Till-plant systems for reducing runoff under low-pressure, center-pivot irrigation

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ABSTRACT: Disk-disk-mulch harrowing, strip-rotary, and tri-level bed shaper till-plant systems were evaluated for their effectiveness in reducing runoff in continuous corn under high- and low-pressure, center-pivot sprinkler irrigation. The center-pivot system was modified to apply water at 55 psi at 0.5 inch/hour and at 20 psi at 1.5 inches/hour on alternate quarters of the circle. The low-pressure irrigation increased irrigation runoff 30% from combined till-plant systems. The strip-rotary till-plant system controlled runoff best, with 12% of the growing-season rainfall and less than 4% of the irrigation water lost as runoff. The effect of water pressure on stored soil water and yields was significant when runoff exceeded 5% of the applied water by sprinkler irrigation. Corn grain yields were not influenced by the effectiveness of till-plant systems to control runoff, but rather by their effectiveness in controlling volunteer corn. Corn grain yields declined 1.3 bushels/acre for every 100 pounds/acre of volunteer corn dry matter produced. Runoff and soil erosion as well as volunteer corn were controlled best by the least amount of tillage and surface-layer incorporation of harvest losses before planting.

CENTRAL Great Plains farmers have installed self-propelled, center-pivot systems on nearly 80% of the sprinkler-irrigated lands in the region. (7). Such systems have several major advantages compared with surface irrigation: labor savings, relatively large aerial coverage, automation, and reduced land preparation.

In Colorado center-pivot systems are in use on more than 90% of the sprinker-irrigated land (7). Most of these systems are on the High Plains of eastern Colorado. Expanded use of center-pivot, sprinkler systems occurred in the 1950s and 1960s when groundwater supplies were presumed inexhaustible and energy resources were abundant and inexpensive.

The center-pivot irrigation systems were designed initially to apply water at pressures of 60 to 85 pounds/square inch for proper sprinkler operation and uniform water distribution. But large amounts of energy are required to operate the systems at these pressures. The 1973 oil embargo and subsequent oil and gasoline shortages increased substantially the price of all energy resources (9). Increased pumping energy costs, falling water tables, and relatively low crop prices emphasize the need for reducing energy requirements in pump irrigation.

The easiest way to reduce energy use is to reduce operating pressures of the sprinkler systems (5, 6). This can be done by first redesigning the pump and well systems and then replacing high-pressure impact sprinkler heads with either low-pressure impact heads or spray nozzles. Low-pressure nozzles produce larger water droplets that can break down soil aggregates and crust and compact the soil surface. The radius of coverage also decreases, and application rates must be doubled or tripled over those with high-pressure impact nozzles. The increased application rates and soil surface compaction associated with low-pressure systems can increase the potential for runoff and soil erosion on some soils.

Operators can reduce potential runoff by using rainfall and soil moisture storage to design capacities for center-pivot systems that result in a lower capacity requirement and lower application rates than designs based on peak-use rates (4). Also, operators can increase the rotation speed of a center-pivot system to reduce the application rate and potential runoff.

Addink and associates (2) showed that designing the application rate pattern to match the soil intake rate reduced runoff as much as 11%. Shallow basins constructed between rows of sugarbeets or potatoes reduced runoff and increased yields (1). Maintaining plant residues on the soil surface helps to increase surface-water retention and infiltration and to reduce runoff (3, 8).

Surface residues are best maintained with herbicides used in conjunction with reduced tillage or no-till systems. Our study was initiated to develop till-plant tillage systems and evaluate their effectiveness for controling runoff and weed growth in continuous corn established under both low- and high-pressure sprinker irrigation. Herein, we report the results of 3 years of research on till-plant systems and their effects on soil water storage, runoff, weed control, and corn yields.

Study methods

We conducted the study on Platner loam soil, a fine montmorillonitic, Aridic Paleustoll at the Central Great Plains Research Station near Akron, Colorado. The site was disk-tilled to remove sod in 1980 and planted to corn. An irrigation well with a static water level at 103 feet and a capacity of about 160 gallons/minute provided water for a five-tower, center-pivot sprinkler system. The 1980 and 1981 corn crops were irrigated with the high-pressure impact sprinklers. In 1982 we modified the sprinkler system to apply water at nozzle pressures of 55 and 20 psi on alternate quarters of the circle. Hydraulic valves controlled the flow through the high-pressure impact and spray nozzles. The valves were actuated by water pressure through a two-way pressure valve that was, in turn, ac-

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tuated by a solenoid energized by a mercury switch riding on a stationary cam at the pivot center.

We designed the nozzle sizing and spacing of both types of heads along the pivot line for a wetted pivot radius of about 520 feet, covering an area of 19 acres, with a maximum application of 1.0 inch of water/revolution. The application rate per revolution was comparable to that of a standard pivot, which is 2.5 times the length of the pivot we used. The application rate, however, was considerably less than what occurs at the end of a 1,300-foot pivot. Nevertheless, our application rates exceeded soil intake rates; thus, we still could evaluate the relative effectiveness of the cultural treatments.

We established main tillage plots, 330 feet long and 150 feet wide, in 1981 on each quarter of the pivot circle to provide four replications. We used a split-plot block design with two herbicide treatments as subplots. In 1982 and 1983 we irrigated alternate replications around the pivot circle with high- and low-pressure nozzles.

The three tillage treatments were conventional, Orthman till-plant, and strip-rotary till-plant. Corn stalks from the previous crop were shredded before till-planting on each treatment. The conventional tillage treatment involved disking twice and mulch treading once or twice before row-crop planting. Some crop residues remained on the soil surface following conventional tillage.

The Orthman tri-level bedder has a shovel at the junction of two V-shaped moldboards. The shovel forms a furrow 5 inches deeper, and the moldboards create a ledge where the crop is planted as well as building a 5-inch ridge of residue and soil above the ledge between alternate rows of corn. The bedder normally is used after conventional tillage on graded land designed for furrow irrigation. For our study we adjusted the tool to eliminate a deep furrow, but still removing enough soil to ridge the crop residue between alternate rows of corn. Each of three tri-level bedders on a toolbar had a pair of row-crop planter units mounted immediately behind to plant the corn seed at the base of both sides of the trash ridge. The trash ridge served as a temporary storage for rainfall and applied water. However, the area between the trash ridges in this treatment was clean and smooth, allowing little surface deterrent to potential runoff.

The strip-rotary treatment also was a minimum tillage situation—a rotary tiller implement with a row-crop planter attached behind the tiller. We removed all but a few knives to till a strip about 6 inches wide and 3 inches deep ahead of each planter unit. The area between rows was left essentially undisturbed.

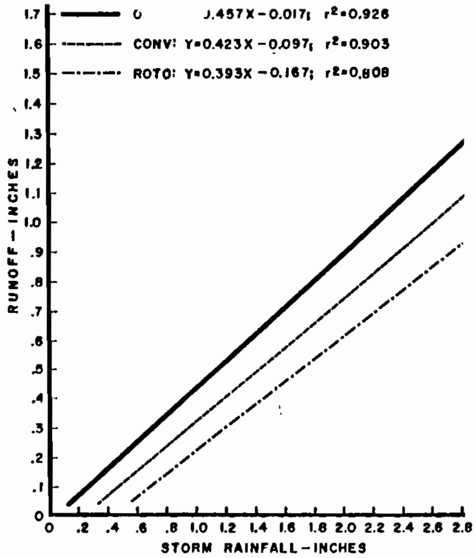

Figure 1. Rainfall runoff as affected by three till-plant systems for continuous corn, 1982-1983.

We split the main tillage plots into two weed control systems, A and B. In system A we applied atrazine at 2 pounds active ingredient/acre as a preemergence treatment each year, a practice used by many Colorado farmers who plant continuous corn. System B was an intensive herbicide practice including a mixture of 1 pound active ingredient/acre of atrazine plus 2.5 pounds active ingredient/acre of alachlor applied preemergence, followed by a postemergence mixture of 0.5 pound active ingredient/acre of 2,4-D plus 0.25 pound active ingredient/acre of dicamba when corn was about 6 inches tall. Corn was not cultivated during the growing season.

We applied N to all treatments at rates of 100 pounds N/acre in 1981 and 150 pounds N/acre in 1982 and 1983 before planting corn. We planted a single cross variety of corn with a 95-day maturity rating in 30-inch rows at a rate to obtain about 24,000 plants/acre. The population was lower than usual for irrigated corn in order to match the water requirement of the crop to the yield capacity of the well.

We oriented runoff plots, 75 feet long and 30 feet wide, in tillage plots in a high-pressure and a low-pressure quadrant on slopes averaging 3.8%. Plots were bordered with galvanized sheet-metal strips and equipped with 2-inch trapezoidal flumes and stage recorders to monitor runoff from rainfall and irrigation. We set up the runoff instrumentation following the preemergence herbicide application but before the start of the irrigation season. A recording rain gauge in each quadrant measured intensity and timing of irrigation application and rainfall. We ran regression analysis on 2 years of rainfall and runoff data. We set up water collectors at 10-foot intervals extending in two lines radially outward from the center, each through one high-pressure and one low-pressure quadrant. The collectors were made from two 4¼-inch plastic funnels sandwiched within a piece of 4-inch PVC sewer pipe cemented between two

Table 1. Growing season rainfall and runoff from continuous corn plots as affected by three till-plant systems.

Date	Storm Rainfall (inches)	Maximum 30-Minute Intensity (in/hr)	Runoff* (inches)		
			Orthman	Rotary	Conventional
1982					
7-14	0.25	0.50	0.12	0.06	0.05
7-15	.44	.88	.29	.18	.22
7-26	1.28	1.37	.63	.27	36
8-09	.49	.53	.16	.04	.08
8-13	2.80	3.31	1.27	1.09	1.48
9-14	.57	.35	.11	.00	.00
Growing season total	8.51	—	2.58	1.64	2.19
1983					
6-26	0.75	0.89	0.25	0.00	0.12
6-27	.35	—	.06	.00	.05
6-28	.34	.20	.17	.00	.00
7-10	.87	1.44	.31	.03	.21
7-16	.45	.27	.19	.04	.02
7-17	.46	.46	.08	.00	.02
7-22	1.27	2.06	.57	.10	.44
7-23	.43	.42	.27	.00	.03
7-26	.88	1.61	.35	.06	.28
Growing season total	6.61	—	2.25	0.23	1.17
Growing season average	7.56		2.42	0.94	1.68
Percent loss			32.0%	12.4%	22.2%

*Runoff values are averages of two plots.

4-inch PVC couplings.

We determined gravimetric soil water content at planting and harvest. Sampling was done at 1-foot intervals to a depth of 5 feet within six subareas per herbicide plot. We sampled total dry matter of planted and volunteer corn on the same sites from three rows, 8 feet long. We measured surface residues only in 1983 at four sites around each runoff plot. We evaluated weed control at harvest by counting the number of weeds in ten 12.5-square-foot areas of each plot.

Results and discussion

Rainfall runoff. We installed the runoff plots in June of 1982 and 1983 after all herbicides had been applied. Six storm events produced runoff in 1982; nine in 1983 (Table 1). The 1983 storms, however, were less intense than those in 1982, and runoff was, therefore, less.

Rainfall runoff was least on the strip-rotary system. For the period of measurement, runoff on this treatment was 12% of rainfall—44% less than that on the conventional tillage plot and 61% less than runoff on the Orthman till-plant plot. We attributed more than 80% of the variation in runoff for any tillage treatment to rainfall amounts (Figure 1). The runoff rate of 0.39 inch/inch of rainfall after the first 0.43 inch of rainfall occurred was lowest for the strip-rotary till-plant system. Runoff from the Orthman till-plant system occurred shortly after the start of rainfall and increased at the average rate of 0.46 inch/inch. Runoff from the conventional tillage treatment occurred after 0.23 inch of rainfall, with a runoff rate of 0.42 inch/inch.

Irrigation runoff. We irrigated the corn eight times at 0.67 inch/revolution in 1982 and ten times at 0.92 inch/revolution in 1983. Water was applied both years at 0.5 inch/hour with the high-pressure nozzle and 1.5 inch/hour with low-pressure nozzles. Converting from high- to low-pressure nozzles increased irrigation runoff by an average of 30% for all tillage treatments (Table 2).

The strip-rotary till-plant system reduced irrigation runoff to less than 4% under the low-pressure application and less than 1% under the high-pressure application (Table 2). This treatment provided the best control of runoff from both irrigation and rainfall. The Orthman till-plant treatment provided the least control of irrigation runoff; losses 40% and 34% from the low- and high-pressure applications, respectively. Annual irrigation runoff from the conventional tillage treatment was 21% and 18% from the low- and high-pressure applications, respectively.

Table 2. Annual irrigatio[illegible] from continuous corn as affected by sprinkler nozzle pressures and till-plant systems.

Nozzle Pressure (psi)	Mean Application (inches)	Intensity (in/hr)	Annual Runoff							
			Orthman		Rotary		Conventional		Mean	
			inches	(%)	inches	(%)	inches	(%)	inches	(%)
55	0.78	0.5	2.43	(33.5)	0.06	(0.9)	1.16	(18.4)	1.22	(17.5)
20	0.85	1.5	2.93	(39.5)	0.32	(3.9)	1.53	(20.5)	1.59	(20.7)
Mean	—	—	2.68	(36.5)	0.19	(2.5)	1.35	(19.5)	—	

Table 3. Crop residues on the soil surface near planting time in 1983 as affected by tillage treatment.

Quadrant	Surface Residue (pounds/acre)			
	Orthman	Strip-Rotary	Conventional	Mean
High-pressure	2,140	6,490	4,620	4,420*
Low-pressure	1,850	6,090	2,270	3,400a
Tillage mean	1,995a	6,290c	3,440b	3,910

*Numbers with same letter within quadrant or tillage means are not significantly different at the 5% level.

Table 4. Total soil water at corn planting and corn grain yields as affected by herbicide treatment and method of till-planting.

Year	Tillage Treatment and Herbicide Treatment					
	Conventional		Orthman		Strip-Rotary	
	A*	B*	A	B	A	B
Soil water in top 5 feet at planting						
	inches					
1981	10.4	10.4	11.3	10.9	11.2	9.3
1982	6.6	6.7	6.4	6.4	6.7	7.4
1983	10.1	10.0	8.9	8.9	9.8	10.1
Mean	9.0a†	9.0a	8.9a	8.5a	9.2a	8.9a
Tillage mean	9.0a		8.7a		9.1a	
Corn grain yields						
	pounds/acre					
1981	5,690	5,330	5,310	5,610	5,830	5,610
1982	1,950	1,190	3,670	3,950	3,190	3,160
1983	3,310	3,100	4,720	5,060	5,080	4,670
Mean	3,650a	3,210a	4,570a	4,880a	4,700a	4,480a
Tillage mean	3,430a		4,720b		4,590b	

*Weed management systems: A = 2 pounds/acre atrazine applied preemergence; B = 1 pound/acre atrazine plus 2.5 pounds/acre alachlor applied preemergence, and 0.5 pound/acre 2,4-D plus 0.25 pound/acre dicamba applied postemergence.

†Numbers with same letter for a weed management system or a till-plant system are not significantly different at the 5% level.

Irrigation and rainfall runoff losses in 1983 were a function of the amount of surface crop residue in each tillage treatment (Table 3). The strip-rotary till-plant method had the highest amount of crop residue remaining on the surface after corn establishment—three times the Orthman till-plant treatment and 1.8 times the conventional tillage plots. Disking the conventional tillage area incorporated about half of the original residue, leaving sufficient surface residue to reduce significantly runoff over the Orthman till-plant system. Crop residue was effective in reducing runoff because runoff losses (Table 1) were inversely proportional to the amount of residue remaining on the soil surface (Table 3).

Soil water. Annual precipitation was at or above normal over the 3-year period. The winter of 1981-1982, however, was very dry. Only 1.2 inches of precipitation occurred over a 5-month period beginning in December—a third of normal—and is reflected in the total soil water content at corn planting (Table 4).

Plant-available soil water storage to the 5-foot rooting depth is about 6.2 inches, about 70% of which is available for plant consumption. In 1981 soil profile storage at corn planting time was near field capacity. In 1982 profile storage was less than 50%, but two 0.5-inch preseason irrigations increased storage to about 60% of capacity. In 1983 favorable winter precipitation filled the profile to 90% of water-holding capacity. The tillage systems or herbicide treatments did not affect the amount of stored water at planting significantly.

Crop yields. Table 4 presents corn grain yields as affected by herbicide and tillage treatment. Herbicide treatment did not influence grain yield in any year. Yields were highest and most uniform across all treatments in 1981, the first year of treatment establishment, when we used high-pressure sprinkler irrigation across all replications throughout the growing season and with favorable stored soil water at planting. Yields were highest on the strip-rotary till-plant system in 1981, but differences due to tillage were not significant.

We observed no irrigation runoff from the strip-rotary till-plant system. There was runoff from the other two systems, particularly the Orthman treatment. These observations were confirmed by actual runoff measurement in 1982 and 1983.

The tillage systems, however, did not have the same effect on corn yields in 1982 and 1983. In those years the Orthman till-plant system produced significantly greater yields than the conventional tillage treatment, but only slightly higher yields than the strip-rotary plots. We associated the yield increases with volunteer corn production.

Weed control. Although the weed management systems did not affect soil water availability or corn grain yields (Table 4), the most effective weed control resulted from the more intensive herbicide treatment. Over the 3-year period, plots with intensive herbicide treatment had 50% fewer weeds than plots with conventional herbicide treatment. The spectrum of weed species was diverse. Redroot pigweed (*Amaranthus retroflexus* L.), skeletonweed [*Lygodesmia juncea* (Pursh) D. Don], and field sandbur (*Cenchrus insertus*, M. A. Curtis) were the most prevalent weeds. The most damaging weed to control was volunteer corn, which was not affected by either herbicide treatment.

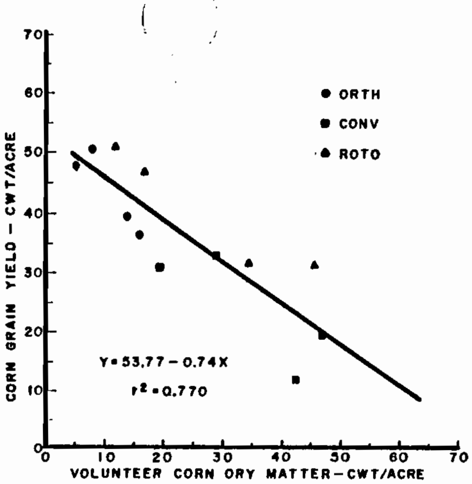

Figure 2. Effect of volunteer corn dry matter production on corn grain yields, 1982 and 1983.

Nozzle pressure effects. Table 5 summarizes soil water at planting, corn grain yields, and volunteer dry matter corn production as affected by tillage system and high- and low-nozzle pressure water application in 1982 and 1983. The total soil water content at corn planting was less on the low-pressure-application areas. Runoff losses also were greatest on the low-pressure areas. Soil water content at planting in the Orthman till-plant system was 10% less than that in either the conventional or the rotary till-plant systems. Again, we associated the soil water content with the significantly greater water runoff losses.

Corn grain yields under low-pressure irrigation also were significantly lower than the yields under the high-pressure irrigation. These yield differences decreased in the strip-rotary system, which had the best runoff control. Effective runoff control increases water availability and crop yields. However, this was not reflected in the average corn grain yields within a tillage treatment. Corn yields from the Orthman and rotary systems were 82% and 69% higher, respectively, than the yield from the conventional tillage treatment. We associated the differences with volunteer corn production (Table 5) rather than soil water or runoff differences.

Volunteer corn problems. Harvesting corn with a field combine results in some corn passing through the machine. The amount depends upon how efficiently the combine is operated. The 1982 volunteer corn crop resulted from inefficient work of a custom combine operator. In 1982 the station acquired a corn head for its own combine, and special attention was given to proper adjustment and operation of the combine. Thus, volunteer production in 1983 was less than half that in 1982 (Table 5). Nevertheless, volunteer corn reduced corn grain yields dramatically. While the volunteer corn never produced any grain, it competed for available water and reduced normal corn yield. The conventional tillage system, which incorporated all corn grain of the previous crop, had the highest production of volunteer corn and the lowest corn grain yields. The strip-rotary system produced significantly less volunteer corn than the conventional tillage treatment, and most of this growth occurred within the corn row that had been strip-tilled. The Orthman till-plant system had the least amount of volunteer corn and the highest corn grain yield because it concentrated all loose corn seed and ears in a residue pile in which germination was unfavorable.

Figure 2 illustrates the effect of volunteer corn production on corn grain yields. Grain yields declined 1.3 bushels/acre for each 100 pounds/acre dry matter volunteer corn production. We attributed more than 75% of the variation in corn grain yields to the variation in volunteer corn production. In practice, many farmers graze livestock on corn fields after harvest, which significantly

Table 5. Total soil water in 5 feet at planting, corn grain yields, and volunteer corn dry matter production as affected by till-plant system and sprinkler nozzle pressures.

	Tillage System and Nozzle Pressure					
	Conventional		Orthman		Strip-Rotary	
Year	High*	Low*	High	Low	High	Low
Soil water in top 5 feet at planting						
	inches					
1982	7.2	6.1	6.8	6.0	7.5	6.6
1983	9.7	10.4	9.6	8.2	10.2	9.7
Mean	8.5a†	8.2a	8.2b	7.1a	8.9a	8.1a
Tillage mean	8.3b		7.6a		8.5b	
Corn grain yields						
	pounds/acre					
1982	1,920	1,220	4,290	3,330	3,340‡	3,020‡
1983	3,300	3,110	5,080	4,710	4,820	4,930
Mean	2,610b	2,160a	4,680b	4,020a	4,080a	3,980a
Tillage mean	2,390a		4,350b		4,030b	
Volunteer corn dry matter						
	pounds/acre					
1982	4,060	4,880	1,490	1,510	3,960	4,030
1983	2,620	2,260	850	850	1,700	1,190
Mean	3,340a	3,570a	1,172a	1,045a	2,830a	2,610a
Tillage mean	3,460c		1,110a		2,720b	

*High pressure, 55 psi at 0.5 inch/hour; low-pressure, 20 psi at 1.5 inches/hour.
†Numbers with same letter for given water pressure level or till-plant system are not significantly different at the 5% level.
‡Corn variety was different in 1982 for the strip-rotary till-plant system due to unavailability of adequate seed supply.

reduces problems associated with volunteer corn. Where livestock grazing is not possible, volunteer corn can be controlled best by minimizing if not eliminating tillage operations that incorporate corn seed into the soil.

Conclusions

Converting a center-pivot sprinkler system from a high-pressure application of 55 psi to a low-pressure application of 20 psi increased irrigation runoff an average of 30% where continuous corn was produced on a 3.8% slope. Irrigation runoff was lowest with the strip-rotary till-plant system, in which water runoff losses were less than 4% and 1% under the low- and high-pressure application rates, respectively. Irrigation runoff for the conventional till-plant system was less than 20%, while water losses on the Orthman till-plant system were 40% and 34% for low- and high-pressure applications, respectively. Rainfall runoff losses were 12%, 22%, and 32% for the strip-rotary, conventional, and Orthman till-plant systems, respectively.

Runoff reduction was a function of the amount of corn residue remaining on the field surface. In 1983 seasonal runoff losses from rainfall and irrigation decreased 0.5 inch for each increase of 1,000 pounds of corn residue on the soil surface at the beginning of the growing season. We attributed about 70% of the variation in runoff to the corn residue on the soil surface.

Herbicide treatment had no significant effect on stored soil water at planting or corn grain yields. Weeds, however, were controlled best where both preemergence and postemergence herbicides were used. Application pressures affected stored soil water differences where water losses to runoff were the greatest. Corn grain yields also were affected by application pressures where seasonal runoff losses exceeded 5% of the irrigated applied water. When runoff was effectively controlled, as in the strip-rotary till-plant system, the effect of application pressures on stored soil water or corn grain yields were not significant.

Till-plant systems that effectively controlled volunteer corn produced the highest corn grain yields. Yields declined 1.3 bushels/acre for each 100 pounds/acre of dry matter production of volunteer corn. The Orthman till-plant system produced the least amount of volunteer corn and the highest corn grain yields. The conventional till-plant system had the highest volunteer production and the lowest corn grain yields, 40 to 45% less than the yields from the till-plant systems. Where post-harvest livestock grazing is not possible on corn fields, volunteer corn establishment can be reduced by using a minimum t. or no-till system.

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Impacts of a chemical dust suppressant/soil stabilizer on the physical and biological characteristics of a stream

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ABSTRACT: Commercially available chemical dust suppressants have been used by industry and government to control fugitive dust, particularly in the western United States. A number of these chemicals have been studied to determine their cost and effectiveness. With exception of Ca and NaCl, which are also used extensively for roadway deicing, and ligninsulfonates, waste products of the pulp and paper industry, the environmental effects of dust suppressants largely are unknown. Coherex, a petroleum resin dust suppressant/soil stabilizer, was accidentally introduced into a stream in southeastern Pennsylvania in May 1979. The chemical imparted a greenish-orange film to the water's surface and a pronounced tackiness to the stream bottom. Although the tackiness was present 3 days later, it was absent on the tenth day. Chemical analysis of stream bottom sediment revealed a sharp reduction in chemical concentration over the 7-day period. The fish and benthic macroinvertebrate communities in the affected reach were damaged, but both communities recovered within 10 days. This recovery was attributed to flushing of Coherex-laden sediment from the stream during peak flows.

FUGITIVE dust is particulate matter introduced into the atmosphere by any means other than a controlled release. Fugitive dust may be generated naturally through wind erosion; by wildfires; or by agricultural, construction, and mining activity. Such dust perhaps is most familiar to many as the result of travel on unpaved roads; in fact, unpaved roads are the major source of fugitive dust in the United States (*4*).

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Gerald A. Barnhart, Vaughn M. Douglass, A. Keith Megay, and Philip H. Slocum conducted the fisheries investigation. Jeffrey L. Nelson assisted in collection of the macroinvertebrate samples. Skelly and Loy Engineers and Consultants conducted the sediment chemical analyses.

In addition to water and waste crankcase oil commonly used to stabilize road or soil surfaces and thereby suppress fugitive dust, many different commercial chemical products are available for dust suppression (*2, 5, 11*). Municipal, state, and federal governments have used chemical dust suppressants and soil stabilizers widely to control roadway dust from construction, logging, mining, and other industries. Examples of successful roadway applications of Coherex in particular include use on construction sites in Illinois (*9*) and Oregon (*15*), coal mines in New Mexico (*8*) and Wyoming (*12*), and city streets and state highways in Oregon (*1*). Other uses unrelated to roadway dust control include reclamation of mined land, revegetation of slopes shaped during highway construction, and stabilization of mine tailings. Dust suppressant/soil