IMPACT OF VEGETATIVE FILTER STRIPS ON HERBICIDE LOSS IN RUNOFF FROM SOYBEAN

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INTRODUCTION

Row crop producers have long relied on relatively intensive tillage practices in their overall production scheme. There are several reasons for tillage, including preparation of a smooth, uniform seedbed; elimination of weeds; and disposal of previous crop residues which could harbor plant pathogens and insects. However, clean tillage also has a number of disadvantages, especially increases in soil erosion. Reverting to a no-till production system can cut soil erosion losses by as much as 91% (12).

There has been a steady increase in the use of reduced tillage systems over the past 15 years. However, the Federal Food Security Act of 1985 has forced producers to quickly re-evaluate their overall tillage and production program and has mandated that soil erosion control measures be instituted within a specified period of time for any land susceptible to erosion. These measures range from terracing, contour plowing, and reduced tillage practices to elimination of crop production in favor of permanent vegetation, i.e. pastures or forests. Agricultural Stabilization and Conservation Service (ASCS) and Soil Conservation Service (SCS) personnel have actively worked with producers in efforts to arrive at workable conservation plans for each individual situation. In the southern states, one of the most popular choices of erosion control for slightly to moderately sloping land has been the establishment of permanent grass filter strips at intervals down the slope. These filter strips are 2 to 4 m in width and are composed of various perennial grass species. Water movement is slowed substantially as it moves across these grassy strips, and the sediment load is greatly reduced. This option has been popular in that producers may continue to use conventional tillage programs between these strips in order to reduce the incidence of weeds, diseases, and insects, while at the same time reducing soil erosion losses.

Vegetative filter strips can effectively reduce sediment and nutrient load from edge-of-field runoff waters (1). These filter strips have been particularly useful in trapping sediments and nutrient contaminants from feedlot runoff (8). In a number of instances vegetative filter strips are considered viable options in Best Management Practices (BMP) selection (2). Producer acceptance of these filter strips has been good, but establishment and management techniques are yet to be clearly defined (9). In addition, a recent publication has called for generation of basic information on the impact of filter strips on chemical and sediment loads in movement from field edges to streams (1).

Soybean producers in the southern states primarily rely on conventional tillage systems in their overall production plans. Currently, 18% of the soybean acreage in Mississippi is under some type of conservation tillage practice (17). However, interest in doublecropping soybeans behind wheat (Triticum aestivum L.) has increased each year (10), and over 40% of doublecropped soybeans are now grown in some form of conservation tillage program (17). Doublecropped soybeans have shown the greatest net return over monocrop systems in either conventional tillage or no-till systems (13). Doublecropped soybeans in either tilled or no-till systems coupled with grass border strips can potentially produce greater net returns, while at the same time reduce overall soil erosion losses. However, even though soil erosion is limited in these cropping systems, the question remaining is whether herbicide loss in runoff is affected. Some studies have shown that herbicide losses increase with tillage (11, 16), whereas others have reported decreases (3, 18). These differences have been attributed to many factors including soil type, antecedent soil moisture, and rainfall intensity. Increasing plant residue on the soil surface has been cited as a factor for increasing alachlor loss (11) due to extensive washoff of herbicide from the crop residue.

A wide variety of herbicides are available to control most, if not all, of the weeds encountered in southern soybeans. Residual herbicides in the chloroacetamide and triazine families are widely used in both conventional tillage and conservation tillage soybean production systems. They are exceptionally well suited for use in reduced and no-till production systems because of their residual activity in soil and lack of need for incorporation. However, the production systems in which these herbicides are used can have a significant impact on their efficacy, persistence, and movement. Straw residue on the soil surface results in less soil reception of metribuzin (4), oryzalin (5), and alachlor (6). A significant portion of these herbicides remained on the straw after as much as 1.3 cm of rainfall.

In order to accomplish the goal of optimal weed control in a soil conservation program, increased reliance on chemical means of weed control is necessary (14). While the benefits of soil conservation programs have already been noted, a new series of concerns now emerge, particularly those associated with environmental contamination through off-site movement in air, soil, and water.

RESEARCH OBJECTIVES

Pesticide contamination of surface waters has become an increasing concern in the past several years, due in part to increased environmental awareness by the general public and several widely publicized incidents of contamination. In Mississippi and the Southern Region, more than 75% of soybean and cotton acreage is treated with some type of soil-applied herbicide. These herbicides are applied to the soil prior to emergence of crops and weeds and are therefore vulnerable to movement in surface runoff through both aqueous and sediment phases.

The Federal Food Security Act of 1985 has forced producers to evaluate production practices from an erosion control standpoint. On moderately sloping land one common recommendation has been the use of permanent grass filter strips which act as traps for sediment. In slight to moderate erosion situations, these filter strips can substantially reduce sediment loss. Grass filter strips have also been evaluated as a potential mechanism to reduce animal waste and water contaminants from feedlots. However, little information is available as to the effect these strips have on off-site movement of herbicides in runoff.

In this research, the potential for contamination of surface waters through agricultural runoff by two prominent soil-applied herbicides will be evaluated. These herbicides will be applied to plots using conventional tillage practices with soybeans planted in a monocrop and doublecrop (behind soft red winter wheat) production program. Additional plots will have no-till soybean production following winter wheat. Herbicide loss from each of these three soybean cropping systems will be evaluated with and without the presence of tall fescue filter strips. Research results will provide information on potential herbicide losses from various tillage systems and will also indicate the overall ability of these grass filter strips to reduce losses. These results will provide key information which can be utilized in recommending conservation programs which reduce sediment losses while eliminating or reducing the potential for off-site movement of herbicides.

MATERIALS AND METHODS

This research was conducted at the Black Belt Branch Experiment Station near Brooksville, MS on established standard (4.5 m by 22 m) soil erosion plots in 1991 and 1992. Plots are bordered with a metal strip to exclude outside runoff, and each plot is equipped with a 15 cm H-type flume. Filter strips consisted of 2.8 m strips of tall fescue (Festuca arundinacea Schreb.). Six soybean plots were used in this research, and treatments included:

1. No-till monocrop soybeans
2. No-till monocrop soybeans with grass filter strip
3. Conventional tillage monocrop
4. Conventional tillage monocrop with grass filter strip
5. No-till (doublecropped behind wheat)
6. No-till (doublecropped behind wheat) with grass filter strip

Metribuzin (0.42 kg ai/ha) and metolachlor (3.4 kg ai/ha) were applied immediately after soybean planting. Paraquat at 0.84 kg ai/ha was also applied to no-till plots in order to kill existing vegetation at planting. Plots were maintained free of weeds after soybean emergence by hand hoeing as necessary.

A rainfall simulator patterned after that described by Bubenzer (7) and Shelton, et al. (15) was used to supplement natural rainfall in order to guarantee a minimum of 5 cm of rainfall at 2-week intervals for a total of 10 weeks. Units are mounted on wheels so they can be moved from plot to plot. Therefore, creation of rainfall events can occur on all plots within a single day. All runoff was collected from each plot and quantified. Composite samples were then obtained and stored immediately at 5°C. Subsequent to the final runoff event, all samples collected were analyzed by the researcher using appropriate GC technology. Residues were determined with a lower detection limit of 250 and 100 ppt for metolachlor and metribuzin, respectively. These concentration values were then combined with the total runoff from the plot in order to determine total loss of each herbicide per runoff event on a per hectare basis and subsequently total yearly loss due to off-site movement in runoff. Regression analysis will be used to describe loss patterns across the tillage system-border strip combinations and will also be used to determine significant differences between these systems.

RESULTS AND DISCUSSION

Total rainfall for the sampling period in 1991 and 1992 was 217 mm and 354, respectively. In 1991 and 1992, the highest total runoff occurred when monocrop soybean was planted no-till, and the lowest runoff occurred when monocrop soybean was planted conventional till with a grass filter strip. In 1991, the rainfall season was 60 days after planting (DAP), and in 1992 it was extended to 110 DAP. Each herbicide was evaluated for loss in runoff water after each runoff event.

The no-till monocrop soybean production system in 1991 lost approximately 2% of the total metribuzin applied without a filter strip, but when a filter strip was present, loss was reduced to levels less than 1% of the total applied (Figure 1). In 1992, metribuzin loss was near 8% of the total amount applied when a filter strip was not used; however, when a filter strip was present, losses were reduced to approximately 2%. The tilled monocrop soybean tillage practice with and without a filter strip had similar losses in 1991 when compared to the no-till monocrop system (Figure 2). When the soil was tilled and a filter strip was not present, approximately 2% of the total amount applied was lost in runoff, but losses were less than 1% of the applied when a strip was present. The 1992 results indicate that without the use of a filter strip a loss of approximately 3% of the total applied occurred, and the presence of a filter strip reduced losses to approximately 2%. The doublecrop production system in 1991 resulted in less than a 1% loss of the total amount applied both with and without the presence of a filter strip (Figure 3). However, in 1992 metribuzin losses were approximately 8% of the total amount applied when a filter strip was not present, and approximately 7% loss was noted when a filter strip was used.

Metolachlor loss patterns were very similar to metribuzin patterns in 1991 and 1992. Metolachlor losses from the no-till monocrop soybean were approximately 2% of the total amount applied (Figure 4). With the presence of a filter strip, losses were reduced to less than 1%. In 1992, metolachlor losses were 5% of the total amount without a filter strip, but when a filter was present, losses were reduced to approximately 2%. The tilled monocrop soybean cropping system had basically the same amount of metolachlor lost in 1991 as the no-till monocrop production system (Figure 5). However, in 1992 approximately 3% of the total amount applied was lost both with and without the filter strip. The no-till doublecrop soybean system in 1991 lost less than 1% of the total amount of metolachlor applied, with or without a filter strip (Figure 6). However, in 1992 losses were much higher, with approximately 5% of the total amount applied lost without a filter strip; when a filter strip was present, loss was reduced to approximately 4%.

SUMMARY

In 1991, the no-till doublecrop soybean production system lost less than 1% of the total amount of metribuzin and metolachlor in runoff, compared to more than 2% with a tillage program which did not utilize a vegetative filter strip. However, in 1992 a filter strip reduced the amount of metribuzin and metolachlor lost throughout the growing season in both no-till and tilled monocrop production systems. Higher losses in 1992 were due to an earlier initial runoff event. This reduces time for degradation and absorption to plant residue or adsorption to soil.

REFERENCES

1. Aull, G. H., III. 1980. Cropland, buffer, and stream: A case study in agricultural nonpoint source water pollution. Ph.D. Dissertation, Michigan State University.

2. Baker, J. L. and H. P. Johnson. 1983. Evaluating the effectiveness of BMPs from field studies. p. 281-304 in Agricultural Management and Water Quality. Iowa State University Press. Ames, IA.

3. Baker, J. L., J. M. Label, and H. P. Johnson. 1978. Effect of tillage systems on runoff losses of pesticides, a rainfall simulation study. Trans. Am. Soc. Agric. Eng. 21:886-892.

4. Banks, P. A. and E. L. Robinson. 1982. The influence of straw mulch on the soil reception and persistence of metribuzin. Weed Sci. 30: 164-168.

5. Banks, P. A. and E. L. Robinson. 1984. The fate of oryzalin applied to straw-mulched and nonmulched soils. Weed Sci. 32:269-272.

6. Banks, P. A. and E. L. Robinson. 1986. Soil reception and activity of acetochlor, alachlor, and metolachlor as affected by wheat (Triticum aestivum), straw, and irrigation. Weed Sci. 34:607-611.

7. Bubenzer, G. D. 1979. Inventory of rainfall simulators. Proc. Rainfall Simulator Workshop. USDA-SEA, ARS-W-10:120-130.

8. Cartmell, E. C. 1973. Grass-filter systems -- another new runoff control method. Feedlot Management. 15:42.

9. Dillaha, T. A., J. H. Sherrard, and D. Lee. 1989. Long-term effectiveness of vegetative filter strips. Water Environ. and Technol. 1:419-421.

10. Edwards, N. and E. G. Morrison. 1982. Effect of straw management, tillage, and planter design on yield of soybeans planted after wheat - a progress report. Miss. Agric. For. Exp. Stn. Res. Rep., Vol. 7, no. 12.

11. Felsot, A. S., J. K. Mitchell, and A. L. Kenimer. 1990. Assessment of management practices for reducing pesticide runoff from sloping cropland in Illinois. J. Environ. Qual. 19:539-545.

12. Griffith, D. R., J. V. Mannering, and J. E. Box. 1986. Soil and moisture management with reduced tillage. Pages 19-57 in M. A. Sprague and G. B. Triplett, eds. No-Tillage and Surface-Tillage Agriculture. John Wiley and Sons, New York.

13. Hairston, J. E., J. O. Sanford, J. C. Hayes, and L. L. Reinschmiedt. 1984. Crop yield, soil erosion, and net returns from five tillage systems in the Mississippi blackland prairie. J. Soil Water Cons. 39:391-395.

14. Shaw, D. R. and H. P. Rainero. 1990. Weed control in soybean under different cropping and tillage systems. J. Prod. Agric. 3:in press.

15. Shelton, C. H., R. D. von Bernuth, and S. P. Rajbhandari. 1985. A continuous-application rainfall simulator. Trans. Am. Soc. Agric. Eng. 28:1115-1119.

16. Smith, C. A. 1990. Runoff and persistence of soil-applied alachlor and imazaquin. M. S. Thesis, Mississippi State University.

17. Spurlock, S. R. and S. K. Misra. 1989. Acreage allocated to conservation tillage practices in Mississippi. Miss. Agric. For. Exp. Stn. Bull. 957.

18. Sukolapong, W., L. L. Whatley, and C. E. Snipes. 1985. Herbicide runoff with different tillage systems. Proc. South. Weed Sci. Soc. 38:443.

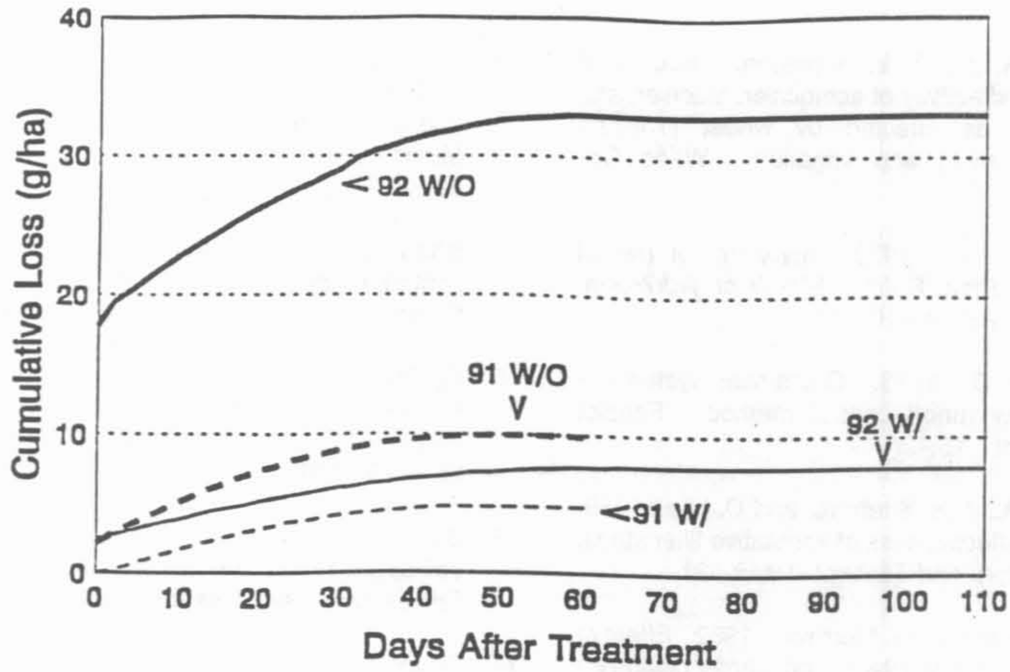

Figure 1. Influence of filter strip on metribuzin in runoff from no-till monocrop soybean in 1991 and 1992.

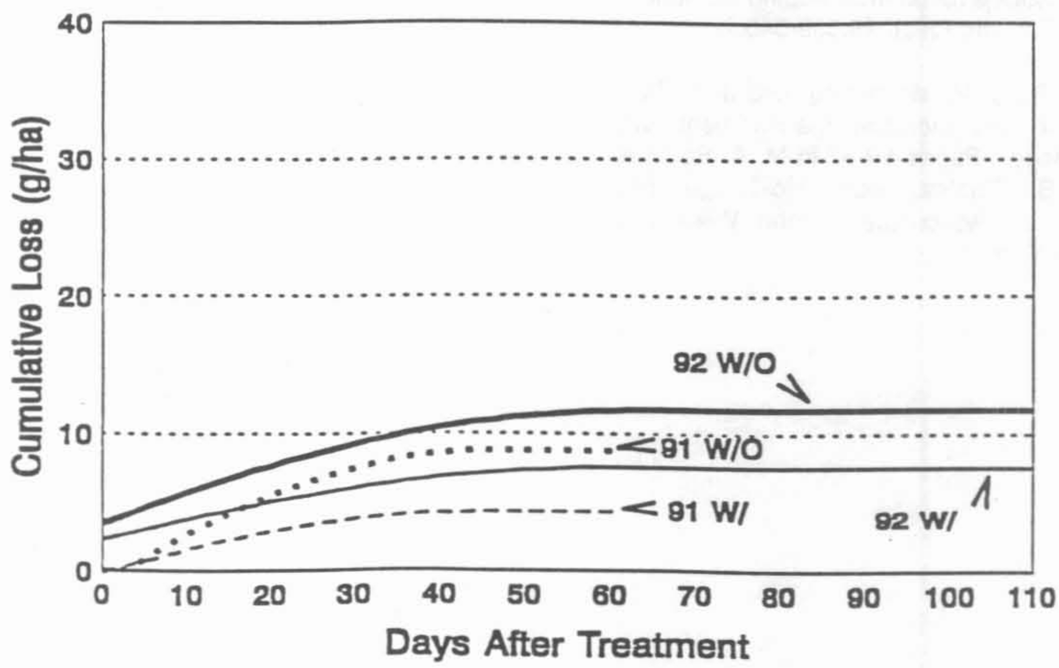

Figure 2. Influence of filter strip on metribuzin in runoff from tilled monocrop soybean in 1991 and 1992.

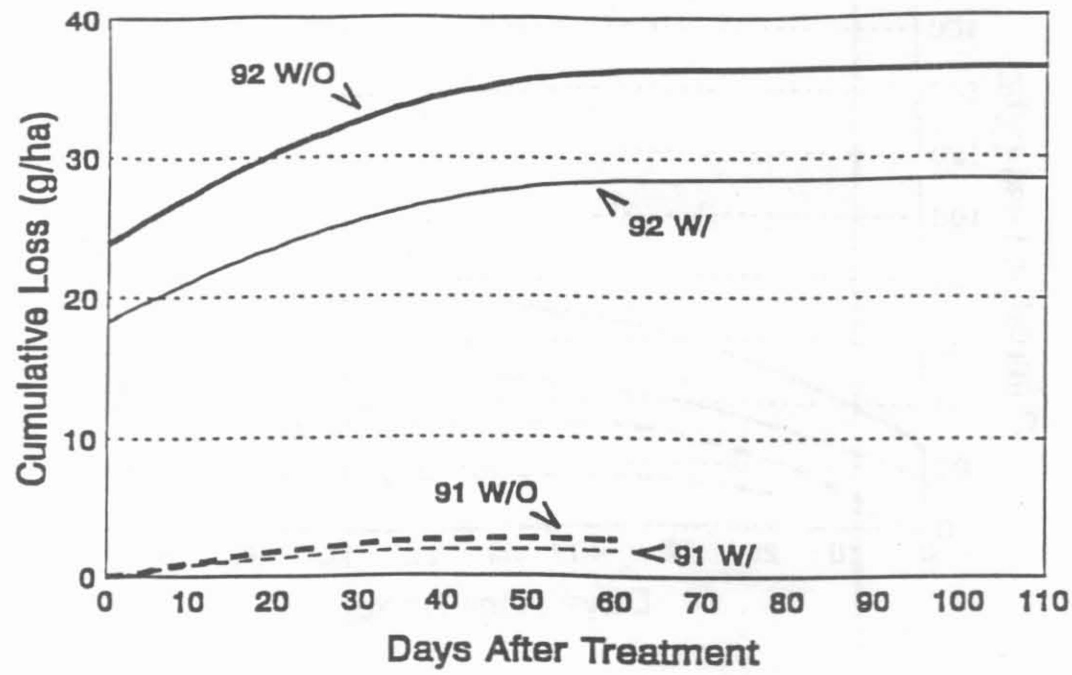

Figure 3. Influence of filter strip on metribuzin in runoff from no-till doublecrop soybean in 1991 and 1992.

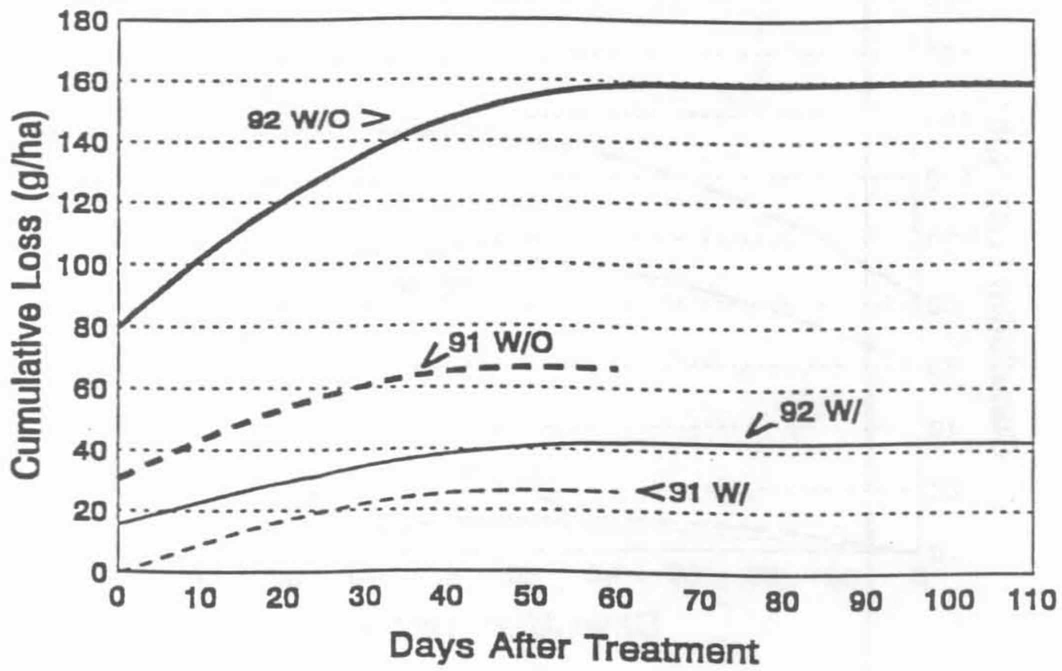

Figure 4. Influence of filter strip on metolachlor in runoff from no-till monocrop soybean in 1991 and 1992.

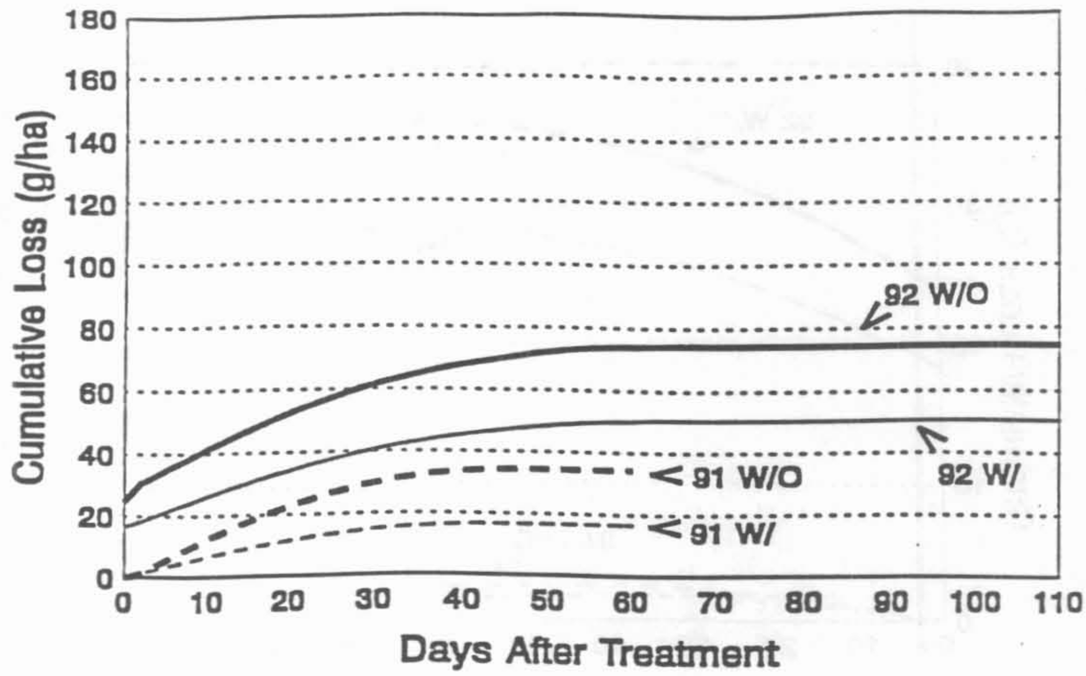

Figure 5. Influence of filter strip on metolachlor in runoff from tilled monocrop soybean in 1991 and 1992.

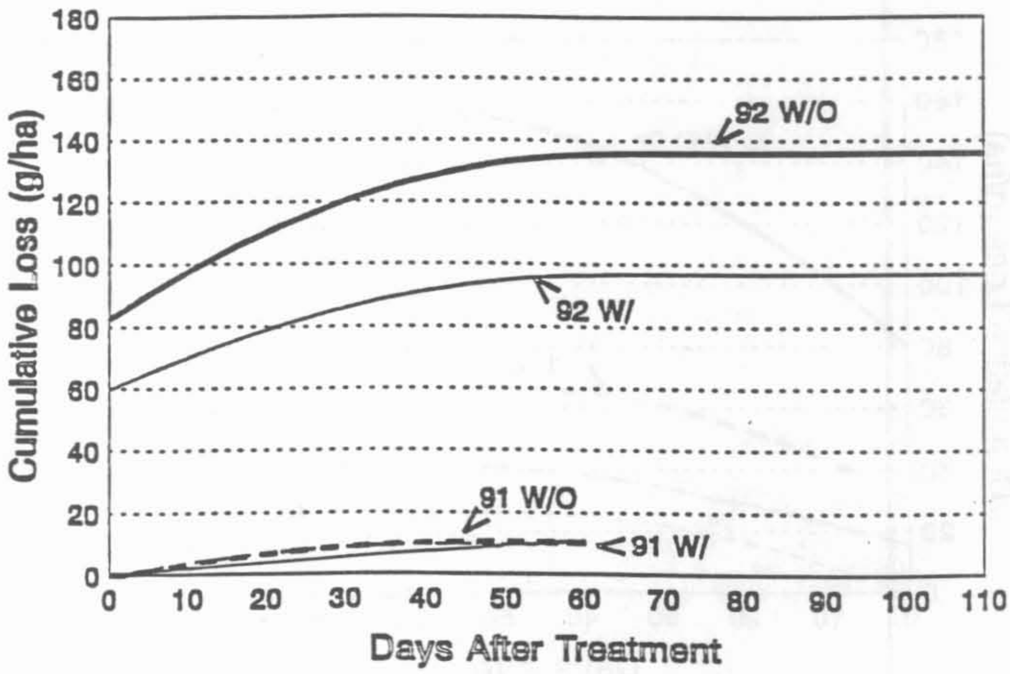

Figure 6. Influence of filter strip on metolachlor in runoff from no-till doublecrop soybean in 1991 and 1992.