BENEFITS OF TRIAZINE HERBICIDES IN REDUCING EROSION AND FUEL USE IN U.S. CORN PRODUCTION. Richard S. Fawcett, President, Fawcett Consulting, Huxley, IA 50124.

Introduction

Soil erosion is one of the greatest threats facing the sustainability of American agriculture. Erosion caused by water and wind reduces present and future crop yields and produces adverse off-site impacts, such as sedimentation of lakes and streams, and transport of nutrients and pesticides to surface waters.

Great strides have been made to reduce erosion and its adverse impacts. Most of this progress had been made due to adoption of conservation tillage systems by farmers. Conservation tillage systems involve reduction or elimination of preplanting tillage in order to leave part or all of the crop residues (leaves and stems) from the previous crop on the soil surface. Conservation Compliance provisions of the 1985 Farm Bill required that farmers participating in any government farm program comply with Conservation Plans designed to reduce erosion on highly erodible land (HEL) to sustainable levels. Over 75% of Conservation Plans used some form of conservation tillage

The 2001 National Resources Inventory (Natural Resources Conservation Service 2003) showed that dramatic decreases in erosion have taken place in the United States since 1982, much of it due to adoption of conservation tillage. Sheet and rill (water) erosion fell from an average 4.0 tons/acre/yr in 1982 to 2.7 tons/acre/yr in 2001, a 33% drop. The average wind erosion rate also dropped 36% during the same period of time. Herbicides, especially the triazine herbicides, have been essential components of conservation tillage, substituting for intensive tillage. No-till systems eliminate all tillage other than that performed by the planter. Mulch tillage systems (often called reduced tillage) eliminate use of the moldboard plow of conventional tillage systems and reduce other tillage to leave part of the previous year's crop residue on the soil surface. In order for tillage systems to be classified as conservation tillage, at least 30% of the soil surface must be covered with crop residue following planting.

Triazine Herbicides and Conservation Tillage

Atrazine and simazine are especially valuable in conservation tillage systems in corn because they provide excellent residual control, and are not tightly adsorbed to surface crop residue, but wash easily from residue to the soil. Atrazine also provides postemergence activity, helping to control emerged weeds. Low vapor pressures also avoid excessive vapor losses of residue-intercepted herbicide. The importance of atrazine to conservation tillage farmers is illustrated by the preferential use of atrazine in conservation tillage. Atrazine was used on 61.7% of conventional tillage corn in 2004 and 84.1% of conservation tillage corn. If atrazine and simazine herbicides were not available, farmers could be expected to increase tillage to control weeds in the absence of effective herbicides.

Soil Erosion Reduction with Conservation Tillage

Reductions in erosion from conservation tillage are due to the protective effects of surface crop residue. Greater levels of residue reduce erosion more (Table 1). Erosion rates following different tillage systems can be predicted from studies which measure how much surface residue remains following tillage. As corn and soybean crops produce differing amounts of crop residue of differing persistence, erosion rates are affected by the preceding crop. Each tillage operation buries additional crop residue. Table 2 shows expected residue cover following various tillage programs and erosion rates that would result, expressed as a percentage of erosion occurring with conventional tillage.

The Conservation Technology Information Center (CTIC) conducts a survey of tillage practices on U.S. cropland every two years. Total acres under conservation tillage, as well as acres in no-till, and acres in mulch tillage are recorded. Mulch tillage can use many different combinations and types of tillage tools, but must leave at least 30% of the soil surface covered with residue. Mulch tillage fields may have anywhere from 30% to as much as 50% or more of the soil surface covered with residue, but

Table 1. Soil erosion as a percent of erosion expected with a moldboard plow system for various residue covers given a percent of the land surface covered by crop residue.

Residue cover[a] (%)	Erosion[b] (%)
10	70
20	43
30	26
40	16
50	10
75	3
100	1

[a]Residue cover is the percent of the land surface covered by crop residue.
[b]Erosion is the percent of that expected if moldboard plowed. (From Laflen, J.M., W.C. Moldenhauer, T.S. Colvin, and W.F. Buchele. 1982. Erosion control. In: Farm agricultural resource management conference on conservation tillage, Iowa State University.)

less residue cover than no-till fields. Fields with 30% residue cover have erosion rates 26% of those under conventional tillage (Table 1). Some mulch tillage fields would have residue coverage of 40 or 50%, with erosion rates of 16% or 10% of conventional. At a minimum, mulch tillage fields would reduce erosion to 26% of conventional. No-till fields usually have about 80% residue cover, reducing erosion to about 3% of conventional (Tables 1 and 2).

Table 2. Expected residue cover and soil erosion for combinations of tillage tools and planters.

Tools[a]	Following corn or meadow		Following soybeans	
	% cover[b]	% soil erosion[c]	% cover[b]	% soil erosion[c]
P (No Till)	81	3	81	3
CP, D, P	31	25	14	57
CP, D, D, P	22	39	7	82
D, D, FC, P	34	19	12	65
D, D, P	40	16	20	43
D, FC, P	48	11	24	36
D, P	57	7	40	15
FC, P	69	4	48	11

[a]The order of operations does not affect the estimates of residue cover or soil erosion.
Abbreviations: P - Plant
CP - Chisel Plow
D - Disc
FC - Field Cultivator
[b] % Cover is percent of the land surface covered by crop residue.
[c] % Soil erosion is the percent of that expected if moldboard plowing had been used instead of the combination of tools given. (Adapted from Laflen, J.M., W.C. Moldenhauer, T.S. Colvin, and W.F. Buchele. 1982. Erosion control In: Farm agricultural resource management conference on conservation tillage, Iowa State University.)

If farms were to switch from mulch tillage to conventional tillage erosion would be 100% of conventional instead of 26%, an increase of 285% ([100%-26%]÷26%). Farms switching from no-till to conventional would have 100% erosion rather than 3% erosion rate, increasing erosion by 3233% ([100%-3%]÷3%). Farms switching from no-till to mulch tillage would have 26% erosion instead of 3%, increasing the erosion rate by 767% ([26%-3%]÷3%).

Fuel Savings with Conservation Tillage

Conservation tillage systems also save fuel due to fewer tillage trips (Table 3). A conventional tillage system consumes about 5.3 gal fuel/acre; a mulch tillage system uses about 3.3 gal/acre; and no-till uses about 1.4 gal/acre fuel (Ayers 1989; Jasa et al. 1991). Conversion from conventional tillage to no-till for row crops would save the equivalent of 3.9 gal/acre of diesel fuel, a reduction of 74%. Switching from conventional tillage to a mulch tillage system would save about 2 gal fuel/acre, a 38% reduction. If fields were converted from conservation tillage back to more tillage intensive systems, fuel use would rise dramatically.

Table 3. Estimated annual increase in soil erosion and fuel use under several tillage change scenarios accompanying loss of the availability of triazine herbicides.

Tillage Conversion Scenarios	Increase Estimated with Reductions in Conservation Tillage	
	Soil Erosion (tons/year)	Fuel Usage (gallons/year)
All No-till to Conventional	153 million	62 million
½ No-Till to Conventional	77 million	31 million
All No-Till to Mulch Till	36 million	30 million
½ No-Till to Mulch Till	18 million	15 million
All Mulch Till to Conventional	99 million	27 million
½ Mulch Till to Conventional	50 million	13 million
All No-Till & Mulch to Conventional	252 million	89 million

Moisture Conservation with Conservation Tillage

Besides saving soil and fuel, conservation tillage systems conserve soil moisture by reducing evaporation caused by tillage. Moisture conservation is especially important in the semi-arid areas of the western U.S. where grain crops can be grown only by storing soil moisture for all or part of a growing season or "fallowing" land. During the time crops are not present, weeds must be controlled to prevent reductions in soil moisture. Traditionally, weed control was done by repeated tillage operations. During the 15 to 19 month fallow period, 5 to 7 tillage passes were made (Regehr and Norwood, In Press). However, tillage increased wind erosion prevalent in these areas, caused evaporation losses of water, and used costly fuel. Ecofallow or chemical fallow systems use herbicides such as atrazine to control weeds in absence of tillage. Atrazine can be used during the fallow period in wheat-sorghum-fallow, wheat-corn-fallow, and wheat-fallow-wheat rotations. Atrazine's low cost and broad spectrum weed control have made these fallow rotations profitable in areas where grain production would otherwise not be economically feasible.

Greater water storage allows shortening of the fallow period, meaning grain crops could be grown more often than in the past. This greater water storage with chemical fallow, compared to conventional tillage fallow, has increased profitability and reduced risk of grain production in the Great Plains of the United States (Norwood 1994). Regehr and Norwood (In Press) have reviewed the importance of atrazine to ecofallow and concluded, "At present, no other herbicide approaches the economic and biological advantages of atrazine." Indeed, Extension Weed Specialists report that nearly all the estimated 1 million ecofallow acres in rotations with corn or sorghum and wheat in Kansas, Nebraska, and Colorado are currently treated with atrazine (personal communication Dave Regehr, Kansas State Univ.; Bob Wilson, Univ. of Nebraska; Bob Klein, Univ. of Nebraska).

Increases in Erosion and Fuel Use if Conservation Tillage Decreases

In order to estimate the effect of increased tillage in fields now under conservation tillage on erosion losses across all U.S. corn, average erosion potential with no surface residue must be estimated for these soils. Because conservation tillage is more often practiced on highly erodible land (it is these HEL fields which must have Conservation Plans), fields now under conservation tillage are more vulnerable to erosion than most current conventional tillage fields, should tillage increase. In 1982, the National Resources Inventory indicated a national average total erosion rate on all cropland of 8 tons/acre (Natural Resources Conservation Service, 2001). By 1982 many farmers had reduced tillage so that 70% of all U.S. cropland was no longer moldboard plowed (Fawcett 1987). Much of this land received repeated tillage, resulting in less than 30% crop residue cover, but erosion would still be reduced compared to plowing. Thus, true erosion potential of cropland would be considerably greater than 8 tons/acre. Considering that land now under conservation tillage is inherently more vulnerable to erosion, 10 tons/acre is a conservative estimate of potential erosion on such land should it return to conventional tillage.

Using a 10 ton/acre average erosion rate potential for land now under conservation tillage, the average erosion rate for conventional tillage, mulch tillage and no-till on such land would be 10 tons/acre, 2.6 tons/acre, and 0.3 tons/acre. (100% x 10 tons; 26% x 10 tons; and 3% x 10 tons). Thus, farms switching from no-till to conventional tillage would increase erosion by 9.7 tons/acre. Farms switching from mulch tillage to conventional would increase erosion by 7.4 tons/acre. Farms switching from no-till to mulch tillage would increase erosion by 2.3 tons/acre.

In 2004, there were 15,817,795 acres of no-till corn and 13,438,132 acres of mulch tillage corn in the U.S. (Conservation Technology Information Center 2004). Table 3 contains estimates of the increases in annual soil erosion and fuel use in the U.S. under several tillage change scenarios which could occur if farmers lost important conservation tillage tools, such as the triazine herbicides. If farmers had to again rely more on tillage for weed control, these possible changes could occur: no-till farmers might switch either to mulch tillage or to conventional tillage; mulch tillage farmers might switch to conventional tillage. If all farmers reverted to conventional tillage, all soil erosion benefits and fuel conservation would be lost, with an estimated annual increase in soil erosion of 252 million tons and estimated annual increase in fuel use of 88.6 million gallons. Even a modest change scenario of ½ no-till acres converting to mulch tillage and ½ of mulch tillage acres converting to conventional tillage would result in an estimated annual increase in erosion of 68 million tons and increased fuel use of 28.4 million gallons.

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