6/123 (Item 123 from file: 50)
0007747812 CAB Accession Number: 19991907666
Drying out of small prairie wetlands after conversion of their catchments from *cultivation* to permanent brome grass.
Publication Year: 1999

16/6/124 (Item 124 from file: 203)
02392652
Detection of the nematode Ditylenchus dipsaci on seed of *alfalfa* (*Medicago* sativa L.) (Controllo del nematode Ditylenchus dipsaci su semente di erba medica [*Medicago* sativa L.])
1999

16/6/125 (Item 125 from file: 203)
02611000

Development of *alfalfa* tolerant to salinity stress using organogenesis technique
2004

16/6/126 (Item 126 from file: 50)
0008313220 CAB Accession Number: 20023026132
Development of a new lucerne variety for *organic* *farming*.
Original Title: Costituzione di una varieta di erba medica per l'agricoltura biologica.
Publication Year: 2001

16/6/127 (Item 127 from file: 266)
00557407
IDENTIFYING NO.: 0184846 AGENCY CODE: AGRIC
DEVELOPMENT OF PEST MANAGEMENT STRATEGIES FOR FORAGE *ALFALFA* PERSISTENCE

16/6/128 (Item 128 from file: 50)
0006404901 CAB Accession Number: 19910744943
Development of a renovation method for grassland with reduced rotary *cultivation*. I. Main factors affecting establishment of herbage.
Publication Year: 1990

16/6/129 (Item 129 from file: 266)
00583087
IDENTIFYING NO.: 0406943 AGENCY CODE: AGRIC
DEVELOPMENT AND UTILIZATION OF SIMPLE SEQUENCE REPEAT (SSR) MOLECULAR MARKERS FOR THE IMPROVEMENT OF *ALFALFA* AND RELATED SPECIES

16/6/130 (Item 130 from file: 5)
18765501 BIOSIS NO.: 200600110896
Development of weed populations with no-*tillage* of winter wheat into living mulches
ORIGINAL LANGUAGE TITLE: Entwicklung der Unkrautpopulationen bei Direktuat von Winterweizen in Lebendmulche
2002

16/6/131 (Item 131 from file: 10)
3608622 20590999 Holding Library: AGL
Diversity and longevity of the soybean debris mycobiota in a no-*tillage* system
1997

16/6/132 (Item 132 from file: 203)
01697339
Dynamics of occurrence of Sitona humeralis Steph. on *alfalfa* fields in south-eastern region of Poland (Dynamika wystepowania oprzedzika wilzynowego (Sitona humeralis Steph.) na plantacjach lucerny siewnej w poludniowo-wschodniej Polsce)
1991
Materials of the 31st Research Session of Institute for Plant Protection. Pt. 2. Posters (Materialy 31 Sesji Naukowej Instytutu Ochrony Roslin. Cz. 2. Postery)

16/6/133 (Item 133 from file: 5)
18941264 BIOSIS NO.: 200600286659
Dynamic of the genetic structure of bacterial and fungal communities at

different developmental stages of *Medicago* truncatula Gaertn. cv. Jemalong line J5
2006

16/6/135 (Item 135 from file: 5)
05894570 BIOSIS NO.: 198069008557
DYNAMICS OF SOIL COLLEMBOLA POPULATIONS INSECTA APTERYGOTA UNDER *ALFALFA* CULTURE IN THE SOMES VALLEY CLUJ DEPARTMENT ROMANIA

16/6/136 (Item 136 from file: 10)
4632518 43919323 Holding Library: AGL
Dynamics of soil organic carbon and soil fertility affected by *alfalfa* productivity in a semiarid agro-ecosystem
2006
URL: http://dx.doi.org/10.1007/s10533-006-9020-z

16/6/138 (Item 138 from file: 5)
10063442 BIOSIS NO.: 199039116831
DISSERTATIONES BOTANICAE VOL. 153. ECOLOGICAL INVESTIGATIONS ON WILD AND *CULTIVATED* PLANTS IN THE EXTREME DESERT OF SOUTH EGYPT
BOOK TITLE: SCHNEIDER, U. DISSERTATIONES BOTANICAE, BAND 153. PFLANZENOEKOLOGISCHE UNTERSUCHUNGEN AN WILD- UND KULTURPFLANZEN IN DER EXTREMWUESTE SUEDAEGYPTENS; (DISSERTATIONES BOTANICAE, VOL. 153. ECOLOGICAL INVESTIGATIONS ON WILD AND *CULTIVATED* PLANTS IN THE EXTREME DESERT OF SOUTH EGYPT). II+292P. E. SCHWEIZERBART'SCHE VERLAGSBUCHHANDLUNG: STUTTGART, WEST GERMANY; J. CRAMER IN DER GEBRUEDER BORNTRAEGER VERLAGSBUCHHANDLUNG: BERLIN, WEST GERMANY. ILLUS. MAPS. PAPER
1990

16/6/139 (Item 139 from file: 5)
15494318 BIOSIS NO.: 200000212631
Distribution of range and *cultivated* grassland plants in southern Alberta
2000

16/6/140 (Item 140 from file: 266)
00572769
IDENTIFYING NO.: 0205406 AGENCY CODE: AGRIC
Ecology and Development of Yellow-flowered *Alfalfa*

16/6/141 (Item 141 from file: 50)
0009472078 CAB Accession Number: 20083031575
Effects of CaCo SUB 3 on *alfalfa* salinity tolerance.
Publication Year: 2006

16/6/142 (Item 142 from file: 50)
0007662176 CAB Accession Number: 19991900235
Effects of the *cultivation* of several fodder crops without irrigation on the regional water balance situation in the Beerze-Reusel area.
Original Title: Effect van de teelt van verschillende voedergewassen zonder beregening op de regionale waterhuishouding in het Beerze-Reusel gebied.
Rapport - DLO Staring Centrum, Instituut voor Onderzoek van het Landelijk Gebied
Publication Year: 1998

16/6/143 (Item 143 from file: 10)
3759438 21993809 Holding Library: AGL

Effect of crop management on C and N in long-term crop rotations after adopting no-*tillage* management: comparison of soil sampling strategies
1998

16/6/144 (Item 144 from file: 10)
3789343 22012154 Holding Library: AGL
Influence of crop rotation, *tillage*, and management inputs on weed seed production
1999

16/6/145 (Item 145 from file: 50)
0009369207 CAB Accession Number: 20073239673
Effects of crop rotation and *tillage* on infestation of Cirsium arvense in *organic* *farming* systems.
Book Title: European weed research society. Proceedings of the 6th EWRS workshop on physical and cultural weed control, Lillehammer, Norway, 8-10 March, 2004
Publication Year: 2004

16/6/146 (Item 146 from file: 50)
0008639339 CAB Accession Number: 20043078912
Effect of crop rotation, *tillage* and residue management on tan spot in the subhumid tropical highlands.
Book Title: Proceedings of Fourth International Wheat Tan Spot and Spot Blotch Workshop, Bemidji, Minnesota, USA, 21-24 July, 2002
Publication Year: 2003

16/6/147 (Item 147 from file: 50)
0007267247 CAB Accession Number: 19960709795
Influence of crop succession and soil *tillage* on wheat take-all (Gaeumannomyces graminis var. tritici).
Proceedings of the third congress of the European Society for Agronomy, Padova University, Abano-Padova, Italy, 18-22 September 1994.
Publication Year: 1994

16/6/148 (Item 148 from file: 10)
3027479 90050589 Holding Library: AGL
Influence of cover crops and *tillage* on seedcorn maggot (Diptera: anthomyiidae) populations in soybeans
1990 Jun

16/6/149 (Item 149 from file: 5)
13515338 BIOSIS NO.: 199699149398
Effect of doubled-CO-2 concentration on the ultrastructure of chloroplasts from *Medicago* sativa and Setaria italica
1996

16/6/150 (Item 150 from file: 50)
0007678255 CAB Accession Number: 19990701361
Effect of different periods of drought stress on regrowth and yield of *alfalfa* cultivar Mesasersa in Kuzestan.
Publication Year: 1998

16/6/151 (Item 151 from file: 50)
0008853924 CAB Accession Number: 20053111212
Effect of different *tillage* and rice residue management practices on weed dynamics and grain yield of wheat.

Publication Year: 2004

16/6/152 (Item 152 from file: 50)
0007987802 CAB Accession Number: 20003021118
The effect of different soil *tillage* on the yields of winter wheat.
Original Title: Vliv ruzneho zpracovani pudy na vynosy ozime psenice.
Publication Year: 2000

16/6/153 (Item 153 from file: 50)
0007539674 CAB Accession Number: 19980705351
The effect of forecrop, soil *tillage* and fertilizer application on yield, its structure and efficiency of winter wheat growing.
Original Title: Vplyv roznej predplodiny, obrabania pody a hnojenia na vysku a strukturu urody a effektivnost' pestovania ozimnej psenice.
Publication Year: 1998

16/6/154 (Item 154 from file: 10)
3771225 22002404 Holding Library: AGL
Effect of phytopthora resistance levels and time of planting on *alfalfa* autotoxicity
1996

16/6/155 (Item 155 from file: 144)
15306009 PASCAL No.: 01-0480004
Efeito de sistemas de producao de graos e de pastagens sob plantio direto sobre o nivel de fertilidade do solo apos cinco anos
(Effect of grain and forage crop production systems under no-*tillage* on soil fertility after five years)
2001

16/6/156 (Item 156 from file: 50)
0009268866 CAB Accession Number: 20073122054
Effects of grain production systems including pastures under no-*tillage* on soil physical properties and yield.
Original Title: Efeitos de sistemas de producao de graos envolvendo pastagens sob plantio direto nos atributos fisicos de solo e na produtividade.
Publication Year: 2004

16/6/157 (Item 157 from file: 50)
0007504814 CAB Accession Number: 19980703050
Effects of great bustards (Otis tarda) on *cultivated* areas in west-central Spain.
Publication Year: 1998

16/6/158 (Item 158 from file: 5)
10802365 BIOSIS NO.: 199192048136
EFFECT OF HERBICIDES ON THE THERMOLUMINESCENCE OF *CULTIVATED* PLANTS AND SEEDS
1990

16/6/159 (Item 159 from file: 5)
13313957 BIOSIS NO.: 199698781790
Effect of hydrocarbons and crude oil contamination on the sensitivity of French bean to *alfalfa* mosaic virus
1995

16/6/160 (Item 160 from file: 5)
13094218 BIOSIS NO.: 199698562051
Influence of *alfalfa* (*Medicago* sativa L.) intercropping and polyethylene mulching on early growth of walnut (Juglans spp.) in central Italy
1995

16/6/161 (Item 161 from file: 10)
3583160 20571777 Holding Library: AGL
Influence of *alfalfa* escapes on estimating spring barley yield
1995

16/6/162 (Item 162 from file: 203)
01903529
Effect of the *alfalfa* stand establishment method on seed yields (Vplyv sposobu zalozenia porastu lucerny na urodu semena)
1995

16/6/163 (Item 163 from file: 50)
0006805441 CAB Accession Number: 19942301417
Effects of mechanical *cultivation* , hoeing, single and combined herbicidal treatments on weed control in faba beans.
Publication Year: 1991

16/6/164 (Item 164 from file: 50)
0007917685 CAB Accession Number: 20000709843
Effects of *Medicago* polymorpha L. cover cropping in Sardinia vineyards.
Publication Year: 2000

16/6/165 (Item 165 from file: 50)
0006725381 CAB Accession Number: 19930765530
Effect of mineral fertilizers and methods of soil *tillage* on crop productivity and nutrient balance in a soil-protecting crop rotation in the Ukrainian forest steppe.
Publication Year: 1990

16/6/166 (Item 166 from file: 5)
10788013 BIOSIS NO.: 199192033784
THE EFFECT OF AMINOETHOXYVINYLGLYCINE AND SILVER ON ETHYLENE SYNTHESIS AND ACTIVITY OF PHENYLALANINE AMMONIA-LYASE IN *ALFALFA* CELL SUSPENSION CULTURE
1991

16/6/167 (Item 167 from file: 144)
16252707 PASCAL No.: 03-0413989
Efeito de sistemas de producao mistos sob plantio direto sobre fertilidade do solo apos oito anos
(Effect of mixed crop prod uction systems under no-*tillage* on soil fertility after eight years)
2003

16/6/169 (Item 169 from file: 5)
18753978 BIOSIS NO.: 200600099373
Effects of the mycorrhizal fungus Glomus intraradices on uranium uptake and accumulation by *Medicago* truncatula L. from uranium-contaminated soil
2005

16/6/170 (Item 170 from file: 10)
3136449 91959993 Holding Library: SDS; AGL
Effects of including *alfalfa* in whole-farm plans comparison of conventional, ridge *till*, and alternative farming systems / by Clarence Mends and Thomas L. Dobbs
1991

16/6/171 (Item 171 from file: 50)
0009378019 CAB Accession Number: 20073209564
Effect of inoculating lactic bacteria community A12 and microbial shifts during *alfalfa* ensiling process.
Publication Year: 2007

16/6/172 (Item 172 from file: 50)
0008891153 CAB Accession Number: 20053150735
Effect of the inherent variation in the mineral concentration of *alfalfa* cultivars on aphid populations.
Publication Year: 2005

16/6/173 (Item 173 from file: 5)
0019495370 BIOSIS NO.: 200700155111
Effect of the inherent variation in the mineral concentration of *alfalfa* cultivars on aphid populations
2005

16/6/174 (Item 174 from file: 50)
0009526997 CAB Accession Number: 20083113534
Effects of no *tillage* and genetic resistance on sunflower wilt by Verticillium dahliae .
Publication Year: 2008

16/6/175 (Item 175 from file: 5)
17649482 BIOSIS NO.: 200400016466
The effect on soil phosphorus in long-term continuous cropping of *alfalfa* in the arid loess regions.
2003

16/6/176 (Item 176 from file: 5)
14055984 BIOSIS NO.: 199799690044
Effect of plastic mulching and *alfalfa* intercropping (*Medicago* sativa L.) on walnut (Juglans spp.) growth and tree-soil water relations during early plantation phases
1994

16/6/177 (Item 177 from file: 50)
0007633313 CAB Accession Number: 19980614914
Effects of plastic mulching and intercropping with *alfalfa* (*Medicago* sativa) on walnut (Juglans spp.) growth and tree/soil water relations during early plantation phases.
Original Title: Effetto della pacciamatura plastica e della consociazione con l'erba medica (*Medicago* sativa L.) sull'accrescimento e sulle relazioni idriche del noce (Juglans spp.) durante le fasi giovanili.
Publication Year: 1994/1995, publ. 1997

16/6/178 (Item 178 from file: 5)

11217233 BIOSIS NO.: 199293060124
EFFECTS OF PERENNIAL FORAGE-LEGUME LIVING MULCHES ON NO-*TILL* WINTER WHEAT AND RYE
1991

16/6/179 (Item 179 from file: 50)
0007213207 CAB Accession Number: 19960705637
The effect of preplant fertilization in the establishment of *alfalfa* -kikuyu grass intercropping in the Venezuelan Andes.
Ecophysiology of tropical intercropping. Proceedings of an international meeting held in Guadeloupe on 6-10 Dec. 1994.
Publication Year: 1995

16/6/180 (Item 180 from file: 5)
0019893882 BIOSIS NO.: 200700553623
Effect of ridge and furrow micro-catchment on soil water in seeded *Medicago* sativa grassland in the semiarid loess hill and gully region of northwestern China
2007

16/6/181 (Item 181 from file: 203)
02158202
Effect of irrigation with saline water on root distribution and forage yield by different root types of *alfalfa* (*Medicago* sativa) under different soil salinity conditions with zero leaching
1996
The Genus *Medicago* in the Mediterranean Region: Current Situation and Prospects in Research (Le Genre *Medicago* en Mediterranee : Bilan et Perspectives de la Recherche)

16/6/182 (Item 182 from file: 50)
0007639497 CAB Accession Number: 19981915362
Effect of irrigation water quality on salt accumulation in soil and mineral contents of *alfalfa* in the United Arab Emirates.
Publication Year: 1998

16/6/183 (Item 183 from file: 5)
12747612 BIOSIS NO.: 199598215445
Effect of Rhizobium meliloti inoculation on the yield and biochemical properties of *alfalfa*
1994

16/6/184 (Item 184 from file: 5)
11868546 BIOSIS NO.: 199396032962
Influence of *tillage* on soybean (Glycine max) herbicide carryover to grass and legume forage crops in Missouri
1993

16/6/185 (Item 185 from file: 50)
0009287251 CAB Accession Number: 20073142785
Effect of *tillage* packages and herbicides on energy and economics of wheat in transplanted rice (Oryza sativa)-wheat (Triticum aestivum) system.
Publication Year: 2007

16/6/186 (Item 186 from file: 5)
18760124 BIOSIS NO.: 200600105519

Effect of *tillage* practices and herbicides on weed dynamics and yield of wheat (Triticum aestivum) under transplanted rice (Oryza sativa)-wheat system in Vertisols
2005

16/6/188 (Item 188 from file: 5)
17406177 BIOSIS NO.: 200300364896
Effect of *tillage* and rotation on organic carbon forms of chernozemic soils in Saskatchewan.
2003

16/6/190 (Item 190 from file: 10)
4830645 43791399 Holding Library: AGL

Influence of *tillage* and rotation systems on distribution of organic carbon associated with particle-size fractions in Chernozemic soils of Saskatchewan, Canada
2006
URL: http://dx.doi.org/10.1007/s00374-005-0032-y

16/6/191 (Item 191 from file: 50)
0009065416 CAB Accession Number: 20063130118
Effect of *tillage* and weed control methods on weeds and yield of rice-wheat and soybean-wheat cropping systems.
Publication Year: 2005

16/6/192 (Item 192 from file: 5)
13158968 BIOSIS NO.: 199698626801
Effects of tall wheatgrass windbreaks on hay production of three *alfalfa* varieties at a semiarid location in Saskatchewan
1995

16/6/193 (Item 193 from file: 50)
0008952546 CAB Accession Number: 20053211665
Effect of timothy sowing ratio on yield and nutritive value of *alfalfa* /timothy bi-crops.
Book Title: Integrating efficient grassland farming and biodiversity. Proceedings of the 13th International Occasional Symposium of the European Grassland Federation, Tartu, Estonia, 29-31 August 2005
Publication Year: 2005

16/6/194 (Item 194 from file: 10)
3787830 22016449 Holding Library: AGL
Influence of oat (Avena sativa) interseeding on weed suppression in the final year of an *alfalfa* (*Medicago* sativa) stand
1999

16/6/195 (Item 195 from file: 10)
3316013 93055163 Holding Library: AGL
Effect of vegetation suppression on the establishment of sod-seeded *alfalfa* in the Aspen Parkland
1992 Oct

16/6/196 (Item 196 from file: 50)
0009349469 CAB Accession Number: 20073186074
Effect of vineyard grass covering with *alfalfa* (*Medicago* sativa)

on nitrogenous compound of grape berry and wine in grape cultivar cabernet sauvignon.
Publication Year: 2007

16/6/197 (Item 197 from file: 50)
0007722982 CAB Accession Number: 19990704323
The effectiveness of oversowing of mountain meadows using different soil *cultivation* treatments.
Original Title: Skutecznoscs podsiewu ak gorskich w zaleznosci od sposobu przygotowania gleby.
Publication Year: 1998

16/6/198 (Item 198 from file: 10)
3238273 92072919 Holding Library: AGL
Effects of weed and invertebrate control on *alfalfa* establishment in oat stubble
1992 Jul

16/6/199 (Item 199 from file: 50)
0008096908 CAB Accession Number: 20003018937
Influence of water stress on the nitrogen fixation of some lines of *Medicago* sativa .
Publication Year: 2000

16/6/200 (Item 200 from file: 10)
4666967 43651175 Holding Library: AGL
Effect of seeding rate on *alfalfa* stand longevity
2004

16/6/201 (Item 201 from file: 50)
0009453287 CAB Accession Number: 20083012296
Influence of soil *cultivation* and fertilizing on productivity and digestibility of lucerne forage.
Publication Year: 2006

16/6/202 (Item 202 from file: 203)
02524298
The effect of soil *cultivation* on changes of its physical and chemical properties (Vplyv obrabania pody na zmeny jej fyzikalnych a chemickych vlastnosti)
2002

16/6/203 (Item 203 from file: 203)
02525831
The influence of selected soil physical parameters on the *alfalfa* hay production (Vplyv fyzikalnych vlastnosti na produkciu lucerny pri rozdielnych systemoch zakladania porastu)
2002

16/6/204 (Item 204 from file: 203)
02584550
The effect of salinity on the growth of *Medicago* polymorpha Linn.
2003

16/6/205 (Item 205 from file: 50)
0007563684 CAB Accession Number: 19980706691
Effect of soil preparation on *alfalfa* dry matter yield.

Original Title: Vplyv pripravy pody na urody lucerny siatej.
Ecological and biological aspects of fodder crop production. Refereed papers from an international research conference held at Nitra, Slovakia, 23 October 1997.
Publication Year: 1997

16/6/206 (Item 206 from file: 10)
3658870 20815229 Holding Library: AGL
The influence of soil *tillage* on the distribution of medic seeds in the soil, regeneration of medics and wheat yields in a medic wheat rotation
1998

16/6/207 (Item 207 from file: 203)
02427410
Effects of salt treatments on the production and chemical composition of salt wort (Salicornia herbacea L.), rhodesgrass [Chloris gayana] and *alfalfa* [*Medicago* sativa]
2000

16/6/209 (Item 209 from file: 143)
0868330 H.W. WILSON RECORD NUMBER: BBAI98022947
Influence of soil texture on *alfalfa* autotoxicity
19980100

16/6/210 (Item 210 from file: 10)
4677312 43937746 Holding Library: AGL
Effect of salt stress on the expression of NHX-type ion transporters in *Medicago* intertexta and Melilotus indicus plants
2007
URL: http://dx.doi.org/10.1111/j.1399-3054.2007.00940.x

16/6/211 (Item 211 from file: 5)
0019912099 BIOSIS NO.: 200700571840
Effect of salt stress on the expression of NHX-type ion transporters in *Medicago* intertexta and Metilotus indicus plants
2007

16/6/212 (Item 212 from file: 50)
0008433709 CAB Accession Number: 20033073813
The effectiveness of sewage sludge in soil recovery on flotation *tilling* tips.
Original Title: Rekultywacyjna efektywnoscs osadow sciekowych na podozu wapna poflotacyjnego.
Publication Year: 2002

16/6/213 (Item 213 from file: 5)
17234642 BIOSIS NO.: 200300193361
Effect of iodine treatments on forage yields of *alfalfa*.
2003

16/6/214 (Item 214 from file: 5)
11202314 BIOSIS NO.: 199293045205
EFFECTS OF TWO CROPPING AND TWO *TILLAGE* SYSTEMS AND PESTICIDES ON PEANUT PEST MANAGEMENT
1991

16/6/215 (Item 215 from file: 10)

3246621 93001066 Holding Library: AGL
   Effect of 2,4-D and dicamba residues on following crops in conservation *tillage* systems
  1992 Jan

 16/6/216   (Item 216 from file: 50)
0007356264   CAB Accession Number: 19971904550
   Effects of four *cultivation* systems for maize on nitrogen leaching. 1. Field experiment.
   Publication Year: 1997

 16/6/217   (Item 217 from file: 50)
0007356263   CAB Accession Number: 19971904549
   Effects of four *cultivation* systems for maize on nitrogen leaching. 2. Model simulation.
   Publication Year: 1997

 16/6/218   (Item 218 from file: 10)
3603606 20588573 Holding Library: AGL
  Eliminating the use of residual herbicides in corn/*alfalfa* rotations
  1990

 16/6/219   (Item 219 from file: 10)
3988515 23269827 Holding Library: AGL
   Eliminating soil disturbance reduces post-*alfalfa* summer annual weed populations
  2001

 16/6/220   (Item 220 from file: 5)
10645971   BIOSIS NO.: 199191028862
EMBRYOLOGY OF SOME PERENNIAL *MEDICAGO* FABACEAE SPECIES
1990

 16/6/221   (Item 221 from file: 266)
00581976
  IDENTIFYING NO.: 0405542   AGENCY CODE: AGRIC
   ENHANCED DISEASE RESISTANCE AND IMPROVED METHODS OF PLANT SELECTION FOR *ALFALFA* AND OTHER LEGUMES

 16/6/222   (Item 222 from file: 156)

4042165   NLM Doc No: 16202815
   Enhancement of lead uptake by *alfalfa* (*Medicago* sativa) using EDTA and a plant growth promoter.
Oct 2005

 16/6/223   (Item 223 from file: 143)
1376551   H.W. WILSON RECORD NUMBER: BBAI00050281
Enhancing pasture productivity with *alfalfa*: a review
20000700

 16/6/224   (Item 224 from file: 5)
0019493452   BIOSIS NO.: 200700153193
Energy crop production on *organic* *farms* without livestock
ORIGINAL LANGUAGE TITLE: Energiepflanzenproduktion in viehlosen Biobetrieben
2006

16/6/225 (Item 225 from file: 10)
3595027 20581030 Holding Library: AGL
Energy requirements for conventional *tillage* following different crop rotations
1997

16/6/226 (Item 226 from file: 203)
02496558
Energetic evaluation of *alfalfa* growing in various systems of soil preparation and differentiated nutrition (Energeticke zhodnotenie pestovania lucerny siatej pri roznych systemoch pripravy pody a diferencovanej vyzive)
2002

16/6/227 (Item 227 from file: 50)
0007700044 CAB Accession Number: 19990702760
Erratum to `Soybean yield as affected by crop rotations, deep *tillage* and irrigation layout on a hardsetting Alfisol'.
Publication Year: 1999

16/6/228 (Item 228 from file: 203)
02710260
2004
Evaluation And Comparison Of Integrated, Chemical And Mechanical Control Of Broadleaf Weeds In Seed *Alfalfa*

16/6/229 (Item 229 from file: 50)
0007094882 CAB Accession Number: 19951910770
Evaluation of forage and grain legumes, no-*till* and fertilizers to restore fertility degraded soils.
15th World Congress of Soil Science, Acapulco, Mexico, 10-16, July, 1994. Transactions, Volume 5a: Commission IV symposia.
Publication Year: 1994

16/6/230 (Item 230 from file: 50)
0009427399 CAB Accession Number: 20073231263
Evaluation of lucerne varieties for organic agriculture.
Book Title: Breeding and seed production for conventional and organic agriculture. Proceedings of the XXVI meeting of the EUCARPIA fodder crops and amenity grasses section, XVI meeting of the EUCARPIA *Medicago* spp group, Perugia, Italy, 2-7 September 2006
Publication Year: 2007

16/6/231 (Item 231 from file: 5)
0019679749 BIOSIS NO.: 200700339490
Evaluation of annual pasture legumes in northern New South Wales. 2. Trifolium and *Medicago* spp. and other legumes
2007

16/6/232 (Item 232 from file: 10)
3483257 20490910 Holding Library: AGL
Evaluation of weed control practices during spring and summer *alfalfa* establishment
1995 Jul

16/6/233 (Item 233 from file: 143)
0502330 H.W. WILSON RECORD NUMBER: BBAI94052894

Evaluation of sainfoin-*alfalfa* mixtures for forage production and compatibility at a semi-arid location in southern Saskatchewan
19941000

16/6/234 (Item 234 from file: 5)
0019620392 BIOSIS NO.: 200700280133
Experimental *cultivation* of shiitake mushroom Lentinula edodes on two agricultural by-products from Guerrero, Mexico
ORIGINAL LANGUAGE TITLE: Cultivo experimental del hongo shiitake, Lentinula edodos, sobre dos subproductos agricolas en Guerrero, Mexico
2006

16/6/235 (Item 235 from file: 50)
0009102273 CAB Accession Number: 20063146549
Experiment on *cultivating* Sorghum sudanense in the lower reaches of the Tarim River.
Publication Year: 2004

16/6/236 (Item 236 from file: 50)
0008177350 CAB Accession Number: 20013091733
Experiments with leguminous crops in a stockless *organic* *farming* system with sugar beets.
Book Title: Designing and testing crop rotations for *organic* *farming*. Proceedings from an international workshop
Publication Year: 1999

16/6/237 (Item 237 from file: 5)
13517974 BIOSIS NO.: 199699152034
Extent of RFLP variability in tetraploid populations of *alfalfa*, *Medicago* sativa
1996

16/6/238 (Item 238 from file: 143)
1768724 H.W. WILSON RECORD NUMBER: BBAI03110537
Extraction of Subsoil Nitrogen by *Alfalfa*, *Alfalfa*-Wheat, and Perennial Grass Systems
20010500

16/6/239 (Item 239 from file: 10)
3503293 20509286 Holding Library: AGL
Establishment of lucerne after maize in conservation *tillage* systems
1994 Sep

16/6/240 (Item 240 from file: 50)
0007983510 CAB Accession Number: 20003004891
Establishing *alfalfa* on high clay soils after application of municipal solid waste.
Publication Year: 2000

16/6/241 (Item 241 from file: 5)
11813270 BIOSIS NO.: 199395115536
Estimation of suitability of the Ascherson's cocksfoot (Dactylis aschersoniana Graebn.) for field *cultivation*
1992

16/6/242 (Item 242 from file: 5)
17406336 BIOSIS NO.: 200300365055
[Efficiency of Gafsa phosphate associated with liming and gypsum and *alfalfa* *Medicago* sativa L. nutrient symptoms.]
ORIGINAL LANGUAGE TITLE: Eficiencia do fosfato natural de Gafsa associado a calagem e gesso e sintomas nutricionais da alfafa, *Medicago* sativa L.
2002

16/6/243 (Item 243 from file: 203)
01816068
[The effect of soil compaction on the production of *alfalfa*, perennial grasses and silage maize] (Uticaj sabijanja zemljista na proizvodnju lucerke, visegodisnjih trava i silokrmne kukuruza)
1993
The effect of soil compaction upon yield of agricultural cultures (Uticaj sabijanja zemljista na prinos poljoprivrednih kultura)

16/6/244 (Item 244 from file: 143)
1273938 H.W. WILSON RECORD NUMBER: BBAI00057772
Field response to selection in *alfalfa* for germination rate and seedling vigor at low temperatures
20000900

16/6/245 (Item 245 from file: 5)
11764369 BIOSIS NO.: 199395066635
Phenolic accumulation and peroxidase activity in in vitro selected *alfalfa* callus cultures resistant to filtrate of Fusarium spp
1992

16/6/246 (Item 246 from file: 5)
11256972 BIOSIS NO.: 199293099863
PHENOTYPIC RECURRENT SELECTION FOR 2N POLLEN AND 2N EGG PRODUCTION IN DIPLOID *ALFALFA*
1991

16/6/247 (Item 247 from file: 5)
14985511 BIOSIS NO.: 199900245171
Phenotypic variation and germplasm discrimination in lucerne (*Medicago* sativa complex) as evidenced by multivariate analysis
1999

16/6/248 (Item 248 from file: 5)
14157750 BIOSIS NO.: 199799791810
Phenylalanine ammonia-lyase activity in *alfalfa* suspension cultures treated with conidia and elicitors of Verticillium albo-atrum
1997

16/6/249 (Item 249 from file: 5)
15378478 BIOSIS NO.: 200000096791
Foraging use of *cultivated* fields by the Houbara Bustard Chlamydotis undulata fuertaventurae Rothschild and Hartert, 1894 on Fuerteventura (Canary Islands)
1999

16/6/250 (Item 250 from file: 50)
0007146712 CAB Accession Number: 19950713861
Formation and production of perennial grass stands depending on methods

of soil *cultivation*.
Publication Year: 1994

16/6/251 (Item 251 from file: 71)
00922874 1998168394
Fate of symbiotically-fixed sup 1sup 5Ninf 2 as influenced by method of *alfalfa* termination
PUBLICATION DATE: 19980000

16/6/253 (Item 253 from file: 10)
3729908 21969873 Holding Library: AGL
Fate of symbiotically-fixed 15N2 as influenced by method of *alfalfa* termination
1998

16/6/254 (Item 254 from file: 50)
0008504921 CAB Accession Number: 20033156584
Photosynthesis in *alfalfa* (*Medicago* sativa L.) under phosphate suppression and ressuply.
Original Title: Fotossintese em *alfalfa* (*Medicago* sativa L.) sob supressao e ressuprimento de fosfato.
Publication Year: 2003

16/6/255 (Item 255 from file: 40)
00457693 ENVIROLINE NUMBER: 97-15303
Phytoremediation of Diesel-Contaminated Soil Using *Alfalfa*
Apr 28-May 1, 97

16/6/256 (Item 256 from file: 10)
3555000 20548811 Holding Library: AGL
Phytotoxicity of ryegrass and clover cover crops, and a lucerne alley crop for no-*till* vegetable production
1996

16/6/257 (Item 257 from file: 5)
12196046 BIOSIS NO.: 199497217331
Study of the phytoestrogen content of goat's rue (Galega orientalis), *alfalfa* (*Medicago* sativa) and white clover (Trifolium repens)
1993

16/6/258 (Item 258 from file: 50)
0007915330 CAB Accession Number: 20001612752
Physical mapping of rRNA genes in *Medicago* sativa and M. glomerata by fluorescent in situ hybridization.
Publication Year: 2000

16/6/259 (Item 259 from file: 266)
00441141
IDENTIFYING NO.: 0343975 AGENCY CODE: NSF
Phosphate Transport in the Arbuscular Mycorrhizal Symbiosis: Functional Analysis of a *Medicago* Truncatula Mycorrhiza-Specific Phosphate Transporter

16/6/260 (Item 260 from file: 5)
16728966 BIOSIS NO.: 200200322477
[The genus *Medicago* in agricultural systems and in safeguarding the environment: The role of annuals.]

ORIGINAL LANGUAGE TITLE: Il genere *Medicago* L. nei sistemi colturali e nella salvaguardia dell'ambiente: Il ruolo delle annuali
2001

16/6/261 (Item 261 from file: 5)
16322239 BIOSIS NO.: 200100494078
Genetic diversity of indigenous Rhizobium leguminosarum bv. viciae isolates nodulating two different host plants during soil restoration with *alfalfa*
2001

16/6/262 (Item 262 from file: 50)
0007445003 CAB Accession Number: 19971611386
Genetic diversity inventory and valuation of spontaneous species belonging to *Medicago* L. genus in Tunisia.
Publication Year: 1996

16/6/263 (Item 263 from file: 50)
0007444996 CAB Accession Number: 19971611379
Genetic diversity, preservation and use of genetic resources of Mediterranean legumes: *alfalfa* and medics.
Publication Year: 1996

16/6/264 (Item 264 from file: 50)
0009427444 CAB Accession Number: 20073231320
Genetic diversity and potential agronomic value of *Medicago* polymorpha L. populations collected in Sicily.
Book Title: Breeding and seed production for conventional and organic agriculture. Proceedings of the XXVI meeting of the EUCARPIA fodder crops and amenity grasses section, XVI meeting of the EUCARPIA *Medicago* spp group, Perugia, Italy, 2-7 September 2006
Publication Year: 2007

16/6/266 (Item 266 from file: 10)
4740671 43981621 Holding Library: AGL
Genetic and physical localization of an anthracnose resistance gene in *Medicago* truncatula
2007
URL: http://dx.doi.org/10.1007/s00122-007-0645-7

16/6/267 (Item 267 from file: 10)
4689432 43883734 Holding Library: AGL
Genetic Mapping Forage Yield, Plant Height, and Regrowth at Multiple Harvests in Tetraploid *Alfalfa* (*Medicago* sativa L.)
2007
URL: http://dx.doi.org/10.2135/cropsci2006.07.0447

16/6/268 (Item 268 from file: 203)
02638542
Genetic transformation of *Medicago* truncatula using system for direct somatic embryogenesis promoted by TDZ
2005

16/6/269 (Item 269 from file: 5)
13073579 BIOSIS NO.: 199598541412
Genetic variability for morphology, growth and forage yield among perennial diploid and tetraploid lucerne populations (*Medicago* sativa L)
1995

16/6/270 (Item 270 from file: 10)
3148910 92010235 Holding Library: AGL
Genetic variation detectable with molecular markers among unadapted germ-plasm resources of *cultivated* peanut and related wild species
1991 Dec

16/6/271 (Item 271 from file: 5)
13620925 BIOSIS NO.: 199699254985
Genetic variation for disease and nematode resistances and forage quality in perennial diploid and tetraploid lucerne populations (*Medicago* sativa L.)
1996

16/6/272 (Item 272 from file: 50)
0007444997 CAB Accession Number: 19971611380
Genetic variation in the *Medicago* sativa complex.
Publication Year: 1996

16/6/273 (Item 273 from file: 5)
15594442 BIOSIS NO.: 200000312755
Genetic variation for seed yield and its components in *alfalfa* (*Medicago* sativa L.) populations
2000

16/6/274 (Item 274 from file: 143)
2101238 H.W. WILSON RECORD NUMBER: BBAI03124033
Genotypes of lucerne (*Medicago* sativa L.) show differential tolerance to manganese deficiency and toxicity when grown in bauxite residue sand
20030200

16/6/275 (Item 275 from file: 5)
15587300 BIOSIS NO.: 200000305613
Gene expression of *Medicago* sativa inoculated with Sinorhizobium meliloti as modulated by the xenobiotics cadmium and fluoranthene
2000

16/6/276 (Item 276 from file: 40)
00554052 ENVIROLINE NUMBER: 98-12730
Groundwater Quality Under Conventional and No *Tillage* : I. Nitrate, Electrical Conductivity, and pH
Jul-Aug 98

16/6/277 (Item 277 from file: 50)
0008241700 CAB Accession Number: 20023085915
Growing processing tomatoes with less *tillage* in California.
Publication Year: 2001

16/6/278 (Item 278 from file: 44)
0000622511 IP ACCESSION NO: 4236064
The growth and morphological variability of Anabaena thermalis Vouk under joint *cultivation* with seedlings of higher plants
ORIGINAL TITLE: Rost i morfologicheskaya izmenchivost' Anabaena thermalis Vouk pri sovmestnom vyrashchivanii s prorostkami vysshikh rastenii
PUBLICATION DATE: 1995

16/6/279 (Item 279 from file: 50)

0009289250 CAB Accession Number: 20073112658
High efficient irrigation scheduling of the perennial *cultivated* forage grasses.
Publication Year: 2006

16/6/280 (Item 280 from file: 266)
00583648
IDENTIFYING NO.: 0407539 AGENCY CODE: AGRIC
HIGH-THROUGHPUT REVERSE GENETICS IN *MEDICAGO* TRUNCATULA

16/6/281 (Item 281 from file: 5)
0019932446 BIOSIS NO.: 200700592187
Hydraulic conductivity and porosity under conventional and no-*tillage* and the effect of three species of cover crop in northern France
2007

16/6/282 (Item 282 from file: 5)
10858618 BIOSIS NO.: 199192104389
THE USE OF HISTOCHEMICAL ANALYSIS AND STEM COLONIZATION FOR DISTINGUISHING REACTIONS OF *ALFALFA* TO VERTICILLIUM WILT
1991

16/6/283 (Item 283 from file: 10)
4573037 43875528 Holding Library: AGL
Identification of Bacterial Groups Preferentially Associated with Mycorrhizal Roots of *Medicago* truncatula
2007
URL: http://aem.asm.org/contents-by-date.0.shtml

16/6/284 (Item 284 from file: 5)
16881693 BIOSIS NO.: 200200475204
Identification and confirmation of aluminum tolerance QTL in diploid *Medicago* sativa subsp. coerulea
2002

16/6/285 (Item 285 from file: 10)
4577415 43880615 Holding Library: AGL
Identification of Sources of Resistance to Phoma medicaginis Isolates in *Medicago* truncatula SARDI Core Collection Accessions, and Multigene Differentiation of Isolates
2006
URL: http://dx.doi.org/10.1094/PHYTO-96-1330

16/6/286 (Item 286 from file: 10)
4832624 43960331 Holding Library: AGL
Immediate Effects of Time and Method of *Alfalfa* Termination on Soil Mineral Nitrogen, Moisture, Weed Control, and Seed Yield, Quality, and Nitrogen Uptake
2007
URL: http://www.tandf.co.uk/journals/titles/01904167.asp

16/6/287 (Item 287 from file: 5)
15307507 BIOSIS NO.: 200000025820
Impact of Agrobacterium tumefaciens co-*cultivation* time and temperature on T-DNA transfer and expression in plant cells
1997

16/6/289 (Item 289 from file: 50)
0009229816 CAB Accession Number: 20073076583
Impact of *alfalfa* mosaic virus subgroup I and II isolates on terpene secondary metabolism of Lavandula vera D.C., Lavandula x alardii and eight cultivars of L. hybrida Rev.
Publication Year: 2006

16/6/290 (Item 290 from file: 41)
0000305809 IP ACCESSION NO: 7159625
Impact of Strip-*till* planting using Various Cover Crops on Insect Pests and Diseases of Peanuts
BOOK TITLE: MAKING CONSERVATION *TILLAGE* CONVENTIONAL: BUILDING A FUTURE ON 25 YEARS OF RESEARCH.
PUBLICATION DATE: 2002

16/6/291 (Item 291 from file: 266)
00580419
IDENTIFYING NO.: 0403586 AGENCY CODE: AGRIC
IMPROVEMENT OF *ALFALFA* AND RELATED SPECIES

16/6/292 (Item 292 from file: 10)
4095626 43615825 Holding Library: AGL
Improvement of somatic embryogenesis in *Medicago* arborea
2003
URL: http://www.kluweronline.com/issn/0167-6857/contents

16/6/293 (Item 293 from file: 5)
0019455942 BIOSIS NO.: 200700115683
Independent action and contrasting phenotypes of resistance genes against spotted *alfalfa* aphid and bluegreen aphid in *Medicago* truncatula
2007

16/6/294 (Item 294 from file: 10)
3278687 93025322 Holding Library: AGL
Infiltration rate of a sandy loam soil: effects of traffic, *tillage*, and plant roots
1992 May

16/6/295 (Item 295 from file: 5)
17487655 BIOSIS NO.: 200300444689
Inferences from mitochondrial DNA patterns on the domestication history of *alfalfa* (*Medicago* sativa).
2003

16/6/296 (Item 296 from file: 10)
3895012 22300508 Holding Library: AGL
Inhibition of ferric chelate reductase in *alfalfa* roots by cobalt, nickel, chromium, and copper
2000

16/6/297 (Item 297 from file: 143)
0499561 H.W. WILSON RECORD NUMBER: BBAI94050110
Inorganic nitrogen supply and symbiotic dinitrogen fixation in *alfalfa*
19940000

16/6/298 (Item 298 from file: 50)
0007682642 CAB Accession Number: 19991001198

Integrated pest management in forage *alfalfa*.
Publication Year: 1998

16/6/299 (Item 299 from file: 50)
0008013965 CAB Accession Number: 20003031846
Integration of weeds into pest management in *alfalfa* agroecosystems.
Book Title: The BCPC Conference: Pests and diseases, Volume 3. Proceedings of an international conference held at the Brighton Hilton Metropole Hotel, Brighton, UK, 13-16 November 2000
Publication Year: 2000

16/6/300 (Item 300 from file: 10)
3762799 21993757 Holding Library: AGL
Intercropping sorghum into *alfalfa* and reed canarygrass to increase biomass yield
1998

16/6/301 (Item 301 from file: 10)
4755076 43990681 Holding Library: AGL
The interrelationship between the *cultivation* of crops and soil-strength dynamics
2007
URL: http://dx.doi.org/10.1002/jpln.200625009

16/6/302 (Item 302 from file: 5)
11398756 BIOSIS NO.: 199294100597
IN-VITRO *CULTIVATION* OF PLANT PARASITIC NEMATODES
1992

16/6/303 (Item 303 from file: 5)
14605611 BIOSIS NO.: 199800399858
In vitro selection for osmotic tolerance in *alfalfa* (*Medicago* sativa L.)
1996

16/6/304 (Item 304 from file: 50)
0007694606 CAB Accession Number: 19992300805
Investigation of genetic background of plant parasitism in the model system of *alfalfa* (*Medicago* sativa) and dodder (Cuscuta trifolii).
Original Title: A novenyi parazitizmus genetikai hatterenek vizsgalata a lucerna (*Medicago* sativa) es a kis aranka (Cuscuta trifolii) modellrendszereben.
Publication Year: 1999

16/6/306 (Item 306 from file: 5)
17343721 BIOSIS NO.: 200300301540
Investigation of variations in NBS motifs in *alfalfa* (*Medicago* sativa), M. edgeworthii, and M. ruthenica.
2003

16/6/307 (Item 307 from file: 50)
0007370686 CAB Accession Number: 19971605978
Insight on segregation distortions in two intraspecific crosses between annual species of *Medicago* (Leguminosae).
Publication Year: 1997

16/6/308 (Item 308 from file: 10)
3059069 91008040 Holding Library: AGL

In situ hybridization of beta-tubulin to *alfalfa* chromosomes
1990 Nov

16/6/309 (Item 309 from file: 5)
11932471 BIOSIS NO.: 199396096887
Karyotype and C-banding in *Medicago* noeana Boiss., Leguminosae
1993

16/6/310 (Item 310 from file: 50)
0007600452 CAB Accession Number: 19980709619
Lucerne: *cultivation*, processing and consumption.
Original Title: La *alfalfa*: cultivo, transformacion y consumo.
Publication Year: 1998

16/6/311 (Item 311 from file: 50)
0006633281 CAB Accession Number: 19921973344
Lucerne *cultivation* and rate of the microbial population of the soil.
Original Title: Kultivace vojlesky a intenzita annosti microbni populace pudy.
Publication Year: 1990

16/6/312 (Item 312 from file: 50)
0006848044 CAB Accession Number: 19940703900
Lucerne: factors affecting its production and utilization.
Original Title: *Alfalfa* : factores que afectan su produccion y utilizacion.
Publication Year: 1992

16/6/313 (Item 313 from file: 5)
0019761215 BIOSIS NO.: 200700420956
Lucerne management in an *organic* *farming* system under dry site conditions
2007

16/6/314 (Item 314 from file: 50)
0007444995 CAB Accession Number: 19971611378
The lucerne in Spain. Characterization of the *cultivated* and spontaneous ecotypes.
Publication Year: 1996

16/6/315 (Item 315 from file: 5)
17905036 BIOSIS NO.: 200400275793
Legume species and management for stockless *organic* *farming*
2003

16/6/316 (Item 316 from file: 203)
02076275
[Algerian experience in the production field of *Medicago* and subterranean clover seeds] (Experience algerienne en matiere de production de semences de medics et de trefle souterrain)
1995
Sylvopastoral systems. Environmental, agricultural and economic sustainability (Systemes sylvopastoraux. Pour un environnement, une agriculture et une economie durables)

16/6/317 (Item 317 from file: 10)
3791089 22018936 Holding Library: AGL
Long-term influence of cropping systems, *tillage* methods, and N sources

on nitrate leaching
1995

16/6/318 (Item 318 from file: 50)
0007583340 CAB Accession Number: 19982302921
Long-term *tillage* and rotation effects on soil seedbank characteristics.
Publication Year: 1998

16/6/319 (Item 319 from file: 10)
3381664 20408920 Holding Library: AGL
Linkage mapping in diploid *alfalfa* (*Medicago* sativa)
1994 Feb

16/6/320 (Item 320 from file: 10)
4761528 43661780 Holding Library: AGL
Large-scale assessment of symbiotic dinitrogen fixation by crops: soybean and *alfalfa* in the Mississippi River Basin
2004
URL: http://hdl.handle.net/10113/8303

16/6/321 (Item 321 from file: 6)
2246693 NTIS Accession Number: MIC-102-05783/XAB
Low disturbance injection of swine manure into *alfalfa* produced for dehy: Final report
c2001

16/6/322 (Item 322 from file: 203)
02448320
1997
Medicago and Trifolium germplasm collection and preservation strategies development (Kan phatthana withi kan kep raksa lae ruapruam chua phan phut ahan sat bang chanit (*Medicago* and Trifolium spp.))

16/6/323 (Item 323 from file: 203)
02645495
1999
Medicago and trifolium germplasm collection and preservation strategies development

16/6/324 (Item 324 from file: 50)
0007445006 CAB Accession Number: 19971611389
Medicago truncatula : a legume model-plant.
Publication Year: 1996

16/6/325 (Item 325 from file: 5)
15887550 BIOSIS NO.: 200100059389
Molecular analysis of genetic variation among *alfalfa* (*Medicago* sativa L.) and *Medicago* ruthenica clones
2000

16/6/326 (Item 326 from file: 50)
0007913654 CAB Accession Number: 20001612632
The mielgas: wild Spanish populations of *alfalfa*. Results of ten years of researches.
Lucerne and medics for the XXI Century. Proceedings XIII Eucarpia *Medicago* spp. Group Meeting, Perugia, Italy, 13-16 September 1999.

Publication Year: 2000

16/6/327 (Item 327 from file: 50)
0006449775 CAB Accession Number: 19912312312
Multiplication of Pratylenchus brachyurus, P. zeae, Radopholus similis Tylenchorhynchus sp. in monoxenic culture on *alfalfa* callus tissues.
Original Title: Multiplicacao de Pratylenchus brachyurus, P. zeae, Radopholus similis, Tylenchorhynchus sp. em culturas monoxenicas em calos de alfafa.
Publication Year: 1990

16/6/328 (Item 328 from file: 50)
0008993560 CAB Accession Number: 20063031974
Management of the *alfalfa* leaf-cutter bee, Megachile rotundata (Hymenoptera: Megachilidae), for *alfalfa* pollination in Mongolia.
Original Title: Der Einsatz der Luzerne-Blattschneiderbiene, Megachile rotundata (Hymenoptera: Megachilidae), zur Bestaubung von Luzerne in der Mongolei.
Book Title: Erforschung biologischer Ressourcen der Mongolei, Band 9
Publication Year: 2005

16/6/329 (Item 329 from file: 266)
00570202
IDENTIFYING NO.: 0202036 AGENCY CODE: AGRIC
Management of Lygus spp. (Hemiptera: Miridae) in *Alfalfa* Seed

16/6/330 (Item 330 from file: 143)
2131034 H.W. WILSON RECORD NUMBER: BBAI07130183
Managing Nitrogen Contaminated Soils: Benefits of N2-Fixing *Alfalfa*
20070500

16/6/331 (Item 331 from file: 50)
0008359728 CAB Accession Number: 20033003667
Moon trifoil - *Medicago* arborea L. in the flora of Croatia.
Original Title: Drvenasta lucerna - *Medicago* arborea L. u Hrvatskoj flori.
Publication Year: 2002

16/6/333 (Item 333 from file: 10)
4872278 22294313 Holding Library: AGL
Mapping of simple sequence repeat (SSR) DNA markers in diploid and tetraploid *alfalfa*
2000
URL: http://hdl.handle.net/10113/14350

16/6/334 (Item 334 from file: 50)
0009427434 CAB Accession Number: 20073231310
Morphology characterization of the *alfalfa* ecotype 'Ampurdan'.
Book Title: Breeding and seed production for conventional and organic agriculture. Proceedings of the XXVI meeting of the EUCARPIA fodder crops and amenity grasses section, XVI meeting of the EUCARPIA *Medicago* spp group, Perugia, Italy, 2-7 September 2006
Publication Year: 2007

16/6/335 (Item 335 from file: 5)
19070960 BIOSIS NO.: 200600416355
Morphologic and agronomic diversity of wild genetic resources of *Medicago*

sativa L. collected in Spain
2006

16/6/336 (Item 336 from file: 203)
02377304
Marker-assisted selection in lucerne. Construction of linkage maps and gene targeting [*Medicago* sativa L.] (Selezione assistita da marcatori molecolari in erba medica. Costruzione di mappe genetiche e mappaggio genico [*Medicago* sativa L.])
1998

16/6/337 (Item 337 from file: 10)
3709651 21807606 Holding Library: AGL
A method to measure genetic distance between allogamous populations of *alfalfa* (*Medicago* sativa) using RAPD molecular markers
1998

16/6/338 (Item 338 from file: 10)
4168017 43622083 Holding Library: AGL
Method and time of *alfalfa* termination affects cereal growth and weed populations
Summary in French.
2003

16/6/339 (Item 339 from file: 40)
00659861 ENVIROLINE NUMBER: 04-07578
Metal-Humic Complexes and Plant Micronutrient Uptake: a Study Based on Different Plant Species *Cultivated* in Diverse Soil Types
Jan 04

16/6/340 (Item 340 from file: 50)
0009116763 CAB Accession Number: 20063195678
NaCl effect on Sinorhizobium meliloti strains in association with *alfalfa* landraces from the pre-saharian regions of Morocco.
Original Title: Effet du Nacl sur des isolats de Sinorhizobium meliloti en association avec des ecotypes de luzerne (*Medicago* sativa L.) des regions pre sahariennes du Maroc.
Publication Year: 2005

16/6/341 (Item 341 from file: 203)
02387581
[Incorporation of Vicia and *Medicago* in leguminous-cereal rotations] (Incorporacion de Vicia y *Medicago* en rotaciones leguminosa-cereal)
1998
[Rotations and farming systems associations of maize in template zones] (Rotaciones y asociaciones de cultivos en sistemas de maiz en zonas templadas)

16/6/342 (Item 342 from file: 143)
0968613 H.W. WILSON RECORD NUMBER: BBAI96010423
Nodulation, biomass production, and nitrogen fixation in *alfalfa* under drought
19960000

16/6/343 (Item 343 from file: 10)
3752869 21988874 Holding Library: AGL
Nitrogen dynamics under greenhouse conditions as influenced by method of

alfalfa termination. 1. Volatile N losses
1998

16/6/344 (Item 344 from file: 10)
3752871 21988879 Holding Library: AGL
Nitrogen dynamics under growth chamber conditions as influenced by method of *alfalfa* termination. 2. Plant-available N release
1998

16/6/345 (Item 345 from file: 143)
0970903 H.W. WILSON RECORD NUMBER: BBAI97040060
The nitrogen dynamics of 1-, 2- and 3-year stands of *alfalfa* in a cropping system
19970615

16/6/346 (Item 346 from file: 143)
0545866 H.W. WILSON RECORD NUMBER: BBAI95042193
Nitrogen fixation and growth of one-year stands of non-dormant *alfalfa* in Manitoba
19950700

16/6/347 (Item 347 from file: 5)
10817279 BIOSIS NO.: 199192063050
NUMBERS AND BIOMASS OF DIPTERA AND COLEOPTERA LARVAE IN THE SOIL UNDER RAPE AND *ALFALFA* FIELDS CROP
1990

16/6/348 (Item 348 from file: 5)
10618270 BIOSIS NO.: 199191001161
A NUMERICAL TAXONOMIC ANALYSIS OF THE *MEDICAGO*-LITTORALIS AND *MEDICAGO* -TRUNCATULA COMPLEX
1990

16/6/350 (Item 350 from file: 5)
16703734 BIOSIS NO.: 200200297245
[Nitrogen metabolism in *alfalfa* nodulated under phosphorus supression and resupply.]
ORIGINAL LANGUAGE TITLE: Metabolismo do nitrogenio em alfafa nodulada sob supressao e ressuprimento de fosforo
2001

16/6/351 (Item 351 from file: 5)
14004216 BIOSIS NO.: 199799638276
Nitrogen requirements of corn (Zea mays L.) as affected by monocropping and intercropping with *alfalfa* (*Medicago* sativa)
1996

16/6/352 (Item 352 from file: 5)
18800724 BIOSIS NO.: 200600146119
No *tillage* escarified - Spatial distribution preferential flows
ORIGINAL LANGUAGE TITLE: Escarificado en siembra directa - Distribucion espacial de los flujos preferenciales
2004

16/6/353 (Item 353 from file: 5)
10181833 BIOSIS NO.: 199089099724

NO-*TILL* PASTURE RENOVATION AFTER SWARD SUPPRESSION BY HERBICIDES
1990

16/6/354 (Item 354 from file: 10)
3231749 92068304 Holding Library: AGL
No-*till* vs. conventional *tillage* for late-planted corn following hay harvest
1992 Apr

16/6/355 (Item 355 from file: 50)
0009177058 CAB Accession Number: 20063220086
Nutrient uptake and nodulation ability of *alfalfa* in an acid purple soil.
Publication Year: 2006

16/6/356 (Item 356 from file: 50)
0006683209 CAB Accession Number: 19930762386
Nutrient uptake by perennial and annual grasses and legumes depending on the dose of mineral fertilizers and methods of soil *tillage*.
Publication Year: 1991

16/6/357 (Item 357 from file: 10)
3434868 20451761 Holding Library: AGL
Nitrate leaching under furrow irrigation as affected by crop sequence and *tillage*
1995 Jan

16/6/358 (Item 358 from file: 50)
0006694340 CAB Accession Number: 19931977602
Nitrate movement after ploughing up of legume-forage stands on *organic* *farms*.
Original Title: Nitratverlagerung nach Umbruch von Leguminosen-Feldfutterbestanden in biologisch-dynamischen Betrieben.
Publication Year: 1991

16/6/359 (Item 359 from file: 50)
0007249777 CAB Accession Number: 19960708295
Nitrate reductase activity in *alfalfa* plants supplied with increasing rates of mineral nitrogen and inoculated with different Rhizobium meliloti strains.
Publication Year: 1996

16/6/360 (Item 360 from file: 5)
13073985 BIOSIS NO.: 199598541818
Nutritive value of some top feeds and *cultivated* fodders
1994

16/6/361 (Item 361 from file: 5)
13769706 BIOSIS NO.: 199799403766
The nutritive value and yield of *alfalfa* in relation to nitrogen fertilization on sulphur industry reclaimed lands
1996

16/6/362 (Item 362 from file: 40)
00449903 ENVIROLINE NUMBER: 97-05602

Novel *Alfalfa* Cleans Fertilizer Spill
Jan 97

16/6/363 (Item 363 from file: 5)
0019787938 BIOSIS NO.: 200700447679
A novel statistical method for assessing SSR variation in autotetraploid *alfalfa* (*Medicago* sativa L.)
2007

16/6/365 (Item 365 from file: 5)
16862609 BIOSIS NO.: 200200456120
A new lodging tolerant and multiple resistant variety of *alfalfa* "Neo-tachiwakaba"
2001

16/6/366 (Item 366 from file: 10)
3602627 20587216 Holding Library: AGL
A new *Medicago* truncatula line with superior in vitro regeneration, transformation, and symbiotic properties isolated through cell culture selection
1997

16/6/367 (Item 367 from file: 10)
3135427 92002080 Holding Library: AGL
A new approach to direct somatic embryogenesis in *Medicago*
1991

16/6/368 (Item 368 from file: 5)
17603084 BIOSIS NO.: 200300559515
Occurrence, inheritance and use of reproductive mutants in *alfalfa* improvement.
2003

16/6/369 (Item 369 from file: 203)
02432429
Studies on breeding of *alfalfa* (*Medicago* sativa L.) cultivars adapted to Konsen district, eastern Hokkaido of Japan
1998

16/6/370 (Item 370 from file: 5)
13974524 BIOSIS NO.: 199799608584
Studies on Coccinella septempunctata brucki mulsant as a biological agent for controlling *alfalfa* aphids
1996

16/6/372 (Item 372 from file: 50)
0009528732 CAB Accession Number: 20083098289
Study on the characteristics of reproductive biology of *alfalfa*.
Publication Year: 2008

16/6/373 (Item 373 from file: 50)
0009043266 CAB Accession Number: 20063089686
Study on the degrading process and vegetation succession of *Medicago* sativa grassland in North Loess Plateau, China.
Publication Year: 2006

16/6/374 (Item 374 from file: 50)

0009122419 CAB Accession Number: 20063175642
Study on influence of sowing time in *alfalfa* variety Gloria and plant density in *alfalfa* variety Adonis upon nectarogenesis and honey production.
Original Title: Studiul influentei epocii de semanat la soiul de lucerna Gloria si a densitatii plantelor la soiul de lucerna Adonis, asupra nectarogenezei si a productiei de miere.
Publication Year: 1996

16/6/375 (Item 375 from file: 41)
0000305404 IP ACCESSION NO: 7150507
On farm conservation of *alfalfa* farmer's units of diversity (FUD) in Morocco
BOOK TITLE: MANAGING BIODIVERSITY IN AGRICULTURAL ECOSYSTEMS.
PUBLICATION DATE: 2001

16/6/376 (Item 376 from file: 50)
0008124412 CAB Accession Number: 20013153332
Study on the genetic diversity of wild *Medicago* falcata .
Publication Year: 2001

16/6/377 (Item 377 from file: 50)
0009534446 CAB Accession Number: 20083099128
Study on allelopathy of root, stem, and leaf aqueous extracts of different *Medicago* sativa varieties.
Publication Year: 2008

16/6/378 (Item 378 from file: 50)
0008221595 CAB Accession Number: 20023039505
Studies on integrated control of weeds in *alfalfa* field.
Publication Year: 2001

16/6/379 (Item 379 from file: 5)
17986420 BIOSIS NO.: 200400357209
Study on the productivity and mineral composition of mixed-seeded *alfalfa* (*Medicago* sativa L.) pastures
2004

16/6/380 (Item 380 from file: 5)
10629012 BIOSIS NO.: 199191011903
A STUDY ON THE VALUE OF *ALFALFA* I. THE STUDY ON THE CHANGE OF NUTRITIVE VALUE DUE TO PROCESSING OF *ALFALFA*
1990

16/6/382 (Item 382 from file: 5)
10286660 BIOSIS NO.: 199090071139
STUDIES ON VARIETAL ECOLOGY OF *ALFALFA* PLANTS 4. INFLUENCE OF PHOTOPERIODIC TREATMENTS ON SEEDLING GROWTH OF *ALFALFA* VARIETIES
1990

16/6/383 (Item 383 from file: 50)
0007696723 CAB Accession Number: 19991102649
On the selectivity and dispersion of *alfalfa* plant bug among its host plants in Eastern Henan cotton region.
Publication Year: 1998

16/6/384 (Item 384 from file: 143)

0439491 H.W. WILSON RECORD NUMBER: BBAI93038430
Oat companion crop management in *alfalfa* establishment
19930900

16/6/385 (Item 385 from file: 203)
02638923
2005
Other insect pests of *alfalfa* and clover (Ostali stetni insekti lucerke i deteline)

16/6/386 (Item 386 from file: 5)
12257100 BIOSIS NO.: 199497278385

Pollen morphology as a tool for determining interspecific relationships in the genus *Medicago*
1993

16/6/387 (Item 387 from file: 10)
3565080 20555934 Holding Library: AGL
Planting date, fungicide, and cultivar effects on sclerotinia crown and stem rot severity in *alfalfa*
1997

16/6/388 (Item 388 from file: 10)
3548519 20543419 Holding Library: AGL
Plant population dynamics in subterranean clover and murex medic swards. 3. Effect of pod burial, summer grazing and autumn *cultivation* on emergence
1996

16/6/389 (Item 389 from file: 5)
12376586 BIOSIS NO.: 199497397871
Plant regeneration from callus cultures of *alfalfa*
1994

16/6/390 (Item 390 from file: 10)
3810883 22027090 Holding Library: AGL
Plant-available nitrogen supply as affected by method and timing of *alfalfa* termination
1999

16/6/391 (Item 391 from file: 203)
02578586
Plants spontaneous alternative host of beneficent insects on an *alfalfa* crop (Plantas espont neas hospederas alternativas de insectos beneficiosos en un cultivo de *alfalfa*)
2003
[Conference 2003. Spanish Weed Science Society. Proceedings, Barcelona [Spain], 4th, 5th and 6th November, 2003] (Congreso 2003. Sociedad Espa ola de Malherbolog a. Actas, Barcelona, 4, 5 y 6 de noviembre de 2003)

16/6/392 (Item 392 from file: 10)
4801489 43636009 Holding Library: AGL
Plasmid transfer from Pseudomonas putida to the indigenous bacteria on *alfalfa* sprouts: characterization, direct quantification, and in situ

location of transconjugant cells
2003

16/6/393 (Item 393 from file: 143)
1838150 H.W. WILSON RECORD NUMBER: BBAI04169156
Penetration of Photosynthetically Active and Ultraviolet Radiation into *Alfalfa* and Tall Fescue Canopies
20041100

16/6/394 (Item 394 from file: 5)
11275004 BIOSIS NO.: 199293117895
PRODUCTIVITY OF *CULTIVATED* DRAINED SODDY-PODZOLIC SOILS FIRST COMMUNICATION SELECTING CROPS AND OPTIMIZING THEIR NUTRITION IN VARIOUS SYSTEMS OF AGRICULTURAL USE OF SODDY-PODZOLIC GLEY SOIL
1991

16/6/395 (Item 395 from file: 143)
0663114 H.W. WILSON RECORD NUMBER: BBAI97004500
Productivity, and composition of smooth and meadow bromegrass mixtures with *alfalfa* under frequent cutting management
19961000

16/6/396 (Item 396 from file: 50)
0006747617 CAB Accession Number: 19930767478
Productivity of drained dernopodzolic soils under *cultivation*. 1. Selecting crops and optimizing their nutrition under different systems of agricultural utilization of gleyed dernopodzolic soil.
Publication Year: 1991

16/6/397 (Item 397 from file: 50)
0006570409 CAB Accession Number: 19920755300
Productivity and feeding value of irrigated lucerne depending on practices of primary soil *tillage* and fertilizer rates.
Publication Year: 1990

16/6/398 (Item 398 from file: 203)
01748196
[Productivity of *alfalfa* and Festuca arundinacea cultivars in mixture and pure] (Produttivita' di cultivar di medica e di Festuca arundinacea in miscuglio ed in purezza)
1992

16/6/399 (Item 399 from file: 5)
13738975 BIOSIS NO.: 199799373035
The productivity of natural and *cultivated* (artificial) coenoses in semi-desert of North-West Caspian Lowland
1996

16/6/400 (Item 400 from file: 50)
0007515020 CAB Accession Number: 19981604100
Production of plant-regenerants in a culture in vitro in annual species of *alfalfa*.
Publication Year: 1996

16/6/401 (Item 401 from file: 143)
0350164 H.W. WILSON RECORD NUMBER: BBAI91054270
Productivity of wheat and *alfalfa* under intercropping

19911000

16/6/402 (Item 402 from file: 203)

02652553
Performance of a new *alfalfa* variety "Lucerne 2002" for green forage yield and quality
2003

16/6/403 (Item 403 from file: 5)
0019667938 BIOSIS NO.: 200700327679
Performance of short-lived perennial grasses grown with and without *alfalfa* at a semiarid location in southern Saskatchewan
2007

16/6/404 (Item 404 from file: 10)
4831088 43806118 Holding Library: AGL
Profitability of Various Corn, Soybean, Wheat, and *Alfalfa* Cropping Systems
2003
URL: http://hdl.handle.net/10113/11875

16/6/406 (Item 406 from file: 5)
19341052 BIOSIS NO.: 200700000793
Preliminary evaluation of diverse lucerne (*Medicago* sativa sspp.) germplasm to identify new material for livestock and cropping based farming systems in Australia
2006

16/6/407 (Item 407 from file: 144)
14886943 PASCAL No.: 01-0034519
Partner Farm concept : A participatory approach to collaboration between specialised *organic* *farms*
Organic agriculture faces its development : the future issues
L'agriculture biologique face a son developpement : les enjeux futurs : Lyon, 6-8 decembre 1999
2000

16/6/408 (Item 408 from file: 50)
0006716922 CAB Accession Number: 19930764733
Peroxidase of cultured *alfalfa* cells.
Publication Year: 1993

16/6/409 (Item 409 from file: 5)
12312244 BIOSIS NO.: 199497333529
Peroxidase activities and contents of phenolic acids in embryogenic and nonembryogenic *alfalfa* cell suspension cultures
1994

16/6/410 (Item 410 from file: 50)
0006404842 CAB Accession Number: 19910744883
The presence of an enzyme that converts indole-3-acetamide into IAA in wild and *cultivated* rice.
Publication Year: 1991

16/6/411 (Item 411 from file: 203)
02658952
2005
[Perspective directions of *alfalfa* breeding in Belarus]

16/6/412 (Item 412 from file: 5)
0020227417 BIOSIS NO.: 200800274356
Prospection of viral diseases of soybeans in several production areas in Argentina and different *tillage* systems
ORIGINAL LANGUAGE TITLE: Prospeccion de enfermedades virales del cultivo de soja en distintas areas de produccion de Argentina y bajo distintos sistemas de labranza
2007

16/6/413 (Item 413 from file: 5)
13867311 BIOSIS NO.: 199799501371
Parasitoids and hyperparasitoids associated with Acyrthosiphon pisum (Harris) and Acyrthosiphon kondoi Shinji (Homoptera: Aphididae) in *alfalfa* (*Medicago* sativa L.) in Albany, California-USA
1996

16/6/414 (Item 414 from file: 5)
12543622 BIOSIS NO.: 199598011455
Pathological relationship of Meloidogyne hapla and Phytophthora megasperma f. sp. medicaginis in twelve *Medicago* sativa L. cultivars
1994

16/6/416 (Item 416 from file: 10)
3320758 20338443 Holding Library: AGL
Potential of trispecies bridge crosses and random amplified polymorphic DNA markers for introgression of *Medicago* daghestanica and M. pironae germplasm into *alfalfa* (M. sativa)
1993 Jun

16/6/417 (Item 417 from file: 203)
02543282
Possibilities of accelerated evaluation of *alfalfa* winterhardiness under Latvia conditions (Lucernas ziemcietibas paatrinatas novertesanas iespeja Latvijas apstaklos)
2003

16/6/418 (Item 418 from file: 5)
19207163 BIOSIS NO.: 200600552558
Qualitative land suitability evaluation for the growth of onion, potato, maize, and *alfalfa* on soils of the Khalat pushan research station
2006

16/6/419 (Item 419 from file: 203)
02629679
Quality and yield from *alfalfa* after applying of organo-mineral amendments on heavy metal polluted soil (Dobiv i kachestvo na lyutserna, poluchena sled meliorativni vazdejstviya na zamarsena s tezhki metali pochva)
2005

16/6/420 (Item 420 from file: 10)
3633626 20612540 Holding Library: AGL

Quantitative comparison of volatile compounds among seven *Medicago* Spp. accessions
1996

16/6/421 (Item 421 from file: 5)
15415554 BIOSIS NO.: 200000133867
Quantitative genetic analysis of erect glandular trichome density in diploid *alfalfa*
2000

16/6/422 (Item 422 from file: 10)
4578589 43881981 Holding Library: AGL
Quantitative trait loci and candidate gene mapping of aluminum tolerance in diploid *alfalfa*
2007
URL: http://dx.doi.org/10.1007/s00122-006-0488-7

16/6/423 (Item 423 from file: 5)
12256211 BIOSIS NO.: 199497277496
Reclamation of sands by crop *cultivation* near oases in Turkmenistan
1994

16/6/424 (Item 424 from file: 50)
0008922974 CAB Accession Number: 20053180498
The recovery of mineral-N applied to mixed stands of Dactylis glomerata L. and *Medicago* sativa L.
Book Title: Optimal forage systems for animal production and the environment. Proceedings of the 12th Symposium of the European Grassland Federation, Pleven, Bulgaria, 26-28 May 2003
Publication Year: 2003

16/6/425 (Item 425 from file: 5)
0019534052 BIOSIS NO.: 200700193793
Ridge-furrow planting of *alfalfa* (*Medicago* sativa L.) for improved rainwater harvest in rainfed semiarid areas in Northwest China
2007

16/6/428 (Item 428 from file: 10)
3517407 20517419 Holding Library: AGL
RFLP linkage map of an *alfalfa* meiotic mutant based on an F1 population
1996 Mar

16/6/429 (Item 429 from file: 50)
0007887179 CAB Accession Number: 20001610656
Registration of CADL 98 *alfalfa* germplasm.
Publication Year: 2000

16/6/430 (Item 430 from file: 50)
0006508944 CAB Accession Number: 19921626950
Registration of W2 x iso-1 and W4 x iso-1 isogenic populations of diploid and tetraploid *alfalfa* germplasm.
Publication Year: 1991

16/6/431 (Item 431 from file: 50)
0007828121 CAB Accession Number: 20001905120
Relationships between growth of *alfalfa* and sulphur levels in selected soils of Misr (Egypt).

Publication Year: 1995, publ. 1999

16/6/432 (Item 432 from file: 5)
18477876 BIOSIS NO.: 200510172376
Relationship between amino acid concentration and aphid (Hemiptera: Aphididae) abundance on *Alfalfa* (*Medicago* sativa L.)

2005

16/6/433 (Item 433 from file: 76)
0001710083 IP ACCESSION NO: 5992689
Relationship of disease resistance and stand persistence in *alfalfa* cultivars from the 1940's to the 1990's
PUBLICATION DATE: 2004

16/6/434 (Item 434 from file: 10)
3775940 22005046 Holding Library: AGL
Relationship of rainfall, cultural practices, soil and plant nutrients, and seedling survival with root disease and parasitic nematode numbers in annual *Medicago* spp. pastures
1999

16/6/435 (Item 435 from file: 5)
13795074 BIOSIS NO.: 199799429134
The role of weeds in *cultivated* and virgin soils on activity and perpetuation of Fusarium oxysporum f. sp. melonis in Fars Province
1996

16/6/436 (Item 436 from file: 50)
0007056219 CAB Accession Number: 19950708478
The relative sustainability of alternative, conventional, and reduced-*till* farming systems.
Publication Year: 1995

16/6/437 (Item 437 from file: 5)
16787982 BIOSIS NO.: 200200381493
Removal of phenol by *alfalfa* plants (*Medicago* sativa L.) grown in hydroponics and its effect on some physiological parameters
2002

16/6/438 (Item 438 from file: 5)
15732035 BIOSIS NO.: 200000450348
Use of RAPD and microsatellite (SSR) variation to assess genetic relationships among populations of tetraploid *alfalfa*, *Medicago* sativa
2000

16/6/439 (Item 439 from file: 10)
3742433 21982585 Holding Library: AGL
Root recolonization of previous root channels in corn and *alfalfa* rotations
1998

16/6/440 (Item 440 from file: 5)
16149820 BIOSIS NO.: 200100321659
Rotation and *tillage* effects on soil organic carbon sequestration in a typic Hapludalf in southern Ontario
2001

16/6/442 (Item 442 from file: 10)
3470982 20479224 Holding Library: AGL
Root exuded non-gene inducing signals limit the nodulation capacity of different *alfalfa* varieties with Rhizobium meliloti
1995

16/6/443 (Item 443 from file: 10)
3517501 20517943 Holding Library: AGL
Root-zone mineral nitrogen changes as affected by crop sequence and *tillage*
1994 Sep

16/6/444 (Item 444 from file: 143)
1288069 H.W. WILSON RECORD NUMBER: BBAI00050408
Reexamining the relationship between fall dormancy and winter hardiness in *alfalfa*
20000700

16/6/445 (Item 445 from file: 143)
0740523 H.W. WILSON RECORD NUMBER: BBAI93010439
Ryegrass companion crops for *alfalfa* establishment: I. Forage yield and *alfalfa* suppression
19930100

16/6/446 (Item 446 from file: 143)
0740524 H.W. WILSON RECORD NUMBER: BBAI93010444
Ryegrass companion crops for *alfalfa* establishment: II. Forage quality in the seeding year
19930100

16/6/447 (Item 447 from file: 203)
01784345
[Some results of studies on *cultivated* fodders]
1991
[Summaries of reports to the Research Conference for 30th Anniversary of the Research Institute of Animal Husbandry]

16/6/449 (Item 449 from file: 50)
0007917698 CAB Accession Number: 20000709830
Results of the experimentation and *cultivation* of lucerne in Albania.
Publication Year: 2000

16/6/450 (Item 450 from file: 5)
18063991 BIOSIS NO.: 200400434780
Responses of the fructose-1,6-bisphosphatase and glutamate dehydrogenase activities of *alfalfa* to boron, gypsum, and limestone amendments of soil
2004

16/6/451 (Item 451 from file: 10)
3700171 21806040 Holding Library: AGL
Response of *alfalfa* to inoculation with Penicillium bilaii (Provide)
1998

16/6/452 (Item 452 from file: 10)
3828758 22040024 Holding Library: AGL
Response of overseeded *alfalfa* and bermudagrass to *alfalfa* row

spacing and nitrogen rate
1999

16/6/453 (Item 453 from file: 71)
01365306 2000043192
Response of overseeded *alfalfa* and bermudagrass to *alfalfa* row sparing and nitrogen rate

16/6/454 (Item 454 from file: 40)
00703146 ENVIROLINE NUMBER: 06-17375
Responses of Soil Water, Nitrogen, and Organic Matter to the *Alfalfa* Crop Rotation in Semiarid Loess Area of China
2006

16/6/455 (Item 455 from file: 50)
0009138959 CAB Accession Number: 20063185400
Researches about the influence of some fertilising system on some fodder plants *cultivated* on reddish-brown soil from Moara Domneasca.
Original Title: Cercetari privind influenta sistemului de fertilizare asupra unor plante furajere *cultivate* pe solul brun-roscat de la Moara Domneasca.
Publication Year: 1997

16/6/456 (Item 456 from file: 203)
02124407
Research concerning the development of root system in different plants *cultivated* on a saline soil during the amelioration process (Cercetari privind dezvoltarea sistemului radicular al unor plante de cultura pe un sol saraturat in curs de ameliorare)
1995

16/6/457 (Item 457 from file: 50)
0009122431 CAB Accession Number: 20063175604
Research on chemical fertilisers and the lead as polluting of fodder plants *cultivated* on reddish-brown soil at Moara Domneasca.
Original Title: Cercetari privind influenta ingraisaimintelor chimice si a plumbului ca poluant la plantele furajere *cultivate* pe solul brun roscat de la Moara Domneascai.
Publication Year: 1998

16/6/458 (Item 458 from file: 50)
0007385990 CAB Accession Number: 19970706077
Resource-saving methods for basic *tillage* of lucerne plots on southern chernozem before sowing soft winter wheat in irrigated rotations in South Ukraine.
Nauchnoe obespechenie agropromyshlennogo kompleksa.
Publication Year: 1996

16/6/459 (Item 459 from file: 50)
0007483833 CAB Accession Number: 19981001649
A subject store for disease resistance of selected *cultivated* plant species.
Original Title: Ein Sachspeicher zur Krankheitsresistenz bei ausgewahlten Kulturpflanzen-arten.
Publication Year: 1997

16/6/460 (Item 460 from file: 143)
1827953 H.W. WILSON RECORD NUMBER: BBAI04165723
Screening for Salinity Tolerance in *Alfalfa*: A Repeatable Method
20041100

16/6/461 (Item 461 from file: 10)
4011978 23287349 Holding Library: AGL
Seedbed preparation, timing of seeding, fertility and root pathogens affect establishment and yield of *alfalfa*
2002

16/6/462 (Item 462 from file: 40)
00607300 ENVIROLINE NUMBER: 01-14271
Sudangrass Uses Water at Rates Similar to *Alfalfa*, Depending on Location
Jul-Aug 01

16/6/463 (Item 463 from file: 144)
11300074 PASCAL No.: 94-0120149
Seed and seedling dynamics over four consecutive years from a single seed set of six annual medics (*Medicago* spp) in North Syria
1993

16/6/464 (Item 464 from file: 143)
0477814 H.W. WILSON RECORD NUMBER: BBAI94028250
Sod-seeding *alfalfa* in spring into established crested wheatgrass in southwest Saskatchewan
19940400

16/6/465 (Item 465 from file: 50)
0007697361 CAB Accession Number: 19990702413
Sugarbeet *cultivation* with limited adopt in conditions of protection of underground water sources.
Original Title: Pestovanie cukrovej repy pri obmedzenych vstupoch v podmienkach ochrany podzemnych zdrojov vody.
Publication Year: 1998

16/6/466 (Item 466 from file: 10)
3285181 93029924 Holding Library: AGL
Shrinkage of bare and *cultivated* soil
1992 Jul

16/6/467 (Item 467 from file: 10)
4867285 44058459 Holding Library: AGL
Short Cuts For Planting *Alfalfa*
2008
URL: http://cropwatch.unl.edu/

16/6/468 (Item 468 from file: 266)
00437984
IDENTIFYING NO.: 0321460 AGENCY CODE: NSF
Sequencing the Gene Space of the Model Legume, *Medicago* Truncatula

16/6/469 (Item 469 from file: 5)
0019534034 BIOSIS NO.: 200700193775
Soil biophysical responses by macroaggregates to *tillage* of two soil types
BOOK TITLE: Advances in Geoecology
2006

16/6/470 (Item 470 from file: 5)
19193031 BIOSIS NO.: 200600538426
Soil chemical changes following manure application on irrigated *alfalfa* and rainfed timothy in southern Alberta
2006

16/6/471 (Item 471 from file: 5)
10811802 BIOSIS NO.: 199192057573
SELECTION OF *ALFALFA* CLONES RESISTANT TO ANALOGUES OF AMINO ACIDS AND STREPTOMYCIN
1990

16/6/472 (Item 472 from file: 50)
0007371899 CAB Accession Number: 19970704888
Selection and utilization of *cultivated* fodder trees and shrubs in Mediterranean extensive livestock production systems.
The optimal exploitation of marginal Mediterranean areas by extensive ruminant production systems. Proceedings of an international symposium organized by HSAP and EAAP and sponsored by EU(DGVI), FAO and CIHEAM, Thessaloniki, Greece, 18-20 June, 1994.
Publication Year: 1996

16/6/473 (Item 473 from file: 50)
0009451305 CAB Accession Number: 20083021662
Soil decontamination of 2,4,6-trinitrotoluene by *alfalfa* (*Medicago* sativa).
Publication Year: 2007

16/6/474 (Item 474 from file: 50)
0007337320 CAB Accession Number: 19970702567
Soil factors limiting growth of lucerne in four soils of the X Region. II. Soil acidity.
Original Title: Factores de suelo limitantes del crecimiento de la *alfalfa* en cuatro suelos de la X Region. II. Acidez del suelo.
Publication Year: 1995

16/6/475 (Item 475 from file: 5)
18758934 BIOSIS NO.: 200600104329
Soil quality responses to *alfalfa* watered with a field micro-catchment technique in the Loess Plateau of China
2006

16/6/476 (Item 476 from file: 5)
15988651 BIOSIS NO.: 200100160490
Soil and *alfalfa* response after amelioration of subsoil acidity in a fine sandy loam Podzol in Prince Edward Island
2000

16/6/477 (Item 477 from file: 10)
4366428 43757472 Holding Library: AGL
Soil microbial characteristics and mineral nitrogen availability as affected by olive oil waste water applied to *cultivated* soil
2005

16/6/478 (Item 478 from file: 5)
14651703 BIOSIS NO.: 199800445950

Soil mites (Acari) of ecotones between a shelterbelt and *cultivated*
  fields in the agricultural landscape near Turew, Poland
1998

16/6/479 (Item 479 from file: 143)
1629864 H.W. WILSON RECORD NUMBER: BBAI03110028
Soil Nitrogen Mineralization in Mixtures of Eastern Gamagrass with
  Alfalfa and Red Clover
20010700

16/6/480 (Item 480 from file: 143)
1424312 H.W. WILSON RECORD NUMBER: BBAI93019817
Soil properties associated with *alfalfa* winter survival at Kamloops,
British Columbia
19930200

16/6/482 (Item 482 from file: 5)
15677514 BIOSIS NO.: 200000395827
Soil organic carbon and 13C abundance as related to *tillage*, crop
 residue, and nitrogen fertilization under continuous corn management in
Minnesota
2000

16/6/484 (Item 484 from file: 5)
11942712 BIOSIS NO.: 199396107128
Salt tolerance variability of wild *alfalfa* during germination
1993

16/6/485 (Item 485 from file: 143)
1791363 H.W. WILSON RECORD NUMBER: BBAI04152806
Soil water balance simulation of *alfalfa* (*Medicago* sativa L.) in the
  semiarid Chinese Loess Plateau
20040915

16/6/486 (Item 486 from file: 10)
3785612 22012126 Holding Library: AGL
  Soil water dynamics after *alfalfa* as influenced by crop termination
technique
  1999

16/6/487 (Item 487 from file: 5)
19000897 BIOSIS NO.: 200600346292
Soil water and *alfalfa* yields as affected by alternating ridges and
  furrows in rainfall harvest in a semiarid environment
2006

16/6/488 (Item 488 from file: 143)
0570057 H.W. WILSON RECORD NUMBER: BBAI96012793
Soil solution chemistry and *alfalfa* response to CaCO3 and MgCO3 on an
acidic Gleysol
19960200

16/6/489 (Item 489 from file: 10)
4329513 43692251 Holding Library: AGL
  Soil carbon and nitrogen changes as influenced by *tillage* and cropping
systems in some Iowa soils
  2005

16/6/490 (Item 490 from file: 5)
19338611 BIOSIS NO.: 200600684006
Soil carbon and nitrogen sequestration following the conversion of cropland to *alfalfa* forage land in northwest China
2007

16/6/492 (Item 492 from file: 143)
1970596 H.W. WILSON RECORD NUMBER: BBAI06154984
Soil carbon pool and effects of soil fertility in seeded *alfalfa* fields on the semi-arid Loess Plateau in China
20060800

16/6/493 (Item 493 from file: 5)
14419582 BIOSIS NO.: 199800213829
Somaclonal variability of morphological and biochemical parameters in regenerated *alfalfa* plants
1997

16/6/494 (Item 494 from file: 143)
1893633 H.W. WILSON RECORD NUMBER: BBAI05157597
Simulated Aspen Understory Microclimate Effects on *Alfalfa* Growth
20050900

16/6/495 (Item 495 from file: 50)
0007444992 CAB Accession Number: 19971611375
Summary of research on *Medicago* at the National Institute of Agronomic Research, Tunisia (INRAT).
Original Title: Synthese des travaux de recherche realises sur les *Medicago* a l'Institut National de la Recherche Agronomique de Tunisie (INRAT).
Publication Year: 1996

16/6/496 (Item 496 from file: 5)
19196554 BIOSIS NO.: 200600541949
Somatic embryogenesis and Agrobacterium mediated genetic transformation in Indian accessions of lucerne (*Medicago* sativa L.)
2006

16/6/498 (Item 498 from file: 5)
13446974 BIOSIS NO.: 199699081034
The supply of phosphorus from native, inorganic phosphorus pools in continuously *cultivated* Mexican agroecosystems
1996

16/6/499 (Item 499 from file: 50)
0008859130 CAB Accession Number: 20053115475
Saponins of *Medicago* sativa as the natural inductor of laccase from Trametes versicolor .
Publication Year: 2005

16/6/500 (Item 500 from file: 5)
17989944 BIOSIS NO.: 200400360733
Suppression of silver-leaf bitter apple (Solanum elaeagnifolium Cav.) by

cultivated pasture crops under dry-land conditions: a preliminary study
2004

16/6/501 (Item 501 from file: 5)
17354397 BIOSIS NO.: 200300311886
Spatial and temporal pattern of colonization of Nabidae (Heteroptera) in *alfalfa* (*Medicago* sativa).
2003

16/6/502 (Item 502 from file: 50)
0006336973 CAB Accession Number: 19911618236
Sources of resistance to *alfalfa* gallfly in lucerne.
Publication Year: 1990

16/6/503 (Item 503 from file: 50)
0009403582 CAB Accession Number: 20073273922
Surveys of false chinch bug, Nysius raphanus (Howard) (Hemiptera: Lygaeidae) and their movement on *cultivated* crops and non-*cultivated* habitats throughout growing season in Colorado.
Publication Year: 2006

16/6/504 (Item 504 from file: 71)
03241584 2006059666
Surveys of Lygus spp. and their movement on *cultivated* crops and non-*cultivated* habitats throughout growing season in Colorado

16/6/505 (Item 505 from file: 50)
0007062192 CAB Accession Number: 19952308930
Survey of virus diseases of wild and *cultivated* legumes in the coastal region of Syria.
Publication Year: 1994

16/6/506 (Item 506 from file: 203)
02523998
Suitability of different legume/grass swards for *organic* *farming*
2002
International Scientific Conference "Scientific Aspects of *Organic* *Farming*". Proceedings of the conference held in Jelgava, Latvia, March 21-22, 2002 (Biologiskas lauksaimniecibas zinatniskie aspekti. Konferences materiali, Latvija, Jelgava, 21.-22.marts, 2002)

16/6/507 (Item 507 from file: 5)
14518593 BIOSIS NO.: 199800312840
Structuration of *alfalfa* genetic diversity using agronomic and morphological characteristics: Relationship with RAPD markers
1998

16/6/508 (Item 508 from file: 50)
0007797440 CAB Accession Number: 19990709893
Use of strip cropping and *alfalfa* to reduce NO SUB 3 -N leaching to shallow groundwater.
ASAE/CSAE-SCGR Annual International Meeting, Toronto, Ontario, Canada, 18-21 July, 1999.
Publication Year: 1999

16/6/509 (Item 509 from file: 50)
0006593943 CAB Accession Number: 19920758078

Strip position, *tillage* , and water regime effects on a strip intercropping rotation.
Publication Year: 1992

16/6/510 (Item 510 from file: 10)
3323032 20355842 Holding Library: AGL
Seventeen years of cropping systems and *tillage* affect velvetleaf (Abutilon theophrasti) seed longevity
1993 Jan

16/6/511 (Item 511 from file: 10)
3499564 20503783 Holding Library: AGL
Sustaining productivity of a Vertisol at Warra, Queensland, with fertilisers, no-*tillage*, or legumes. 1. Organic matter status
1995

16/6/512 (Item 512 from file: 10)
4745497 43951936 Holding Library: AGL
Threecornered *Alfalfa* Hopper (Hemiptera: Membracidae): Seasonal Occurrence, Girdle Distribution, and Response to Insecticide Treatment on Peanut in South Carolina
2007
URL: http://dx.doi.org/10.1603/0022-0493(2007)100[1229:TAHHMS]2.0.CO;2

16/6/513 (Item 513 from file: 5)
16843617 BIOSIS NO.: 200200437128
Tillage and chlorpyrifos treatment effects on peanut arthropods: An incidence of severe burrower bug injury
2001

16/6/514 (Item 514 from file: 266)
00558875
IDENTIFYING NO.: 0187199 AGENCY CODE: AGRIC
Tillage and Crop Rotations for Eastern South Dakota

16/6/515 (Item 515 from file: 266)
00553508
IDENTIFYING NO.: 0157659 AGENCY CODE: AGRIC
TILLAGE , CROPPING SEQUENCES, AND OTHER PRACTICES TO ENHANCE AGRICULTURAL SUSTAINABILITY

16/6/516 (Item 516 from file: 50)
0008377119 CAB Accession Number: 20033007911
Tillage effect and duration of prairies on the physical condition in Vertic Argiudol soil in Argentina.
Original Title: Efecto de la labranza y duracion de las praderas sobre la condicion fisica de un suelo Argiudol Vertico de Argentina.
Publication Year: 2002

16/6/517 (Item 517 from file: 5)
11941779 BIOSIS NO.: 199396106195
Tillage effects on near-surface soil hydraulic properties
1993

16/6/518 (Item 518 from file: 76)
0001229503 IP ACCESSION NO: 4296902
Tillage effects on water runoff and soil erosion after sod

PUBLICATION DATE: 1998

16/6/519 (Item 519 from file: 10)
3653289 20627197 Holding Library: AGL
Tillage effect on soil water content and corn yield in a strip intercropping system
1997

16/6/520 (Item 520 from file: 5)
16035730 BIOSIS NO.: 200100207569
Tillage effect on soil water content and soybean (Glycine max) yield in a strip intercropping system
2001

16/6/521 (Item 521 from file: 10)
3285217 93029960 Holding Library: AGL
Tillage - and traffic-induced changes in macroporosity and macropore continuity: air permeability assessment
1992 Jul

16/6/522 (Item 522 from file: 5)
16218911 BIOSIS NO.: 200100390750
Temporal effects on the composition of a population of Sinorhizobium meliloti associated with *Medicago* sativa and Melilotus alba
2001

16/6/523 (Item 523 from file: 50)
0009427425 CAB Accession Number: 20073231301
Temperate forage legume and grass genetic resources: capitalizing on the U.S. germplasm system.
Book Title: Breeding and seed production for conventional and organic agriculture. Proceedings of the XXVI meeting of the EUCARPIA fodder crops and amenity grasses section, XVI meeting of the EUCARPIA *Medicago* spp group, Perugia, Italy, 2-7 September 2006
Publication Year: 2007

16/6/524 (Item 524 from file: 156)
3593609 NLM Doc No: 10898396
Total arsenic, lead, and cadmium levels in vegetables *cultivated* at the Andean villages of northern Chile.
Jun 8 2000

16/6/525 (Item 525 from file: 5)
0020046717 BIOSIS NO.: 200800093656
Undersowing wheat with different living mulches in a no-*till* system. I. Yield analysis
2007

16/6/526 (Item 526 from file: 5)
0020046718 BIOSIS NO.: 200800093657
Undersowing wheat with different living mulches in a no-*till* system. II. Competition for light and nitrogen
2007

16/6/527 (Item 527 from file: 5)
16340530 BIOSIS NO.: 200100512369
Updating and extending genetic characterization and classification of

phytoplasmas from wild and *cultivated* plants in southern Italy
2001

16/6/528 (Item 528 from file: 71)
03331441 2006110223
Urease activity as affected by *cultivation* and soil depth: A kinetic approach

16/6/529 (Item 529 from file: 266)
00574506
IDENTIFYING NO.: 0207579 AGENCY CODE: AGRIC
Using association mapping to identify markers for cell wall constituents and biomass yield in *alfalfa*

16/6/530 (Item 530 from file: 5)
0020096500 BIOSIS NO.: 200800143439
Variability of morphological traits in natural populations of *Medicago* truncatula Gaertn in Morocco
ORIGINAL LANGUAGE TITLE: Variabilite des caracteres morphologiques des populations naturelles de *Medicago* truncatula Gaertn. an Maroc
2007

16/6/531 (Item 531 from file: 76)
0001075393 IP ACCESSION NO: 3889516
Virus diseases of ornamental shrubs. VII. *Alfalfa* mosaic virus (AMV) and a carlavirus infecting Ruscus hypoglossum
PUBLICATION DATE: 1994

16/6/532 (Item 532 from file: 10)
4076424 23339636 Holding Library: AGL
Variation among and within Italian *alfalfa* ecotypes by means of bio-agronomic characters and amplified fragment length polymorphism analyses
2003

16/6/533 (Item 533 from file: 10)
3633627 20612541 Holding Library: AGL
Variation in aphid alarm pheromone content among glandular and eglandular-haired *Medicago* accessions
1996

16/6/534 (Item 534 from file: 5)
13055814 BIOSIS NO.: 199598523647
Variation in generative cell plastid nucleoids and male fertility in *Medicago* sativa
1995

16/6/535 (Item 535 from file: 50)
0008243442 CAB Accession Number: 20023053798
Viruses on *cultivated* forage legumes in Syria.
Publication Year: 2001

16/6/536 (Item 536 from file: 10)
3319812 20337472 Holding Library: AGL
Weed control in oat (Avena sativa)-*alfalfa* (*Medicago* sativa) and effect on next year corn (Zea mays) yield
1992 Oct

16/6/537 (Item 537 from file: 6)
1907080 NTIS Accession Number: MIC-95-04349
Weed control for row-cropped *alfalfa*: Final research report
c1995

16/6/538 (Item 538 from file: 266)
00573309
IDENTIFYING NO.: 0206170 AGENCY CODE: AGRIC
Weed Management in Reduced-*tillage* Agriculture

16/6/539 (Item 539 from file: 266)
00552232
IDENTIFYING NO.: 0014360 AGENCY CODE: AGRIC
Weeds in *Cultivated* Agronomic Row Crops and Their Management

16/6/540 (Item 540 from file: 203)
02639246
2005
Weed in *alfalfa* and clover fields and their control (Korovi u lucerki i detelini i njihovo suzbijanje)

16/6/541 (Item 541 from file: 10)
3762066 21990423 Holding Library: AGL
Weed seedbanks and corn growth following continuous corn or *alfalfa*
1998

16/6/542 (Item 542 from file: 203)
02111270
Weed seeds in *alfalfa* seed [in the Vojvodina Province [Yugoslavia]] (Seme korova u semenu lucerke Vojvodine [Yugoslavia])
1995

16/6/543 (Item 543 from file: 10)
3918059 23212918 Holding Library: AGL
Weed suppression by annual legume cover crops in no-*tillage* corn
2001

16/6/544 (Item 544 from file: 10)
3913743 23211260 Holding Library: AGL
Wheat stem maggot in spring wheat-*alfalfa* intercrops with different crop management intensities
2000

16/6/545 (Item 545 from file: 50)
0008230004 CAB Accession Number: 20023041348
Ways of intensification of fodder grass *cultivation* on irrigated lands.
Publication Year: 2002

16/6/546 (Item 546 from file: 5)
15124985 BIOSIS NO.: 199900384645
Winter wheat pests and their natural enemies under *organic* *farming* system in Slovakia: Effect of ploughing and previous crop
1999

16/6/547 (Item 547 from file: 143)
1629977 H.W. WILSON RECORD NUMBER: BBAI03110154
Weather Impacts on Maize, Soybean, and *Alfalfa* Production in the Great Lakes Region, 1895-1996
20010900

16/6/548 (Item 548 from file: 5)
14740353 BIOSIS NO.: 199900000013
Water quality in an irrigated sandy soil: Ridge *tillage* in rotated corn and soybean compared with full-width *tillage* in continuous corn
1998

16/6/549 (Item 549 from file: 50)
0008252890 CAB Accession Number: 20023065874
Water management of irrigation for *alfalfa* in a Red-Yellow Latosol (Hapludox).
Original Title: Manejo da agua na irrigacao da alfafa num Latossolo Vermelho-Amarelo.
Publication Year: 2002

16/6/550 (Item 550 from file: 203)
02212190
1997
[Yugoslav varieties and hybrids of the *cultivated* plants] (Jugoslovenske sorte i hibridi poljoprivrednog bilja)

16/6/551 (Item 551 from file: 50)
0006492792 CAB Accession Number: 19920750696
Yield of a crop rotation with lucerne in relation to fertilizers and *tillage* methods.
Publication Year: 1990

16/6/552 (Item 552 from file: 5)
13006163 BIOSIS NO.: 199598473996
Yields of *alfalfa* varieties selected for Aphanomyces resistance in Kentucky
1995

16/6/553 (Item 553 from file: 10)
3631976 20610835 Holding Library: AGL
Yield and nitrogen uptake of rotated corn in a ridge *tillage* system
1997

16/6/554 (Item 554 from file: 143)
1630120 H.W. WILSON RECORD NUMBER: BBAI03110355
Zone of Autotoxic Influence around Established *Alfalfa* Plants
20020900

16/6/555 (Item 555 from file: 203)
02158200
[Synthesis of research activities on *Medicago* at the "Institut National de la Recherche Agronomique" of Tunisia] (Synthese des travaux de recherche realises sur les *Medicago* a l'Institut National de la Recherche Agronomique de Tunisie)
1996
The Genus *Medicago* in the Mediterranean Region: Current Situation and Prospects in Research (Le Genre *Medicago* en Mediterranee : Bilan et

Perspectives de la Recherche)

16/6/556 (Item 556 from file: 50)
0008058472 CAB Accession Number: 20013068616
First observations regarding the nitrate content under the root zone of various *cultivations*.
Original Title: Prime osservazioni sulla concentrazione di N nitrico sotto la zona radicale in sistemi colturali diversi.
Publication Year: 2001

16/6/557 (Item 557 from file: 10)
3158678 92014087 Holding Library: AGL
C-banding of *alfalfa* chromosomes: standard karyotype and analysis of a somaclonal variant
1991 Jul

16/6/558 (Item 558 from file: 50)
0008996361 CAB Accession Number: 20063058932
Carbon and N mineralization as affected by soil *cultivation* and crop residue in a calcareous wetland ecosystem in Central Iran.
Publication Year: 2006

16/6/559 (Item 559 from file: 10)
4414426 43777021 Holding Library: AGL
Carbon and N mineralization as affected by soil *cultivation* and crop residue in a calcareous wetland ecosystem in Central Iran
2006

S3 31057 GLYPHOSATE
S4 817567 CONTAMINATION
S5 8467700 AIR OR WATER OR SOIL OR SOILS OR GROUNDWATER OR SEDIMENT? ?
S6 28645322 PY=1926:1989
S17 20807 S3 NOT S6
S18 463 S17 AND S4 AND S5
S19 229 RD S18 (unique items)
S20 229 S19 NOT (S15 OR S10)

21/6/1 (Item 1 from file: 10)
4712857 43957306 Holding Library: AGL
The Absence of *Glyphosate* Residues in Wet *Soil* and the Adjacent Watercourse after a Forestry Application in New Brunswick
2007

21/6/2 (Item 2 from file: 5)
12298959 BIOSIS NO.: 199497320244
Accumulation of 2,4-D and *glyphosate* in fish and *water* hyacinth
1994

21/6/3 (Item 3 from file: 40)
00256363 ENVIROLINE NUMBER: 94-01661
Additive Effects of Herbicide Combinations on Aquatic Non-Target Organisms
May 11-15, 93

21/6/4 (Item 4 from file: 40)
00673626 ENVIROLINE NUMBER: 05-01954
Adsorption and Cosorption of Cadmium and *Glyphosate* on Two *Soils* with Different Characteristics
Dec 04

21/6/5 (Item 5 from file: 40)
00270394 ENVIROLINE NUMBER: 95-00813
Adsorption and Desorption of *Glyphosate* in Some European *Soils*
1994

21/6/6 (Item 6 from file: 5)
14259404 BIOSIS NO.: 199800053651
Adsorption of *glyphosate* on the clay mineral montmorillonite: Effect of Cu(II) in solution and adsorbed on the mineral
1997

21/6/7 (Item 7 from file: 5)
13509621 BIOSIS NO.: 199699143681
Adsorption of atrazine, simazine, and *glyphosate* in *soils* of the Gnangara Mound, Western Australia
1996

21/6/8 (Item 8 from file: 266)
00585843
IDENTIFYING NO.: 0409955 AGENCY CODE: AGRIC
AUGMENTATIVE BIOHERBICIDE STRATEGIES FOR CONTROL OF INVASIVE WEEDS

21/6/9 (Item 9 from file: 144)
17772232 PASCAL No.: 06-0366995
Agricultural pesticide residues in farm ditches of the Lower Fraser

valley, British Columbia, Canada
2006

21/6/10 (Item 10 from file: 266)
00576322
IDENTIFYING NO.: 0209768 AGENCY CODE: AGRIC
Agroforestry/Riparian in Central PlainsSDTDPXBTAT

21/6/11 (Item 11 from file: 5)
18426425 BIOSIS NO.: 200510120925
Amphibian communities in stormwater detention ponds along roads of Southeast France.
ORIGINAL LANGUAGE TITLE: Communautes d'amphibiens des bassins d'eau de pluie autoroutiers du Sud-Est de la France
2004

21/6/12 (Item 12 from file: 144)
14969679 PASCAL No.: 01-0122867
Analytical methods to determine phosphonic and amino acid group-containing pesticides
2001

21/6/13 (Item 13 from file: 144)
16277748 PASCAL No.: 03-0440897
Analysis of *glyphosate* and glufosinate by capillary electrophoresis-mass spectrometry utilising a sheathless microelectrospray interface
Electrophoresis in tubes, capillaries and microchips: with recognition of Stellan Hjerten

2003

21/6/14 (Item 14 from file: 144)
18585668 PASCAL No.: 08-0171496
Analysis of *glyphosate* and aminomethylphosphonic acid by capillary electrophoresis with electrochemiluminescence detection
2008

21/6/15 (Item 15 from file: 50)
0008149478 CAB Accession Number: 20013178221
Analysis of *glyphosate* and its metabolite, aminomethylphosphonic acid, in agricultural products by HPLC.
Publication Year: 2001

21/6/16 (Item 16 from file: 156)
3855988 NLM Doc No: 13129785
Analysis of *glyphosate* residues in cereals using liquid chromatography-mass spectrometry (LC-MS/MS).
Aug 2003

21/6/17 (Item 17 from file: 10)
4667778 43705267 Holding Library: AGL
Applicability of the quantification of genetically modified organisms to foods processed from maize and soy
2005

21/6/18 (Item 18 from file: 266)
00570535
IDENTIFYING NO.: 0202606 AGENCY CODE: AGRIC
Application of solid-phase microextraction (SPME) fibres in monitoring organic contaminants in the Sugar Creek watershed

21/6/19 (Item 19 from file: 5)
16010870 BIOSIS NO.: 200100182709
Behavior of *glyphosate* and aminomethylphosphonic acid (AMPA) in *soils* and *water* of reservoir Radeburg II catchment (Saxony/Germany)
2001

21/6/20 (Item 20 from file: 156)
3986138 NLM Doc No: 15719990
Black-bellied whistling duck (Dendrocygna autumnalis) brain cholinesterase characterization and diagnosis of anticholinesterase pesticide exposure in wild populations from Mexico.
Feb 2005

21/6/21 (Item 21 from file: 41)
0000276470 IP ACCESSION NO: 6398588
Black-bellied whistling duck (Dendrocygna autumnalis) brain cholinesterase characterization and diagnosis of anticholinesterase pesticide exposure in wild populations from Mexico
PUBLICATION DATE: 2005

21/6/22 (Item 22 from file: 266)
00579953
IDENTIFYING NO.: 0402726 AGENCY CODE: AGRIC
BIOLOGICALLY BASED INTEGRATED MANAGEMENT OF AQUATIC RIPARION & TERRESTRIAL INVASIVE WEEDS

21/6/23 (Item 23 from file: 5)
16713456 BIOSIS NO.: 200200306967

Between-row mowing+banded herbicide to control annual weeds and reduce herbicide use in no-till soybean (Glycine max) and corn (Zea mays)
2001

21/6/24 (Item 24 from file: 156)
4186445 NLM Doc No: 17432331
Coca and poppy eradication in Colombia: environmental and human health assessment of aerially applied *glyphosate*.
2007

21/6/25 (Item 25 from file: 156)
3909262 NLM Doc No: 15095878
Chemical and biomonitoring to assess potential acute effects of Vision herbicide on native amphibian larvae in forest wetlands.
Apr 2004

21/6/26 (Item 26 from file: 5)
0019634137 BIOSIS NO.: 200700293878
Chronic exposure to sub-lethal concentration of a *glyphosate*-based herbicide alters hormone profiles and affects reproduction of female Jundia (Rhamdia quelen)

2007

21/6/27 (Item 27 from file: 41)
0000284790 IP ACCESSION NO: 6408160
Cold-climate vegetative buffer zones as pesticide-filters for surface runoff
BOOK TITLE: Diffuse Pollution and Basin Management
PUBLICATION DATE: 2005

21/6/28 (Item 28 from file: 10)
4808049 43988906 Holding Library: AGL
Combination of a pesticide exposure and a bacterial challenge: In vivo effects on immune response of Pacific oyster, Crassostrea gigas (Thunberg)
2007
URL: http://dx.doi.org/10.1016/j.aquatox.2007.06.002

21/6/29 (Item 29 from file: 10)
4428862 43791928 Holding Library: AGL
A Comparative Risk Assessment of Genetically Engineered, Mutagenic, and Conventional Wheat Production Systems \h [electronic resource]
2005
URL: http://dx.doi.org/10.1007/s11248-005-1411-8

21/6/30 (Item 30 from file: 41)
0000283465 IP ACCESSION NO: 6018242
Comparative Toxicity of *Glyphosate*-Based Herbicides: Aqueous and *Sediment* Porewater Exposures
PUBLICATION DATE: 2004

21/6/31 (Item 31 from file: 76)
0001934389 IP ACCESSION NO: 6282264
A Comparison of Two Factorial Designs, a Complete 3 x 3 Factorial and a Central Composite Rotatable Design, for Use in Binomial Response Experiments in Aquatic Toxicology
PUBLICATION DATE: 2004

21/6/32 (Item 32 from file: 41)
0000283023 IP ACCESSION NO: 5982416
Concentrations of *Glyphosate* and AMPA in *Sediment* Following Operational Applications of Rodeo to Control Smooth Cordgrass in Willapa Bay, Washington, USA
PUBLICATION DATE: 2003

21/6/33 (Item 33 from file: 5)
17261508 BIOSIS NO.: 200300220227
Condensation nucleation light scattering detection with ion chromatography for direct determination of *glyphosate* and its metabolite in *water*.
2003

21/6/34 (Item 34 from file: 50)
0007890582 CAB Accession Number: 20001910170
Contamination of the 'Afgedamde Maas' with pesticides and fertilizers: a survey of pollutants.
Original Title: Belasting van de 'Afgedamde Maas' door bestrijdingsmiddelen en meststoffen: een inventarisatie van probleemstoffen.
Rapport - DLO Staring Centrum, Instituut voor Onderzoek van het Landelijk Gebied

Publication Year: 1999

21/6/35 (Item 35 from file: 245)
062384
Contaminant Minimum-Dose Threshold Concentrations for *Water* Quality Sensors 2005

21/6/36 (Item 36 from file: 50)
0007646438 CAB Accession Number: 19982304307
Contamination in irrigation *water* wells by some herbicides in the Comunidad Valenciana (Spain) citrus areas.
Comptes-rendus 6eme symposium Mediterraneen EWRS, Montpellier, France, 13-15 Mai, 1998.
Publication Year: 1998

21/6/37 (Item 37 from file: 5)
15650274 BIOSIS NO.: 200000368587
Contamination and persistence of endophyte-free ryegrass pastures established by spray-drilling, and intensively grazed by dairy cows in the Waikato region of New Zealand
2000

21/6/38 (Item 38 from file: 5)
0019722894 BIOSIS NO.: 200700382635
Contribution by urban and agricultural pesticide uses to *water* *contamination* at the scale of the Marne watershed
2007

21/6/39 (Item 39 from file: 76)
0001300211 IP ACCESSION NO: 4451086
Control and spread of alligator weed Alternanthera philoxeroides (Mart.) Griseb., in Australia: lessons for other regions
PUBLICATION DATE: 1998

21/6/40 (Item 40 from file: 10)
4762045 43835166 Holding Library: AGL
The Current Status and Environmental Impacts of *Glyphosate*-Resistant Crops
2006
URL: http://hdl.handle.net/10113/7373

21/6/41 (Item 41 from file: 156)
4122526 NLM Doc No: 16899736
The current status and environmental impacts of *glyphosate*-resistant crops: a review.
Sep-Oct 2006

21/6/42 (Item 42 from file: 41)
0000232344 IP ACCESSION NO: 5560184
A Critical Assessment of the Potential Wildlife Toxicity of *Glyphosate* in Ontario with Consideration for Endocrine Disruption
PUBLICATION DATE: [nd]

21/6/43 (Item 43 from file: 50)
0008525642 CAB Accession Number: 20033178639
Criteria for evaluation of the leaching potential of herbicides used in Parana.

Original Title: Criterios para avaliacao do potencial de lixiviacao dos herbicidas comercializados no Estado do Parana.
Publication Year: 2003

21/6/44 (Item 44 from file: 41)
0000131017 IP ACCESSION NO: 3637806
Cu(II)-*glyphosate* system: A study by anodic stripping voltammetry and the influence on Cu adsorption by montmorillonite
PUBLICATION DATE: 1994

21/6/45 (Item 45 from file: 5)
11989701 BIOSIS NO.: 199497010986
Degradation behavior of the pesticides *glyphosate* and diflubenzuron in *water*
1993

21/6/46 (Item 46 from file: 50)
0007695082 CAB Accession Number: 19991903184
Degradation of selected pesticide active ingredients and commercial formulations in *water* by the photo-assisted Fenton reaction.
Publication Year: 1999

21/6/48 (Item 48 from file: 40)
00407146 ENVIROLINE NUMBER: 93-03079
Degradation of 14C-*Glyphosate* in Saskatchewan *Soils*
Apr 93

21/6/49 (Item 49 from file: 50)
0008031115 CAB Accession Number: 20013036493
The Danish EPA's assessment and approval of *glyphosate*.
Original Title: Milj<o>styrelsens vurdering og godkendelse af glyphosat.
Publication Year: 2001

21/6/50 (Item 50 from file: 40)
00450457 ENVIROLINE NUMBER: 97-07406
Direct Surface Analysis of Pesticides on *Soil* , Leaves, Grass, and Stainless Steel by Static Secondary Ion Mass Spectrometry
Feb 97

21/6/51 (Item 51 from file: 50)
0007309926 CAB Accession Number: 19972300189
Determination of chlorthal-dimethyl residues in tubers of saffron (Crocus sativus L.) by HPLC.
Publication Year: 1996

21/6/52 (Item 52 from file: 144)
14022673 PASCAL No.: 99-0211073
Bestimmung von Glyphosat und Aminomethylphosphonsaeure (AMPA) in Wasser : Methodik und erste Ergebnisse aus Schleswig-Holstein
(Determination of *glyphosate* and aminomethyl-phosphonic acid (AMPA) in *water* : Methodology and first results from Schleswig-Holstein)
1999

21/6/53 (Item 53 from file: 10)
3940838 23231085 Holding Library: AGL
Determination of *glyphosate* and aminomethylphosphonic acid in crops by

capillary gas chromatography with mass-selective detection: collaborative study
2001

21/6/54 (Item 54 from file: 10)
3492502 20498090 Holding Library: AGL
Determination of *glyphosate* and (aminomethyl)phosphonic acid in *soil*, plant and animal matrices, and *water* by capillary gas chromatography with mass-selective detection
1994 Dec

21/6/55 (Item 55 from file: 10)
3850189 22067295 Holding Library: AGL
Determination of *glyphosate* residues in plants by precolumn derivatization and coupled-column liquid chromatography with fluorescence detection
2000

21/6/57 (Item 57 from file: 5)
10739215 BIOSIS NO.: 199191122106
DETERMINATION OF THE HERBICIDE *GLYPHOSATE* AND ITS METABOLITE
AMINOMETHYLPHOSPHONIC ACID BY GAS CHROMATOGRAPHY WITH FLAME PHOTOMETRIC DETECTION
1991

21/6/58 (Item 58 from file: 144)
14890245 PASCAL No.: 01-0038092
Development of California Public Health Goals (PHGs) for chemicals in drinking *water*
2000

21/6/59 (Item 59 from file: 5)
15153153 BIOSIS NO.: 199900412813
Development of an ultrasensitive enzyme immunoassay for the analysis of *glyphosate* in community *water* systems
1999

21/6/60 (Item 60 from file: 50)
0008450312 CAB Accession Number: 20033076771
Development of the analytical method of residual pesticides in sugar (Part V). Determination of *glyphosate* on the residual pesticide in sugar using HPLC with fluorescence detection.
Publication Year: 2002

21/6/61 (Item 61 from file: 266)
00580602
IDENTIFYING NO.: 0403876 AGENCY CODE: AGRIC
DEVELOPMENT OF *WATER* MANAGEMENT TECHNOLOGY AND EFFICIENT CROPPING SYSTEMS FOR MID SOUTH

21/6/62 (Item 62 from file: 41)
0000207816 IP ACCESSION NO: 5125928
Dynamics of *glyphosate* and aminomethylphosphonic acid in a forest *soil*

in Galicia, north-west Spain
PUBLICATION DATE: 2001

21/6/63 (Item 63 from file: 10)
3473279 20480240 Holding Library: AGL
Dissipation of *glyphosate* and aminomethylphosphonic acid in North American forests
1994 Aug

21/6/64 (Item 64 from file: 76)
0000890954 IP ACCESSION NO: 9308651
Dissipation of *Glyphosate* and Aminomethylphosphonic Acid in *Water* and *Sediments* of Boreal Forest Ponds
PUBLICATION DATE: 1993

21/6/65 (Item 65 from file: 266)
00565351
IDENTIFYING NO.: 0196167 AGENCY CODE: AGRIC
Ecotoxicological Effects of Contaminants in Aquatic Ecosystems

21/6/66 (Item 66 from file: 40)
00256355 ENVIROLINE NUMBER: 94-01653
Ecotoxic Effects of Four Herbicides (*Glyphosate*, Alachlor, Chlortoluron and Isoproturon) on the Algae Chlorella pyrenoidosa Chick.
May 11-15, 93

21/6/67 (Item 67 from file: 156)
4029382 NLM Doc No: 16041711
Efficacy and fate of *glyphosate* on Swedish railway embankments.
Sep 2005

21/6/68 (Item 68 from file: 203)
01540489
Effect of cover crops on weed infestation in maize (Wirkung von Bodendeckern auf die Verunkrautung in Mais)
1990

21/6/69 (Item 69 from file: 40)
00549458 ENVIROLINE NUMBER: 98-08240
Effects of Edifenphos and *Glyphosate* on the Immune Response and Protein Biosynthesis of Bolti Fish (Tilapia nilotica)
1998

21/6/70 (Item 70 from file: 10)
4765054 43961216 Holding Library: AGL
Effects of dredging an agricultural drainage ditch on *water* column herbicide concentration, as predicted by fluvarium techniques
2007
URL: http://hdl.handle.net/10113/7540

21/6/71 (Item 71 from file: 5)
14426245 BIOSIS NO.: 199800220492
Effect of flow rate on the adsorption and desorption of *glyphosate*, simazine and atrazine in columns of sandy *soils*
1998

21/6/72 (Item 72 from file: 41)

0000256512 IP ACCESSION NO: 6535626
Influence of phosphate on the mobility of pesticide *glyphosate* in different *soils*
PUBLICATION DATE: 2005

21/6/73 (Item 73 from file: 156)
4123894 NLM Doc No: 16174533
Effect of *glyphosate* herbicide on acetylcholinesterase activity and metabolic and hematological parameters in piava (Leporinus obtusidens).
Oct 2006

21/6/74 (Item 74 from file: 5)
14244856 BIOSIS NO.: 199800039103
Effect of *glyphosate* on the development of Pseudosuccinea columella snails
1997

21/6/75 (Item 75 from file: 156)
087578 NLM Doc No: NTIS/02971767 Sec. Source ID: NTIS/PB93121309
Effect of *Glyphosate* and Nitrapyrin on Selected Bacterial Populations in Continuous-Flow Culture.
1992

21/6/76 (Item 76 from file: 203)
01913428
Effects of agricultural pesticides on freshwater plankton communities in enclosures
1994
Contamination of pesticides from agricultural and industrial areas to *soil* and *water*

21/6/77 (Item 77 from file: 40)
00384147 ENVIROLINE NUMBER: 91-03252
Effects of the Herbicide *Glyphosate* on Nitrification in Four *Soils* from Atlantic Canada
Jun 90

21/6/78 (Item 78 from file: 40)
00411820 ENVIROLINE NUMBER: 93-07764
Influence of Herbicides on Transformations of Urea Nitrogen in *Soil*
1993

21/6/79 (Item 79 from file: 76)
0001878085 IP ACCESSION NO: 7017766
Effects of the Herbicides Roundup and Avans on Euglena gracilis
PUBLICATION DATE: 2006

21/6/80 (Item 80 from file: 50)
0009086731 CAB Accession Number: 20063129307
Effect of heavy metals and herbicides on immune capacities in Pacific oyster, Crassostrea gigas .
Publication Year: 2006

21/6/81 (Item 81 from file: 5)
10835626 BIOSIS NO.: 199192081397
EFFECT OF ALFALFA MEDICAGO-SATIVA ROOTS ON MOVEMENT OF ATRAZINE AND ALACHLOR THROUGH *SOIL*
1991

21/6/82 (Item 82 from file: 5)
14172459 BIOSIS NO.: 199799806519
Influence of natural organic matter on the sorption of biocides onto goethite, II. *Glyphosate*
1997

21/6/83 (Item 83 from file: 10)
4877763 44045213 Holding Library: AGL
Effects of pesticides on community composition and activity of *sediment* microbes - responses at various levels of microbial community organization
2008
URL: http://dx.doi.org/10.1016/j.envpol.2007.07.003

21/6/84 (Item 84 from file: 203)
01913429
Effects of pesticides on different zooplankton taxa in mesocosm experiments
1994
Contamination of pesticides from agricultural and industrial areas to *soil* and *water*

21/6/85 (Item 85 from file: 50)
0006767860 CAB Accession Number: 19932339123
The effect of reduced cultivation, ploughing and herbicides on the occurence of volunteer cereal grains in winter wheat and barley.
Publication Year: 1993

21/6/86 (Item 86 from file: 41)
0000247993 IP ACCESSION NO: 6177718
Effect of Root Death and Decay on Dissipation of Polycyclic Aromatic Hydrocarbons in the Rhizosphere of Yellow Sweet Clover and Tall Fescue
PUBLICATION DATE: 2005

21/6/87 (Item 87 from file: 5)
18111717 BIOSIS NO.: 200500018782
Effects of thiophanate-methyl and *glyphosate* on asexual and sexual reproduction in the rotifer Brachionus calyciflorus Pallas
2004

21/6/88 (Item 88 from file: 50)
0008273313 CAB Accession Number: 20013105423
Effect of *soil* *contamination* of *glyphosate* solution on Cyperus esculentus L.
Original Title: Efecto de la contaminacion con suelo de la solucion herbicida de glifosato en el control de Cyperus esculentus L.
Publication Year: 2001

21/6/90 (Item 90 from file: 50)
0008575008 CAB Accession Number: 20043013531
The effect of spray particle size and distribution on drift and efficacy of herbicides.
Publication Year: 2004

21/6/91 (Item 91 from file: 10)
3822916 22044822 Holding Library: AGL
Effects of 2,4-D, *glyphosate* and paraquat on growth, photosynthesis and

chlorophyll-a synthesis of Scenedesmus quadricauda Berb 614
2000

21/6/92 (Item 92 from file: 156)
3969653 NLM Doc No: 15660608
Elicitation of expert judgments of uncertainty in the risk assessment of herbicide-tolerant oilseed crops.
Dec 2004

21/6/93 (Item 93 from file: 41)
0000179563 IP ACCESSION NO: 4365091
Environmental degradation of polyacrylamides. II. Effects of environmental (outdoor) exposure
PUBLICATION DATE: 1997

21/6/94 (Item 94 from file: 156)
4029385 NLM Doc No: 16041722
Environmental fate of herbicides trifluralin, metazachlor, metamitron and sulcotrione compared with that of *glyphosate*, a substitute broad spectrum herbicide for different *glyphosate*-resistant crops.
Sep 2005

21/6/95 (Item 95 from file: 266)
00566742
IDENTIFYING NO.: 0197733 AGENCY CODE: AGRIC
Environmental Impacts of Forest Herbicides

21/6/96 (Item 96 from file: 50)
0009336000 CAB Accession Number: 20073199982
Environmental impacts of transgenic herbicide-resistant crops.
Publication Year: 2007

21/6/97 (Item 97 from file: 50)
0009297831 CAB Accession Number: 20073132555
Enzymatic activity of *soil* contaminated with triazine herbicides.
Publication Year: 2007

21/6/98 (Item 98 from file: 144)
15180463 PASCAL No.: 01-0345076
ETUDE DES EFFETS D'APPLICATIONS REPETEES DE CUIVRE SUR L'ACTIVITE ET LA DIVERSITE DE LA MICROFLORE DES SOLS
(EFFECTS OF REPEATED APPLICATIONS OF COPPER ON ACTIVITY AND DIVERSITY OF *SOIL* MICROFLORA) 2000-04; 2000

21/6/99 (Item 99 from file: 266)
00571835
IDENTIFYING NO.: 0204294 AGENCY CODE: AGRIC
Evaluating the physical and biological availability of pesticides and pharmaceuticals in agricultural contexts

21/6/100 (Item 100 from file: 5)
12254744 BIOSIS NO.: 199497276029
Evaluation of the mobility of C-14-labelled pesticides in *soils* by thin layer chromatography using a linear analyser
1994

21/6/101 (Item 101 from file: 41)

0000271841 IP ACCESSION NO: 5401917
Evolution of the pesticide *contamination* of rivers in the Ile-de-France
ORIGINAL TITLE: Evolution de la *contamination* des cours d'eau par les pesticides en Ile-de-France
PUBLICATION DATE: 2002

21/6/103 (Item 103 from file: 156)
135511 NLM Doc No: NTIS/02990874 Sec. Source ID: NTIS/PB96199559
Evaluation and Selection of Analytical Methods for Lawn-Applied Pesticides.
1996

21/6/104 (Item 104 from file: 5)
17702823 BIOSIS NO.: 200400083580
Estimation of *soil* phosphate adsorption capacity by means of a pedotransfer function.
2004

21/6/105 (Item 105 from file: 156)
4247005 NLM Doc No: 18186337
Facilitated transport of diuron and *glyphosate* in high copper vineyard *soils*.
Dec 1 2007

21/6/106 (Item 106 from file: 50)
0009519762 CAB Accession Number: 20083103461
Fate and behavior of chlorpyrifos and *glyphosate* at a field level in Apalta catchment I. Experimental phase.
Book Title: Environmental fate and ecological effects of pesticides
Publication Year: 2007

21/6/107 (Item 107 from file: 50)
0008038106 CAB Accession Number: 20013047631
Fate of foodborne bacterial pathogens in pesticide products.
Publication Year: 2001

21/6/108 (Item 108 from file: 76)
0000659569 IP ACCESSION NO: 9009606
Fate of *Glyphosate* in a Canadian Forest Watershed: 1. Aquatic Residues and Off-Target Deposit Assessment
PUBLICATION DATE: 1990

21/6/109 (Item 109 from file: 76)
0000659568 IP ACCESSION NO: 9009607
Fate of *Glyphosate* in a Canadian Forest Watershed: 2. Persistence in Foliage and *Soils*
PUBLICATION DATE: 1990

21/6/110 (Item 110 from file: 5)
15002412 BIOSIS NO.: 199900262072
Fate of agrochemical residues, associated with malt and hops, during brewing
1999

21/6/111 (Item 111 from file: 266)
00569638
IDENTIFYING NO.: 0201364 AGENCY CODE: AGRIC
Fate and Impact of Gene Migration from Transgenic Creeping Bentgrass

Production Fields

21/6/112 (Item 112 from file: 50)
0007874396 CAB Accession Number: 20002302163
Features of using herbicides on hillsides with radiation technogenic *contamination*.
Publication Year: 1998

21/6/114 (Item 114 from file: 50)
0008773324 CAB Accession Number: 20053018188
Glyphosate.
Publication Year: 2004

21/6/115 (Item 115 from file: 41)
0000254603 IP ACCESSION NO: 6445337
Glyphosate degradation as a *soil* health indicator for heavy metal polluted *soils*
PUBLICATION DATE: 2005

21/6/116 (Item 116 from file: 156)
4046638 NLM Doc No: 15951002
Glyphosate adsorption in *soils* compared to herbicides replaced with the introduction of *glyphosate* resistant crops.
Nov 2005

21/6/117 (Item 117 from file: 156)
4194300 NLM Doc No: 17411011
Glyphosate and AMPA analysis in sewage sludge by LC-ESI-MS/MS after FMOC derivatization on strong anion-exchange resin as solid support.
May 15 2007

21/6/118 (Item 118 from file: 50)
0007602637 CAB Accession Number: 19982303244
Glyphosate and AMPA in *soil*.
Original Title: Glyphosat og AMPA i jord.
Publication Year: 1998

21/6/119 (Item 119 from file: 144)
13306543 PASCAL No.: 98-0030824
Glyphosat in der Ruhr Analytik und Ergebnisse
(*Glyphosate* in the River Ruhr : Analytical methods and results)
1997

21/6/120 (Item 120 from file: 50)
0007654813 CAB Accession Number: 19982304440
Glyphosate (roundup).
Publication Year: 1998

21/6/121 (Item 121 from file: 41)
0000284387 IP ACCESSION NO: 6237719
Glyphosate, other herbicides, and transformation products in Midwestern streams, 2002
PUBLICATION DATE: 2005

21/6/123 (Item 123 from file: 10)
4734257 43973929 Holding Library: AGL
Glyphosate translocation from plants to *soil* - does this constitute a

significant proportion of residues in *soil*
2007
URL: http://dx.doi.org/10.1007/s11104-007-9387-1

21/6/124 (Item 124 from file: 50)
0009420995 CAB Accession Number: 20073254671
Glyphosate: worldwide situation and consequences for Switzerland.
Original Title: Le *glyphosate* : bilan de la situation mondiale et analyse de quelques consequences malherbologiques pour la Suisse.
Publication Year: 2007

21/6/125 (Item 125 from file: 5)
10777895 BIOSIS NO.: 199192023666
GLYPHOSATE SKIN BINDING ABSORPTION RESIDUAL TISSUE DISTRIBUTION AND SKIN DECONTAMINATION
1991

21/6/126 (Item 126 from file: 40)
00454948 ENVIROLINE NUMBER: 97-12226
The Use of *Glyphosate* as the Sole Source of Phosphorus or Carbon for the Selection of *Soil* -Borne Fungal Strains Capable to Degrade This Herbicide
Jun 97

21/6/127 (Item 127 from file: 50)
0007188280 CAB Accession Number: 19962300674
Glyphosate, part 2: human exposure and ecological effects.
Publication Year: 1995

21/6/129 (Item 129 from file: 40)
00401824 ENVIROLINE NUMBER: 92-12357
Genotoxic Effect Induced by Herbicides Atrazine *Glyphosate* in Plants of Vicia faba Grown in Different *Soils*
Aug 12, 92

21/6/131 (Item 131 from file: 50)
0008262277 CAB Accession Number: 20023068082
Grass crops as weeds.
Original Title: Kulturgraesser som ukrudt.
Publication Year: 2002

21/6/132 (Item 132 from file: 41)
0000241958 IP ACCESSION NO: 5955581
Does grassland farming pose a threat to *groundwater*? A comparative study of leaching from pasture and cut sward
ORIGINAL TITLE: Kuormittaako nurmiviljely pohjavettae? Vertailussa saeiloerehunurmi ja laidun
PUBLICATION DATE: 2003

21/6/133 (Item 133 from file: 144)
17570367 PASCAL No.: 06-0158103
Gestion des *sediments* de l'assainissement pluvial : analyse des risques sanitaires lies aux hydrocarbures aromatiques polycycliques et aux pesticides. Application aux *sediments* des bassins de retention/infiltration
2005; 2005

21/6/134 (Item 134 from file: 76)
0002004298 IP ACCESSION NO: 7588470
Highway stormwater detention ponds in the Mediterranean region: Functioning and Biodiversity Evaluation of *water* quality and its impact on aquatic animal communities.
ORIGINAL TITLE: Les bassins d'eau pluviale autoroutiers en region Mediterraneenne: Fonctionnement et Biodiversite Evaluation de l'impact de la pollution routiere sur les communautes animales aquatiques
PUBLICATION DATE: 2005

21/6/135 (Item 135 from file: 156)
051526 NLM Doc No: NTIS/02930158 Sec. Source ID: NTIS/PB2004107408
Herbicides and their Transformation Products in Source-*Water* Aquifers Tapped by Public-Supply Wells in Illinois, 2001-02.
2003

21/6/136 (Item 136 from file: 144)
16308784 PASCAL No.: 03-0473017
Behandlung versiegelter Flaechen - moegliche Quelle fuer die Belastung von Oberflaechengewaessern mit Pflanzenschutzmitteln
((Herbicide treatment of urban areas: a possible source of surface *water* *contamination*))
2002

21/6/137 (Item 137 from file: 266)
00555433
IDENTIFYING NO.: 0179283 AGENCY CODE: AGRIC
Herbicides: Evaluations in Ornamental Plant Production and Sorption to *Soils* and Potting Media

21/6/138 (Item 138 from file: 5)
14984208 BIOSIS NO.: 199900243868
Hydrotalcites and organo-hydrotalcites as sorbents for removing pesticides from *water*
1999

21/6/139 (Item 139 from file: 40)
00271764 ENVIROLINE NUMBER: 95-00267
Hydrogen-Bonding Interactions Between the Herbicide *Glyphosate* and *Water*-Soluble Humic Substances
Nov 94

21/6/140 (Item 140 from file: 5)
10523939 BIOSIS NO.: 199141036565
IMPACT OF AN ORGANOPHOSPHATE HERBICIDE *GLYPHOSATE* ON PERIPHYTON COMMUNITIES DEVELOPED IN EXPERIMENTAL STREAMS
1991

21/6/141 (Item 141 from file: 50)
0007439093 CAB Accession Number: 19971911804
Improvement of floodplain and swampy farmlands polluted by radionuclides.
Publication Year: 1996

21/6/142 (Item 142 from file: 5)
12917671 BIOSIS NO.: 199598385504
Improved method for the determination of *glyphosate* in *water*

1995

21/6/143 (Item 143 from file: 266)
00581669
IDENTIFYING NO.: 0405209 AGENCY CODE: AGRIC
IMPROVING SURFACE *WATER* QUALITY WITH ALTERNATIVE CROPPING SYSTEMS AT FIELD AND WATERSHED SCALES

21/6/144 (Item 144 from file: 266)
00559286
IDENTIFYING NO.: 0187864 AGENCY CODE: AGRIC
Integrated management of winter annual grass weeds in eastern Washington dryland crop systems

21/6/145 (Item 145 from file: 50)
0008999163 CAB Accession Number: 20063034647
Interactions of calcium ions with weakly acidic active ingredients slow cuticular penetration: a case study with *glyphosate*.
Publication Year: 2004

21/6/146 (Item 146 from file: 10)
4057470 23319018 Holding Library: AGL
Investigation of the herbicide *glyphosate* and the plant growth regulators chlormequat and mepiquat in cereals produced in Denmark
2001

21/6/147 (Item 147 from file: 266)
00581807
IDENTIFYING NO.: 0405357 AGENCY CODE: AGRIC
IRRIGATION SYSTEMS AND PRECISION MGMT STRATEGIES TO CONSERVE *WATER* AND PROTECT *WATER* QUALITY

21/6/148 (Item 148 from file: 10)
4311076 43682641 Holding Library: AGL
Leaching of *glyphosate* and amino-methylphosphonic acid from Danish agricultural field sites
2005

21/6/150 (Item 150 from file: 10)
4380835 43767826 Holding Library: AGL
Leaching of *glyphosate* and AMPA under two *soil* management practices in Burgundy vineyards (Vosne-Romanee, 21-France)
2005

21/6/151 (Item 151 from file: 156)
3704936 NLM Doc No: 11767144
Liquid chromatography/electrospray ionization/isotopic dilution mass spectrometry analysis of n-(phosphonomethyl) glycine and mass spectrometry analysis of aminomethyl phosphonic acid in environmental *water* and vegetation matrixes.
Nov-Dec 2001

21/6/152 (Item 152 from file: 10)
4076684 23339900 Holding Library: AGL
Long-term fate of *glyphosate* associated with repeated Rodeo applications to control smooth cordgrass (Spartina alterniflora) in Willapa Bay, Washington

2001

21/6/153 (Item 153 from file: 10)
3580847 20569385 Holding Library: AGL
Levels of the herbicide *glyphosate* in well *water*
1996

21/6/154 (Item 154 from file: 10)
4830223 43762243 Holding Library: AGL
Mobility and leaching of *glyphosate*: a review
2005
URL: http://www.interscience.wiley.com/jpages/1526-498X/

21/6/155 (Item 155 from file: 41)
0000130126 IP ACCESSION NO: 3626776
Mobility of pesticides in *soils*. Influence of *soil* properties and pesticide structure
PUBLICATION DATE: 1994

21/6/156 (Item 156 from file: 10)
3917726 23212368 Holding Library: AGL
Mobility of *soil* nitrogen and microbial responses following the sudden death of established turf
2000

21/6/158 (Item 158 from file: 156)
3906684 NLM Doc No: 15074680
Modeling the kinetics of the competitive adsorption and desorption of *glyphosate* and phosphate on goethite and gibbsite and in *soils*.
Mar 15 2004

21/6/159 (Item 159 from file: 156)
4106835 NLM Doc No: 16532367
Molecular identification and expression of differentially regulated genes of the European flounder, Platichthys flesus, submitted to pesticide exposure.
May-Jun 2006

21/6/161 (Item 161 from file: 266)
00581493
IDENTIFYING NO.: 0405012 AGENCY CODE: AGRIC
MANAGEMENT PRACTICES TO REDUCE MOVEMENT OF AGRO-CHEMICALS TO SURFACE AND GROUND WATERS IN NC U.S.

21/6/162 (Item 162 from file: 50)
0007288434 CAB Accession Number: 19962302846
Managing riparian weeds.
Publication Year: 1995

21/6/163 (Item 163 from file: 10)
4114916 43627974 Holding Library: AGL
Mineralization of *glyphosate* in compost-amended *soil* under controlled conditions
2004

21/6/164 (Item 164 from file: 50)
0007481024 CAB Accession Number: 19982300753

Mineralization of [SUP 14 C]*glyphosate* and its plant-associated residues in arable *soils* originating from different farming systems.
Publication Year: 1997

21/6/165 (Item 165 from file: 266)
00586447
IDENTIFYING NO.: 0410786 AGENCY CODE: AGRIC
MAINTAINING *SOIL* RESOURCES FOR EFFECTIVE CONSERVATION AND HERBICIDE MANAGEMENT IN MID-SOUTH CROP PRODUCTION

21/6/166 (Item 166 from file: 76)
0000642511 IP ACCESSION NO: 2291643
Method for the determination of residues of the herbicide *glyphosate* and its principal metabolite, aminomethylphosphonic acid, in plant materials by nitrogen-selective gas chromatography.
PUBLICATION DATE: 1990

21/6/167 (Item 167 from file: 144)
17616792 PASCAL No.: 06-0206716
Matrix solid-phase dispersion extraction and determination by high-performance liquid chromatography with fluorescence detection of residues of *glyphosate* and aminomethylphosphonic acid in tomato fruit
2005

21/6/168 (Item 168 from file: 10)
4875387 44014513 Holding Library: AGL
Mycotoxin occurrence and Aspergillus flavus *soil* propagules in a corn and cotton *glyphosate*-resistant cropping systems
2007
URL: http://hdl.handle.net/10113/14128

21/6/169 (Item 169 from file: 50)
0007090253 CAB Accession Number: 19952310514
Misguided herbicides?
Publication Year: 1994

21/6/170 (Item 170 from file: 266)
00556809

IDENTIFYING NO.: 0183498 AGENCY CODE: AGRIC
Measuring Chronic Exposure to Biotoxins and Chemicals

21/6/171 (Item 171 from file: 10)
4791979 44013354 Holding Library: AGL
Measurement and modelling of *glyphosate* fate compared with that of herbicides replaced as a result of the introduction of *glyphosate*-resistant oilseed rape
2008
URL: http://dx.doi.org/10.1002/ps.1519

21/6/172 (Item 172 from file: 156)
3706586 NLM Doc No: 11775355
[Analysis of *glyphosate* and its metabolite, aminomethylphosphonic acid, in agricultural products by HPLC]
Oct 2001

21/6/173 (Item 173 from file: 245)

058269
  Non-Point Pollution of the Paris Metropolitan Area Rivers by Pesticides: Assessment, Prevention and Best Management Practices   2003

 21/6/174   (Item 174 from file: 10)
4667266 43667148 Holding Library: AGL
   N and P leaching and microbial *contamination* from intensively managed pasture and cut sward on sandy *soil* in Finland
  2004

 21/6/175   (Item 175 from file: 266)
00583844
  IDENTIFYING NO.: 0407750   AGENCY CODE: AGRIC
  NARCOTIC CROP CONTROL STRATEGIES

 21/6/176   (Item 176 from file: 41)
0000256437   IP ACCESSION NO: 6520431
Novel AroA with High Tolerance to *Glyphosate*, Encoded by a Gene of Pseudomonas putida 4G-1 Isolated from an Extremely Polluted Environment in China
PUBLICATION DATE: 2005

 21/6/177   (Item 177 from file: 5)
18765565   BIOSIS NO.: 200600110960
Occurrence of pesticides in surface *water* originating from agricultural areas
ORIGINAL LANGUAGE TITLE: Auftreten von pflanzenschutmitteln in oberflachengewassern mit landwirtschaftlich gepragten einzugsgebieten
2002

 21/6/178   (Item 178 from file: 5)
0019504572   BIOSIS NO.: 200700164313
On-line *water* quality parameters as indicators of distribution system *contamination*
2007

 21/6/179   (Item 179 from file: 50)
0008303067   CAB Accession Number: 20023125349
    Optimization and performance evaluation of the analysis of *glyphosate* and AMPA in *water* by HPLC with fluorescence detection.
   Publication Year: 2002

 21/6/180   (Item 180 from file: 50)
0008736772   CAB Accession Number: 20043192199
   The use of organic wastes for *soil*-covering of vineyards.
   Publication Year: 2004

 21/6/181   (Item 181 from file: 50)
0009070643   CAB Accession Number: 20063118595
   Pedotransfer function for estimation of phosphate adsorption capacity on a wide range of *soils*.
   Book Title: *Soil* abiotic and biotic interactions and the impact on the ecosystem and human welfare
   Publication Year: 2005

 21/6/182   (Item 182 from file: 50)
0008514625   CAB Accession Number: 20033162509

Proceedings of the Third International Conference on Fungi: Hopes and Challenges III - *Soil* Microbiology, Cairo, Egypt, 30 October - I November, 2002.
Publication Year: 2003

21/6/183 (Item 183 from file: 5)
10729576 BIOSIS NO.: 199191112467
PRECONCENTRATION OF HYDROPHILIC AND HYDROPHOBIC PESTICIDES FROM AQUEOUS SOLUTIONS AND EXTRACTION OF RESIDUES USING THE POLYMERIC SORBENT WOFATIT Y 77 II. EXTENSION OF THE STUDIES TO HYDROPHOBIC PESTICIDES AQUEOUS EXTRACTION OF PESTICIDES FROM PLANT MATERIAL AND *SOIL*
1991

21/6/184 (Item 184 from file: 50)
0008179168 CAB Accession Number: 20023016228
Predicted impact of transgenic, herbicide-tolerant corn on drinking *water* quality in vulnerable watersheds of the mid-western USA.
Publication Year: 2002

21/6/185 (Item 185 from file: 50)
0007293118 CAB Accession Number: 19962302930
The progress and development of herbicides for weed management in the tropics.
Publication Year: 1996

21/6/186 (Item 186 from file: 245)
061374
Parameters for Rapid Contaminant Detection in a *Water* Distribution System 2005

21/6/187 (Item 187 from file: 50)
0009482834 CAB Accession Number: 20083046039
The potential of *contamination* of *groundwater* by pesticides in Dourados river watershed, MS - Brazil.
Original Title: Potencial de contaminacao da agua subterranea por pesticidas na Bacia do Rio Dourados, MS.
Publication Year: 2007

21/6/188 (Item 188 from file: 144)
15337493 PASCAL No.: 02-0024181
Potential of microcolumn liquid chromatography and capillary electrophoresis with flame photometric detection for determination of polar phosphorus-containing pesticides
2001

21/6/189 (Item 189 from file: 50)
0006865552 CAB Accession Number: 19942306110
The Poa species: problems and management in Danish arable fields.
Brighton crop protection conference, weeds. Proceedings of an international conference, Brighton, UK, 22-25 November 1993.
Publication Year: 1993

21/6/190 (Item 190 from file: 156)
4021689 NLM Doc No: 16020099
Pesticide *contamination* inside farm and nonfarm homes.
Jul 2005

21/6/191 (Item 191 from file: 266)
00559251
IDENTIFYING NO.: 0187809 AGENCY CODE: AGRIC
PESTICIDE DEGRADATION BY MICROBES UNDER MODIFIED *SOIL* CONDITONS

21/6/192 (Item 192 from file: 40)
00613077 ENVIROLINE NUMBER: 02-01376
Pesticide Influence on *Soil* Enzymatic Activities
Nov 01

21/6/193 (Item 193 from file: 5)
17728323 BIOSIS NO.: 200400099080
Pesticide use among farmers in the Amazon basin of Ecuador.
2003

21/6/194 (Item 194 from file: 5)

0019839745 BIOSIS NO.: 200700499486
Pesticides in the Rhone river delta (France): Basic data for a field-based exposure assessment
2007

21/6/195 (Item 195 from file: 50)
0008829851 CAB Accession Number: 20053072254
Pesticides applied in eucalyptus and coconut palm plantations: preliminary analysis.
Original Title: Risco de contaminacao de aguas por pesticidas aplicados em plantacoes de eucaliptos e coqueiros: analise preliminar.
Publication Year: 2001

21/6/196 (Item 196 from file: 156)
3793706 NLM Doc No: 12549246
Pesticide use and practices in an Iowa farm family pesticide exposure study.
Nov 2002

21/6/197 (Item 197 from file: 50)
0008182786 CAB Accession Number: 20023008378
Postcolumn fluorogenic labeling for the HPLC analysis of *glyphosate* and AMPA in matrix oil.
Book Title: Cutting-edge technologies for sustained competitiveness: Proceedings of the 2001 PIPOC International Palm Oil Congress, Chemistry and Technology Conference, Kuala Lumpur, Malaysia, 20-22 August 2001
Publication Year: 2001

21/6/198 (Item 198 from file: 266)
00553082
IDENTIFYING NO.: 0138596 AGENCY CODE: AGRIC
REDUCING THE POTENTIAL FOR ENVIRONMENTAL *CONTAMINATION* BY PESTICIDES AND OTHER ORGANIC CHEMICALS

21/6/199 (Item 199 from file: 50)
0006800727 CAB Accession Number: 19942300979
Red rice (Oryza sativa): competition studies for management decisions.
Publication Year: 1993

21/6/200 (Item 200 from file: 144)

14014409 PASCAL No.: 99-0202198
Rapid determination of *glyphosate* in cereal samples by means of pre-column derivatisation with 9-fluorenylmethyl chloroformate and coupled-column liquid chromatography with fluorescence detection
1999

21/6/201 (Item 201 from file: 266)
00580396
IDENTIFYING NO.: 0403552 AGENCY CODE: AGRIC
REPLACEMENT OF HERBICIDES AND METHYL BROMIDE BY MICROBIOLOGICAL CONTROL OF WEEDS

21/6/202 (Item 202 from file: 5)
10823495 BIOSIS NO.: 199192069266
RATE CONSTANTS FOR DIRECT REACTIONS OF OZONE WITH SEVERAL DRINKING *WATER* CONTAMINANTS
1991

21/6/203 (Item 203 from file: 156)
4202286 NLM Doc No: 17562462
Review of potential environmental impacts of transgenic *glyphosate* -resistant soybean in Brazil.
Jun-Jul 2007

21/6/204 (Item 204 from file: 50)
0007770016 CAB Accession Number: 19990707697
Ryegrass *contamination* of endophyte-free dairy pastures after spray-drilling in autumn.
Publication Year: 1997, publ. 1998

21/6/205 (Item 205 from file: 41)
0000146309 IP ACCESSION NO: 3842414
Residue detections in *soil* and shallow *groundwater* after long-term herbicide applications in southern Alberta
PUBLICATION DATE: 1995

21/6/206 (Item 206 from file: 144)
13693513 PASCAL No.: 98-0447752
Risque de *contamination* des eaux souterraines par l'herbicide glyophosate : situation en 1997
(Risk of *contamination* of groundwaters by the herbicide *glyphosate* : situation in 1997)
1998

21/6/207 (Item 207 from file: 41)
0000165998 IP ACCESSION NO: 4221706
Solubility products of six metal-*glyphosate* complexes in *water* and forestry *soils*, and their influence on *glyphosate* toxicity to plants
PUBLICATION DATE: 1997

21/6/208 (Item 208 from file: 50)
0007733213 CAB Accession Number: 19992301379
Simultaneous determination of residual phosphorus-containing amino acid herbicides in agricultural products by HPLC.
Publication Year: 1999

21/6/209 (Item 209 from file: 76)

0000865915 IP ACCESSION NO: 3002901
Simple determination of *glyphosate* and its metabolite (aminomethylphosphonic acid) in fruits and vegetables by high performance liquid chromatography with fluorescence detection.
PUBLICATION DATE: 1992

21/6/210 (Item 210 from file: 10)
3502465 20508316 Holding Library: AGL
Simple and rapid determination of the herbicides *glyphosate* and glufosinate in river *water*, *soil* and carrot samples by gas chromatography with flame photometric detection
1996 Mar01

21/6/211 (Item 211 from file: 5)
18478035 BIOSIS NO.: 200510172535
Specific contributions of decaying alfalfa roots to nitrate leaching in a Kalamazoo loam *soil*
2005

21/6/212 (Item 212 from file: 41)
0000169421 IP ACCESSION NO: 4290693
Spatial analysis of herbicide decay rates in Louisiana
PUBLICATION DATE: 1997

21/6/213 (Item 213 from file: 40)
00555411 ENVIROLINE NUMBER: 98-14200
Sorption of *Glyphosate* and Cu(II) on a Natural Fulvic Acid Complex: Mutual Influence
Sep 98

21/6/214 (Item 214 from file: 50)
0006715474 CAB Accession Number: 19932333696
Survey of farm wells for pesticides, Ontario, Canada, 1986 and 1987.
Publication Year: 1990

21/6/216 (Item 216 from file: 245)
039761 SM190142
Standard Methods for the Examination of *Water* and Wastewater, 19th Edition: Section 6651 *Glyphosate* Herbicide 19th Edition, 1995

21/6/217 (Item 217 from file: 266)
00580993
IDENTIFYING NO.: 0404418 AGENCY CODE: AGRIC
SUSTAINABILITY OF *SOIL* RESOURCES IN WEED AND CROP MANAGEMENT SYSTEMS IN MID SOUTH AGRICULTURE

21/6/218 (Item 218 from file: 144)
16975920 PASCAL No.: 05-0036049
ToF-SIMS as an alternative tool for the qualitative and quantitative analysis of polar herbicides
Secondary ion mass spectrometry SIMS XIV: Proceedings of the Fourteenth International Conference on Secondary Ion Mass Spectrometry and Related Topics, San Diego, California, USA, September 14-19, 2003
2004

21/6/219 (Item 219 from file: 5)
14469051 BIOSIS NO.: 199800263298

Time effects of three contaminants on the durability and permeability of a solidified sand
1998

21/6/220 (Item 220 from file: 50)
0009194289 CAB Accession Number: 20073037476
Trace element mobilization in *soils* by *glyphosate*.
Publication Year: 2006

21/6/221 (Item 221 from file: 156)
3937673 NLM Doc No: 15312724
Transfer of hexazinone and *glyphosate* through undisturbed *soil* columns in *soils* under Christmas tree cultivation.
Oct 2004

21/6/222 (Item 222 from file: 50)
0007788265 CAB Accession Number: 19992302381
Toxicity of herbicides for Spirodela punctata (G.F.W. Meyer) Thompson and Salvinia minima Baker (aquatic macrophytes).
Original Title: Toxicidade de herbicidas para as macrofitas aquaticas Spirodela punctata (G.F.W. Meyer) Thompson e Salvinia minima Baker.
Publication Year: 1996

21/6/223 (Item 223 from file: 203)
02579069
Toxicity of three *glyphosate* formulations to Aphanius iberus (Toxicidad de tres formulaciones de glifosato sobre Aphanius iberus)
2003
[Conference 2003. Spanish Weed Science Society. Proceedings, Barcelona [Spain], 4th, 5th and 6th November, 2003] (Congreso 2003. Sociedad Espa ola de Malherbolog a. Actas, Barcelona, 4, 5 y 6 de noviembre de 2003)

21/6/224 (Item 224 from file: 5)
18916129 BIOSIS NO.: 200600261524
Urban contributions of *glyphosate* and its degradate AMPA to streams in the United States
2006

21/6/225 (Item 225 from file: 50)
0008928506 CAB Accession Number: 20053161843
Urban areas - source of pesticide-*contamination* of surface *water*?
Book Title: Second International Symposium on plant health in urban horticulture, Berlin, Germany, 27-29 August, 2003
Publication Year: 2003

21/6/226 (Item 226 from file: 144)
17115056 PASCAL No.: 05-0182167
Vadose zone processes and chemical transport : Leaching of *glyphosate* and amino-methylphosphonic acid from danish agricultural field sites
2005

21/6/227 (Item 227 from file: 76)
0001714809 IP ACCESSION NO: 5982533
As the Worm Turns: Eisenia fetida Avoids *Soil* Contaminated by a *Glyphosate*-Based Herbicide
PUBLICATION DATE: 2004

```
 21/6/228     (Item 228 from file: 245)
063711
    *Water*   Quality  Sensor  Responses  to  Injected  Contaminants  in  a
Chloraminated Pipe Loop   2006

 21/6/229     (Item 229 from file: 50)
0008549430   CAB Accession Number: 20033205509
    [  SUP  14  C]-*glyphosate* : uptake into Echium plantagineum following
 pre-emergent application.
   Book   Title:    The  BCPC  International  Congress:  Crop  Science  and
 Technology, Volumes 1 and 2. Proceedings of an international congress held
 at the SECC, Glasgow, Scotland, UK, 10-12 November 2003
   Publication Year:  2003
```

Supplemental Searches

The USDA Economic Research Service Web site (http://www.ers.usda.gov/) was searched for all articles pertaining to:

- alfalfa
- tillage
- biotechnology