COMPARATIVE COST AND EFFECTIVENESS OF POLYACRYLAMIDE AND STRAW MULCH ON SEDIMENT LOSS FROM FURROW IRRIGATED POTATOES

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Abstract

Polyacrylamide and straw mulch were used to reduce soil erosion on furrow irrigated potatoes. The PAM rate started out at 1 lb/ac per irrigation, then in the second irrigation of the wheel rows the rate was reduced to 0.2 lb/ac. The rate was increased to 0.5 lb/ac for all subsequent irrigations. Wheat straw was applied at 930 lb/ac. Over 16 irrigations, the untreated furrows lost a total of 47.6 tons/ac of soil washed out as sediment. The straw mulched furrows lost a total of 9.5 tons/ac. The PAM treated furrows lost a total of 18.0 tons/ac. Straw mulching decreased the amount of sediment loss by 80 percent, while PAM decreased the amount of sediment loss by 62 percent. Techniques are discussed to improve the effectiveness of both methods of erosion reduction.

During 16 irrigations straw mulching increased water infiltration from 33.7 to 54.9 percent of applied water, while PAM increased the infiltration to 36.8 percent.

Introduction

Polyacrylamide, otherwise known as PAM, has recently been used to reduce soil erosion. Polyacrylamide is a class of polymers made of long chains of acrylamide molecules. PAM has been used for many years in waste-water treatment, water purification plants, paper production, and as a settling agent for food processing and packaging.

Directly applied to water, PAM binds the soil together so the water does not break off soil particles as easily as the water advances down the furrow. PAM also acts as an agent to settle already suspended particles of soil. It gathers and carries sediment to the bottom of the furrow, instead of off the field. Using PAM, soil erosion has been reduced by 20-95 percent (Lentz et al. 1992).

Mechanically applied straw mulch has been effective in reducing sediment loss in Malheur County under furrow irrigation in the last few years. Straw mulching is very laborious and time consuming when done by hand, but there are machines on the market that work very effectively. Straw mulch is applied to the bottom of the furrow and acts as an agent to slow down water in the furrow. By slowing down the water in the furrow, the soil is not as easily eroded and the larger wetted area in the furrow bottom improves infiltration (Bert, 1984; Brown, 1985; Brown and Kemper, 1987; Brown et all 988; Carter, 1976).

Procedures

Our experiments were conducted on a potato field with 27 plots, each plot 3 hills wide and 250 feet long. The potatoes were planted in hills 12 inches tall and 36" apart. The Russet Burbank seed pieces were planted on April 29 at 8 inches deep and 9 inches apart. Each piece weighed approximately 2 ounces. The furrows of 12 plots were strawed before the first irrigation, and 12 plots were non-strawed. Straw mulch was applied mechanically (Hobson Mulching System, Hobson Manufacturing Inc., Ontario, OR). In addition there were three non-strawed PAM plots. For the three plots treated with PAM (Superfloc® A-836 Flocculant, Cytec Co.), there were 12 comparison plots that were non-strawed and untreated. The slope on this field was 3 percent. Water was applied at approximately 3 gal/min in each furrow. Inflow and outflow readings were taken at approximate one-hour intervals for every irrigation, Imhoff cones were used to determine the amount of sediment loss at the same time as the outflow readings were taken.

Granular matrix sensors (Watermark Soil Moisture Sensor Model 20055, Irrometer Co., Riverside, CA) were placed both 70 feet from the top and bottom of 10 plots. Sensors were installed 4 inches from the middle of the top of the hill and placed at the 8-inch depth, with 4 per plot. Two sensors were also placed at 16 inch depths in two replicates of each treatment. Sensors were read daily at 8 a.m. starting June 21 using a 30 KTCD meter (Irrometer Co., Riverside, CA) that had previously been calibrated to soil water potential (Eldredge et al., 1993).

To apply PAM to the furrows, granular PAM was dissolved in water to a concentration of 0.02 to 0.1 percent. The PAM solution was applied directly into the irrigation water before it advanced down the furrow. In such a small experiment, the solution for each furrow was held in a 5-gallon nurse tank and was applied into the irrigation water. Gated pipe was arranged so that all plots were irrigated during each irrigation set, but the duration of irrigation in the non-mulched furrows was longer due to slower water infiltration rate. The crop was irrigated using alternating furrow irrigation. Wheel rows were irrigated first, then non-wheel rows. On the first irrigation of each furrow in this field, we applied PAM at 1 lb/ac. PAM was applied at 0.2 lb/ac to the wheel rows during the third irrigation. On the fourth (and subsequent) irrigations, PAM was applied at 0.5 lb/ac.

Water and Sediment Measurement

Onset of water inflow and water outflow, and measurements of water inflow rate, water outflow rate, and sediment yield were recorded during each irrigation. Water inflow rates were recorded and outflow rates were recorded for the irrigated furrow next to the center hill in each plot. For each water outflow rate reading, a 1-liter sample was placed in an Imhoff cone and allowed to settle for 15 minutes. Sediment content in the water, y in g/l, was found to be related to the Imhoff cone reading after 15 minutes (x) by the equation:
$y = 1.015x$
$r^2 = 0.98$
$p < 0.0001$.

Composite water samples were collected in 5-gallon buckets to obtain sediment samples for nutrient analysis during each irrigation. Sediment was analyzed for nitrate-N, ammonium-N, total N, phosphate-P, and total P.

Total inflow, outflow, infiltration, and sediment loss were integrated from field measurements using a Lotus Improv program "InfilCal 5.0" (Shock and Shock, 1993).

Results

The potato crop emerged and grew normally. Irrigations began on June 1. The very large total applied water per acre to alt treatments in this field was due to furrow length, only 250 feet. Shorter irrigation durations were needed to maintain adequate soil water potential for plots with furrow mulching or PAM. Hence less total water was applied on the straw and PAM plots (compare Table 1 with Figures 1 and 2).

In the untreated check plots, a large proportion of the applied water was lost as runoff (Table 3,Figures 3 and 4). The use of PAM shifted the fate of water towards infiltration rather than runoff. Furrow mulching was even more effective in enhancing infiltration and reducing runoff.

Both PAM and furrow mulching were effective at reducing total sediment loss (Figures 5,6, and 7, Tables 2 and 3).

Discussion

Limitations of this trial

During the first irrigation of the wheel-traffic furrows, more sediment was lost from the strawed furrows than was expected (Figure 5). The straw-mulching machine may have aggravated this soil loss, because too much weight was placed on the press wheels during straw application. The pointed press wheels left a narrow crease in the bottom of the furrows. During the first irrigation, the water tended to follow the narrow crease creating a channel below the straw, aggravating soil loss. Furrow mulching technique is evidently as important as the material and machinery.

During the second irrigation of the PAM plots in the wheel-traffic furrows, the PAM rate was reduced to 0.2 lb/ac and the product was applied evenly over the irrigation duration, rather than at the beginning. Erosion control with PAM failed during the second irrigation of the wheel rows (Figure 5, Table 2) and left a narrow channel that probably increased soil losses and decreased water infiltration during subsequent irrigations of the wheel-traffic furrows. The success of the PAM treatments in the non-wheel-traffic furrows reveals their promise and the partial failure in the non-wheel rows emphasizes the need for application technology. The PAM applied during the first irrigation of the wheel rows was inadequate to protect these furrows during their second irrigation with a low PAM rate. During the second irrigation, the PAM rate should have been 0.5 lb/ac and applied mostly during the advance of the irrigation water.

Costs Of Application

The estimated cost of straw mulching is $56.75 per acre (Table 4). This includes the cost of tractor time, added labor, renting a straw mulching machine, and buying/delivery of straw at 800 lb/ac. Added inconveniences of straw would be that there could be no cultivation in the field after the straw was applied, and the buyer would have to contact someone to furnish baled straw.

The estimated cost of using PAM is $68.25 per acre (Table 4). This includes the cost of granular PAM, mixing it into a solution, and delivery. The inconveniences include setting up a system to apply the PAM, changing the rate of application, and monitoring the system for damage or clogging.

Potato economic return may more than offset the cost of furrow mulching with straw or applying PAM. Potato yield and/or quality responses are expected from better crop irrigation because potato is a crop highly sensitive to water stress.

Table 1. Effects of straw furrow mulching and PAM on the irrigation duration, total applied water, and average 8 am soil water

potential for furrow irrigated potatoes, Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1994.

	Irrigation records			Average soil water potential[‡]	
Erosion control treatment	Number	Duration	Applied water	8"[§]	16"
		hrs	ac-in/ac	------ kPa ------	
Check	16	587	116.5	-47	-27
Straw	16	504	99.1	-30	-17
PAM	16	540	106.6	-32	-22
LSD (0.05)	-	-	2.4	-15	-

‡ From June 24 to August 23, 1994

§ Based on the average value of 4 sensors in each of four check plots, four plots with strawed furrows, and 2 plots receiving PAM.

Table 2. Effects of straw furrow mulching or PAM on the sediment loss from furrow irrigated potatoes through eight irrigations of wheel-traffic furrows and eight irrigation of non-traffic furrows. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1994.

Sediment loss from wheel traffic furrows									
	Date of irrigation onset								
Erosion control treatment	6/1	6/15	6/28	7/5	7/11	7/18	7/26	8/10	Total
	---------- t/ac ----------								
Check	3.8	8.6	7.0	3.7	2.5	1.9	2.2	2.1	31.9
Straw	2.3	1.5	0.7	1.5	0.8	0.8	0.6	0.3	8.5
PAM	0.3	6.6	3.2	3.3	1.3	0.5	0.3	0.2	15.5
LSD(0.05)	1.8	2.9	3.8	1.8	0.8	0.5	0.8	0.2	5.9
Sediment loss from non-wheel traffic furrows									
	Date of irrigation onset								
Erosion control treatment	6/9	6/22	6/30	7/7	7/13	7/20	8/1	8/17	Total
	---------- t/ac ----------								
Check	0.3	2.3	5.0	2.8	2.5	1.3	0.7	0.7	15.7
Straw	0.0	0.0	0.1	0.3	0.3	0.1	0.1	0.0	1.0
PAM	0.0	0.7	0.9	0.3	0.3	0.1	0.1	0.0	2.5
LSD(0.05)	ns	1.7	1.4	1.5	0.6	0.5	0.3	0.3	1.5

Table 3. Effects of straw furrow mulching and PAM on the inflow, outflow, infiltration, sediment loss, percent runoff, and percent infiltration from furrow irrigated potatoes through 16 irrigations. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1994.

Erosion control treatment	Irrigation water applied			Percent runoff	Percent infiltration	Sediment loss
	applied	runoff	infiltration			
	------ ac-in/ac ------			----- % -----		t/ac
Control	116.5	77.3	39.2	66.3	33.7	47.6
Straw	99.1	44.8	54.3	45.1	54.9	9.5
PAM	106.6	67.4	39.2	63.2	36.8	18.0
LSD(0.05)	2.4	9.3	8.6	8.4	8.4	3.7

Table 4.

Estimated costs of furrow mulching with straw or using PAM season-long to reduce erosion from furrow irrigated potatoes. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1994.

Estimated cost of straw mulching	cost/acre
80 hp tractor 0.4 hrs/ac	$8.00
Mulcher use for one acre	$20.00
2 workers salary plus benefits for 0.4 hrs	$6.00
800 lb straw, $1.00/50 lb bale (production cost by user)	$16.00
Straw transport, $0.25/bale	$4.00
SUBTOTAL	$54.00
5 month interest at 1%/month	$2.75
TOTAL	$56.75

Polyacrylamide cost estimate	cost/acre
9 lb of raw material at $4.50/lb	$42.75
Mixing, delivery, services	$20.25
Equipment amortized	$2.00
SUBTOTAL	$65.00
5 month interest at 1% /month	$3.25
TOTAL	$68.25

Figure 1. Soil water potential at 8-inch depth in potato hills. Furrow-irrigated potatoes were treated with furrow mulching, PAM in the irrigation water, or an untreated check. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1994.

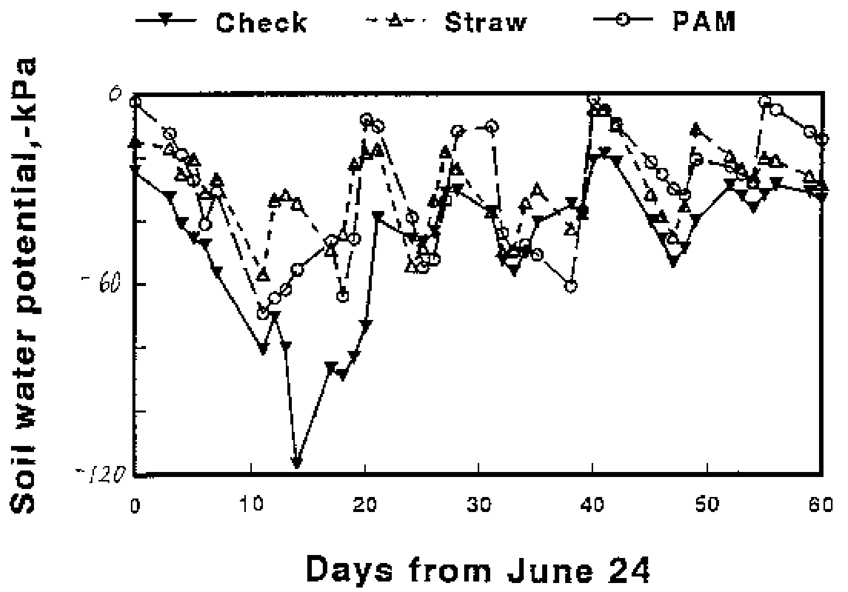


Figure 2. Soil water potential at 16-inch depth in potato hills. Furrow-irrigated potatoes were treated with furrow mulching, PAM in the irrigation water, or an untreated check. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1994

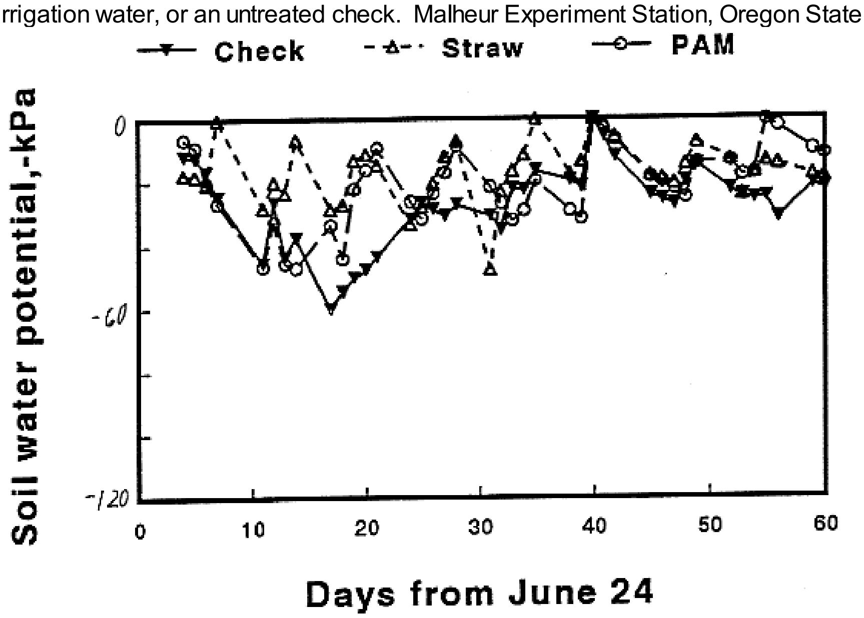


Figure 3. Effects of furrow mulching with straw or of PAM in the irrigation water on the water applied, runoff, and infiltration in furrow-irrigated potatoes. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1994

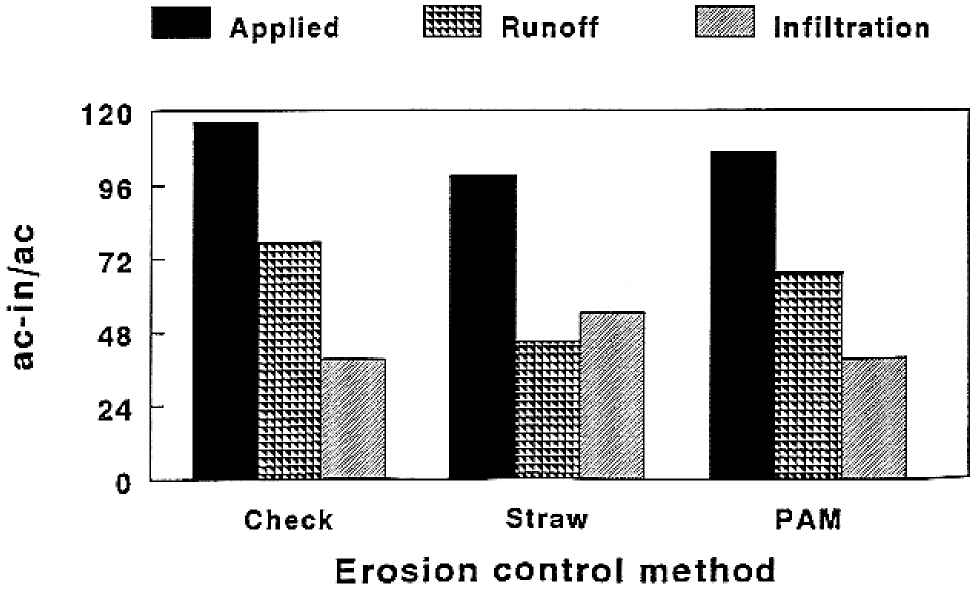


Figure 4. Effects of furrow mulching with straw or of PAM in the irrigation water on the water leaving the field as runoff or entering the soil as infiltration. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1994

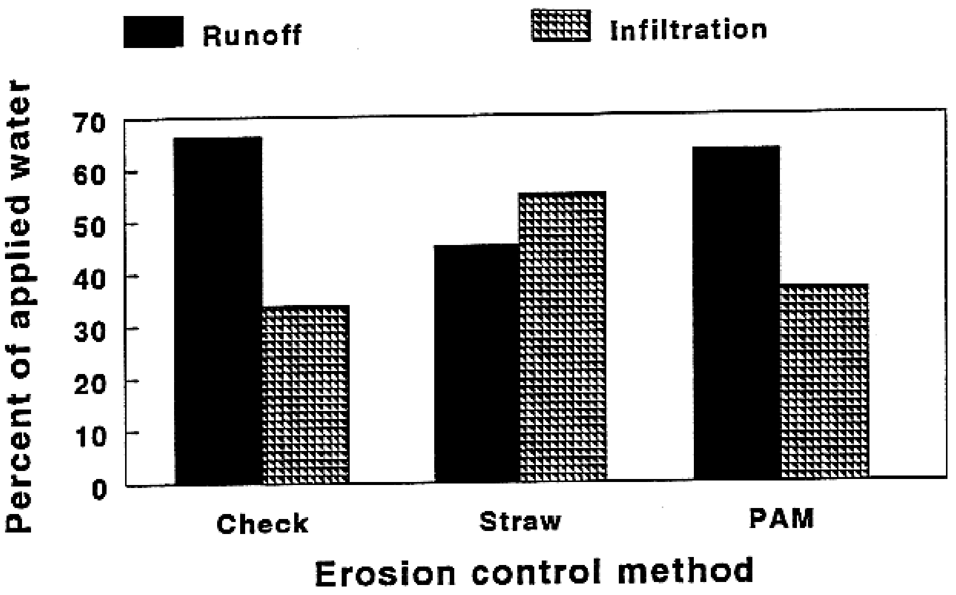


Figure 5. Effects of furrow mulching with straw or of PAM in the irrigation water on the sediment loss from wheel-traffic furrows during eight successive irrigations. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1994

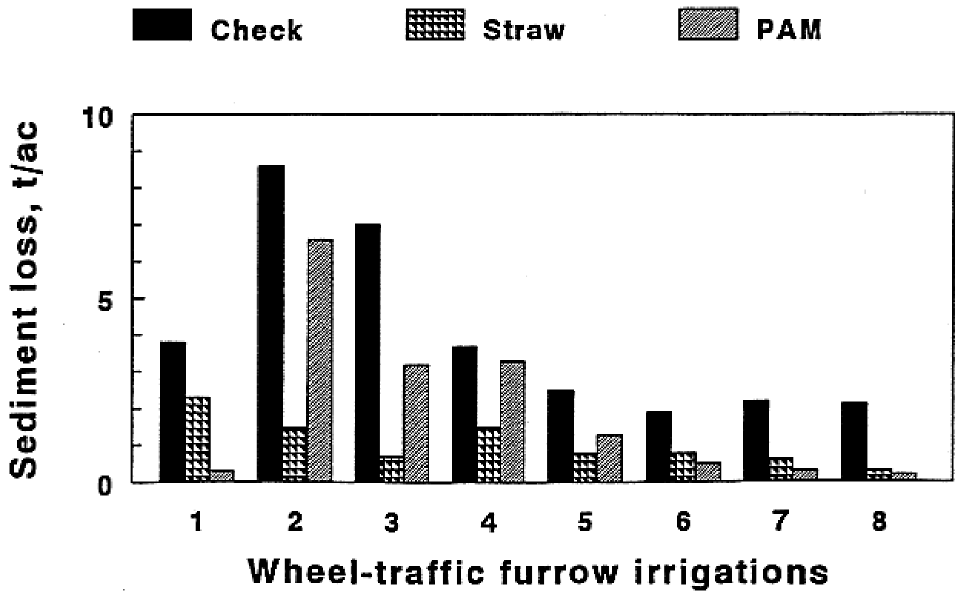


Figure 6. Effects of furrow mulching with straw or of PAM in the irrigation water on the sediment loss from non-wheel-traffic furrows during eight successive irrigations. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1994.

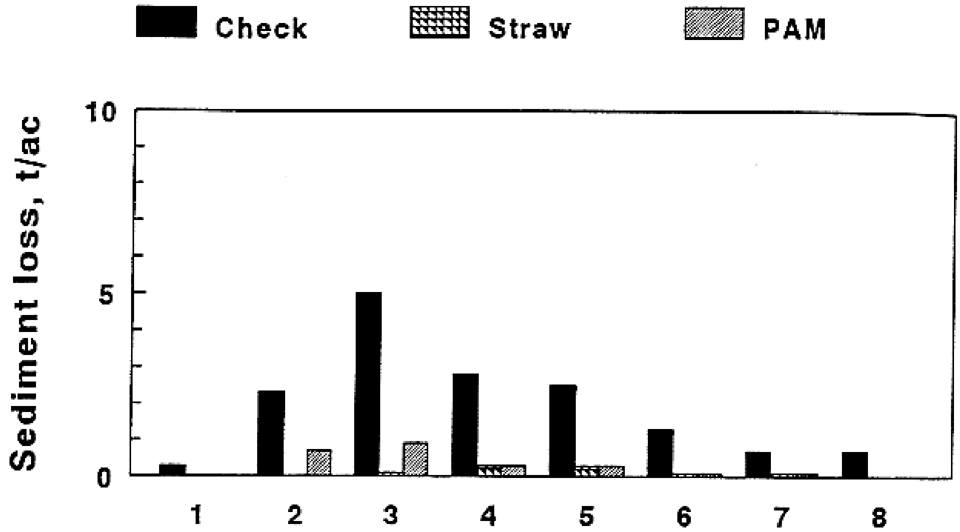
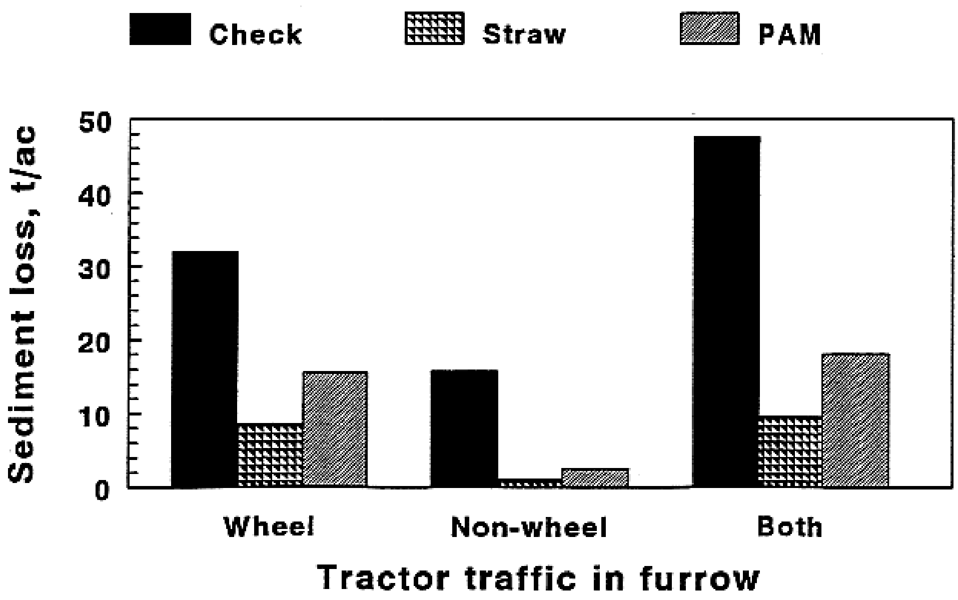


Figure 7. Reduction in season long sediment lost from furrow im'gations using furrow mulching with straw or using PAM in the irrigation water. Sediment losses are reported for wheel traffic furrows, non-wheel traffic furrows, and for both together. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1994.



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