LOW PRESSURE SPRAY MODE AND TILLAGE MANAGEMENT FOR CORN

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ABSTRACT

Low pressure spray devices can be used to reduce operating costs but good management is necessary to insure benefits. The LEPA bubble mode performs well as long as reservoir tillage is used and ground slope is less than 1-2 percent. Reservoir tillage is somewhat effective in reducing runoff and holding water where it is applied. It is important to select a spray device with a large enough wetted diameter to minimize runoff and maintain corn yield.

INTRODUCTION

Low pressure (6-15 psi at the nozzles) sprinkler systems are becoming quite popular due to small operating costs caused by the reduced pressure requirements. This includes; 1) low pressure spray nozzles at tassel height 2) various combinations of in-canopy nozzle heights 3) various spacing distances and spray modes. Ground slope becomes very important as the pressure and resulting spray pattern is reduced. High application rates and interference of the crop canopy with the spray patterns can cause much runoff and non-uniformity (resulting in reduced yields). Reservoir tillage can help reduce runoff and hold water where it is applied. Poor design or management may cause growers to over-irrigate to compensate for runoff and non-uniformity. This could greatly reduce the benefits gained by low pressure. Some operating conditions may actually produce higher operating costs than would have been obtained with a medium pressure system. The systems studied had well capacities near 6 gpm/acre. Low pressure systems are easier to manage for low capacity wells due to low flow rates, however potential yield is greatly reduced.

Current research at Kansas State University and the University of Nebraska includes evaluation of Low Energy Precision Application (LEPA) sprinkler systems, low pressure in-canopy spray systems and above the crop low pressure spray systems. Several study sites have been monitored for performance over the last 2-3 years. This paper will summarize the performance of various systems and give general guidelines for management of low pressure systems.

KANSAS STATE UNIVERSITY RESULTS

Procedures

Two studies were conducted at the Southwest Research-Extension Center at Garden City. An in-canopy spray mode/tillage study was conducted on slope ranging up to 6% for three seasons (1990-1992). Spray mode treatments were flat spray and the LEPA "bubble" mode. Tillage treatments were; 1)conventional, 2)subsoil (rip), 3)basin till (furrow dikes) and 4)implanted reservoir (ripping and pitting). Irrigation amounts were kept between 0.75 and 1 inch. Berms (borders) were installed across the field to prevent water from one treatment from running onto any treatment further downhill. Irrigation amounts were 21.1, 16.7 and 8.5 inches for 1990, 1991 and 1992 respectively. Rainfall amounts during the growing season were 3.8, 8.0 and 13.3 inches for 1990, 1991 and 1992 respectively. Thus the total amount of irrigation and rainfall received during the growing season was 24.9, 24.7 and 21.8 inches for 1990, 1991 and 1992 respectively.

Another study was conducted for two seasons (1991-1992). In-canopy flat spray nozzle spacing was evaluated. Nozzles were generally 18 to 36 inches above the ground. Ground slope was near 1%. Spacing treatments were 5 feet and 10 feet in 1991. A 15 feet spacing treatment was added in 1992. This spacing is not very practical especially near the end of a pivot because the pressure requirement goes up to 20 psi to get enough flow for each nozzle. A 15 feet nozzle spacing in the canopy is not recommended, but was included to evaluate how the crop canopy interferes with the spray pattern.

Corn was planted in circular rows for both studies. The soil is a silt loam with good water holding capacity (2 inches/foot of available water). Irrigation was scheduled using climatic data. No corrections were made for "ineffective" rainfall (ie the full amount of rainfall was assumed to have been absorbed by the soil without runoff. The studies were irrigated to keep the depletion from exceeding 2 inches.

The depletion for the spray mode/tillage study was generally not allowed to go over 1-1.25 inches.

Soil water was monitored to a depth of 5 feet, weekly, in each plot for each study (except in 1991 for the spacing study). Forty feet of row was hand harvested from each plot. Yield was adjusted to 15.5% moisture and is reported in bushels per acre.

Results and Discussion

Yield results and average ground slope by treatment for the spray mode/tillage study are given in Table 1. The yield data can be slightly misleading because slope is an important factor. The average slope for bubble-mode plots (3.5%) was higher than slope for flat spray plots (2.3%) in 1990 and 1991 and resulted in lower yield for the bubble-mode plots. Treatments were re-randomized each year. Greater than average rainfall (11.9 inches from June through August for 1992--mostly small events as compared to the 30-year average of 7.6 inches), along with higher slope for the flat spray treatment, produced variable results with slightly higher yield for the bubble-mode plots.

Slope was more constant among tillage treatments since tillage treatments were laid out parallel to the slope. Differences in tillage and spray mode will be evaluated based on the 2-year averages for 1990-1991 because the unusually high rainfall for 1992 confounded the results. Therefore the 2-year averages from Table 1 is useful for comparing tillage treatments. Basin till dikes were installed poorly (smaller) in 1990 affecting the results slightly. There is little difference among tillage treatments when using the flat spray mode. Implanted reservoir showed large increases in yield (20 bu/a) when using the bubble mode as compared to the other tillage treatments. Basin till would have performed somewhat better had the dikes been installed better in 1990.

The soil water content at the time of subsoiling and implanting reservoirs, is important. Subsoiling is more effective when the soil water content is relatively dry. Soil that is too dry can present a problem of large clods (need for slower tractor speeds) and more damage to the root system. Subsoiling in wet soil will just make a small channel for water to run in, especially when the bubble mode is used. Crop rows should be run parallel to the slope whenever possible. Some growers prefer to apply a small amount of water (0.5 inch) in the flat spray mode immediately following subsoiling or implanting reservoirs for two reasons; 1)reduce plant stress due to cut or exposed roots and 2)help "set" dikes--wetting the soil and then allowing it to dry helps maintain soil structure and may preserve the surface storage longer.

Another way of looking at the data is to plot yield verses ground slope and draw the best fit lines through the data by tillage type. Only 1990 and 1991 data was used for this analysis. Figure 1 shows the data for the bubble mode and Figure 2 shows the data for the spray mode. This analysis gives a better picture of the effect of ground slope on yield. Notice that the slope of the lines are flatter for the spray mode (averages -12 bu per percent ground slope) than for the bubble mode (averages -24 bu per percent ground slope). The lines are relatively flat for the implanted reservoir treatment (-14 bu per percent ground slope for the bubble mode and -3 bu per percent ground slope for the flat spray mode).

Results from the in-canopy flat spray nozzle spacing study are given in Table 2. Little differences occurred in yield. This happened in 1992 due to the unusually high rainfall amount. Since this study had small ground slope (1 percent) this appears reasonable. Some concern should be given to slope greater than 1 percent based on the results from 1991 and from the spray mode/tillage study. Yield tended to be greater for the samples taken next to the nozzles for the wider spaced treatments than yield samples taken further away from the nozzles. Soil water data from 1992 can be used to support this concern. Figure 3 shows the average soil water content of the upper 5 feet of profile for the various treatments along with the precipitation and irrigation events.

UNIVERSITY OF NEBRASKA RESULTS

Runoff Tests

Runoff experiments were conducted near Alliance, Nebraska on August 6 and 8 of 1991. The outer three spans of a seven span center pivot were evaluated. The fifth span was equipped with LEPA devices set to the bubble mode. Nelson Spinners were placed 42 inches above the soil surface and were spaced 10 feet apart for the sixth span. The last span was equipped with Spinners placed just below the truss rod height of the pivot. The Spinners were spaced at about 17 feet for the seventh span. The pivot was nozzled for 800 gallons per minute. The soils at the site are classified as a Creighton very fine sandy loam with a 1 to 3% slope.

The field was planted in a circular fashion with 30 inch row spacings. Alternate eight-row widths were dammer-diked[1] to provide increased surface storage of irrigation and rain. The intermediate eight-row widths were conventionally farmed with no extra tillage following the final cultivation of the year. The tillage treatments were replicated three times under each span of the pivot. Runoff was measured for each replication under each span of the pivot. Measurements were made at a point approximately 300 feet from the crest of the hill. The upper reach of the runoff plot was 200 feet from the top of the hill. Thus the 100 foot long plots experienced both runoff and runon.

Results of the experiment are summarized in Figures 4 and 5. The average depth applied was 1.0 inches on August 6, and 0.7 inches on August 8. Both tests show that a considerable amount of runoff occurred. The depth of runoff represents the total amount of water that ran off of the plots. The runoff depth is expressed as the equivalent depth of runoff. Remember that water was allowed to run on to the 100 foot plot, thus the runoff could have occurred due to that applied by the pivot on that plot or due to water that ran onto the plot from land upstream of the plot.

Runoff on plots irrigated with the LEPA devices averaged 0.5 inches on August 6 and about 0.45 inches on August 8. These values represent the cumulative runoff from the entire 300 feet of the field above the measurement point. If the runoff is averaged for the entire 300 feet, the runoff on August 6 represents about 17% of the total application and on August 8 about 22% of the gross application. The numbers illustrate how runoff accumulates downstream. For the point just downstream of the runoff measurement the equivalent of 1.5 inches would be applied to the field instead of the 1.0 inches that the pivot was set to apply. We do not know how much water infiltrated at that point however. Clearly the bottom of the sidehill will receive substantially more water than the 1.0 inch application that the pivot should have applied there.

Runoff is less for the Spinners than the LEPA devices. The Spinners placed in the corn canopy produce more runoff than when the devices are placed above the crop canopy. It should be remembered that the Spinners that were placed above the canopy were on the last span of the pivot and that the LEPA devices were located on the fifth span. The application rate must increase along the pivot to apply equal amounts of water. Therefore the runoff values for the LEPA devices would be much higher for the seventh span.

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[1]Mention of trade names does not constitute endorsement.

The dammer-diker tillage did not significantly reduce runoff for our tests. The soil at this location is easily eroded and maintaining the dikes is difficult. Large rains early in the year, or earlier irrigations, severely eroded the dikes. Results in 1992 showed that runoff was worse when the field was dammer-diked. In this case, the dikes eroded completely, providing a channel for the water. Thus, finding ways to maintain the dikes appears to be very important. We are continuing the runoff measurements, but 1992 data has not been analyzed.

Spacing of Spinners

In 1992 we measured the soil water content in the top 12 inches of the soil before and after an irrigation. For this experiment a second center pivot was used. The soil was nearly flat in this case and there was very little if any runoff from the plots. The system we studied had Spinners placed 42 inches above the soil surface and spaced at 13 feet 9 inches. The field was planted to corn grown in straight rows. The experiments were conducted at a location so that the center pivot lateral was perpendicular to the direction of the rows.

We measured the water content in each of 21 rows and at three locations between successive rows. Remember that the Spinners were spaced at 13' 9" apart which is equivalent to 5.5 of the 30 inch rows. The change in soil water content across the 21 rows is shown in Figure 6. Clearly there is a pattern to the distribution of water. The 13' 9" spacing is clearly too wide for this application. We will continue to evaluate spacing criteria for various devices in the future.

CONCLUSIONS

Low pressure spray devices require good design up front to avoid runoff and poor uniformity problems. All spray devices should be designed to apply water at a rate that is less than the rate the soil can absorb water. A true LEPA system should be designed to have no runoff from an irrigation--ie the volume of applied water should be less than the volume of surface storage available. In-canopy nozzle spacing should be limited to 10 feet or less and limited to ground slope less than 1-2 percent. Nozzle spacing greater than 10 feet in the canopy may result in poor water distribution, runoff and reduced yield.

Table 1. Average corn yield (bu/ac) and field slope for spray mode and tillage treatments (1990-1992). The two year average (1990-1991) is used for analysis since high rainfall in 1992 confounded results. Letters denote significant differences at the 0.05 level. Data taken at the Southwest Research-Extension Center, Garden City, KS. The least significant difference (LSD) for spray mode treatments was 37.6 bu/ac and the LSD for tillage treatments was 14 bu/ac.

	Bubble Mode		Flat Spray		Average	
	Yield (bu/ac)	Slope (%)	Yield (bu/ac)	Slope (%)	Yield (bu/ac)	Slope (%)
1990						
Conventional	168	3.3	211	2.2	190	2.8
Basin Till	175	3.4	214	2.4	194	2.9
Subsoil	176	3.2	225	2.5	200	2.8
Implanted Reservoir	204	3.8	226	2.8	215	3.3
Average	181	3.4	219	2.5		
1991						
Conventional	146	3.9	217	2.1	182	3.0
Basin Till	151	3.3	232	2.1	191	2.7
Subsoil	142	3.6	222	2.1	182	2.8
Implanted Reservoir	169	3.7	231	1.8	200	2.8
Average	152	3.6	225	2.1		
1992						
Conventional	213	2.1	190	2.7	202	2.4
Basin Till	209	2.2	212	2.5	211	2.4
Subsoil	204	2.5	200	2.4	202	2.5
Implanted Reservoir	210	2.2	181	2.6	195	2.4
Average	209	2.2	196	2.6		
2-year average (1990-1991)						
Conventional	157	3.6	214	2.2	186B	2.9
Basin Till	163	3.4	223	2.3	193B	2.9
Subsoil	159	3.4	223	2.3	191B	2.9
Implanted Reservoir	187	3.8	228	2.3	208A	3.1
Average	167B	3.5	222A	2.3		

Table 2. Corn yield, bu/ac, by position for various in-canopy flat spray nozzle spacings. "Next" refers to samples taken from the row directly adjacent to nozzles in a particular spacing treatment. "Outside" refers to samples taken from the row furthermost from nozzles in a particular spacing treatment. "Middle" refers to samples taken from the row between the closest and furthermost rows in the 15 feet spacing treatment. Data taken at the Southwest Research-Extension Center, Garden City, KS.

Spacing Treatment	Row Position Inches From Nozzle	1991 (bu/ac)	1992 (bu/ac)	Average (bu/ac)
5 ft	15	205	183	194
10 ft next	15	218	198	208
10 ft outside	45	205	195	200
15 ft next	15	---	195	195
15 ft middle	45	---	197	197
15 ft outside	75	---	191	191

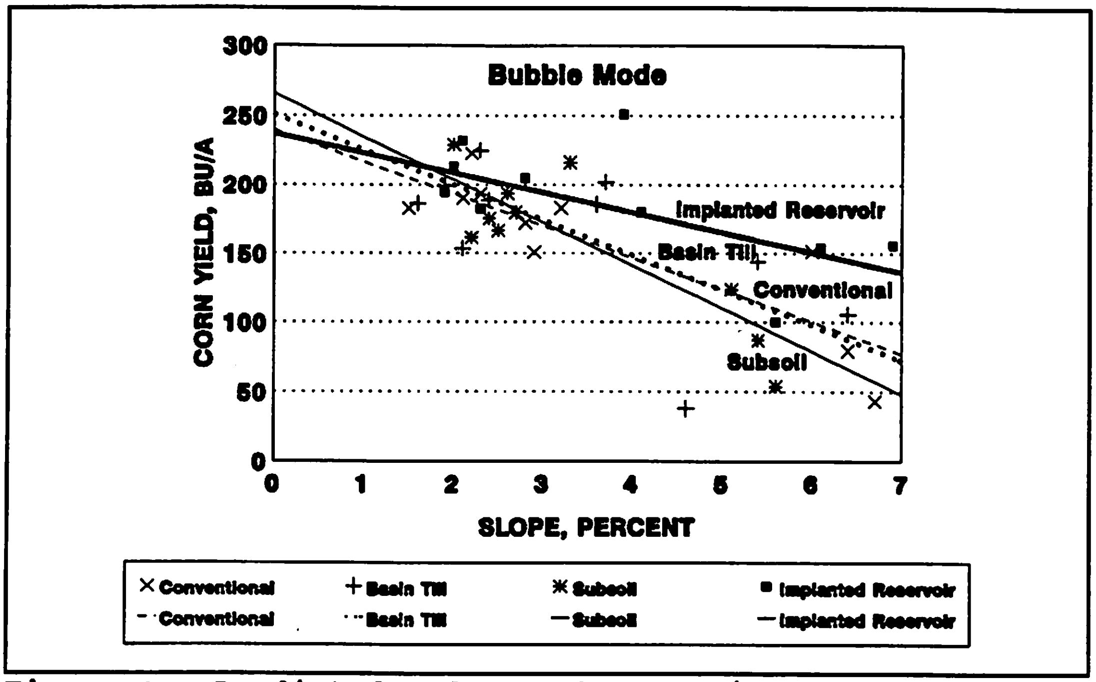

Figure 1. Predicted and actual corn yield (1990-1991) as a function of ground slope for LEPA nozzles in the bubble mode. Spray mode/tillage study at the Southwest Research-Extension Center, Garden City, Kansas.

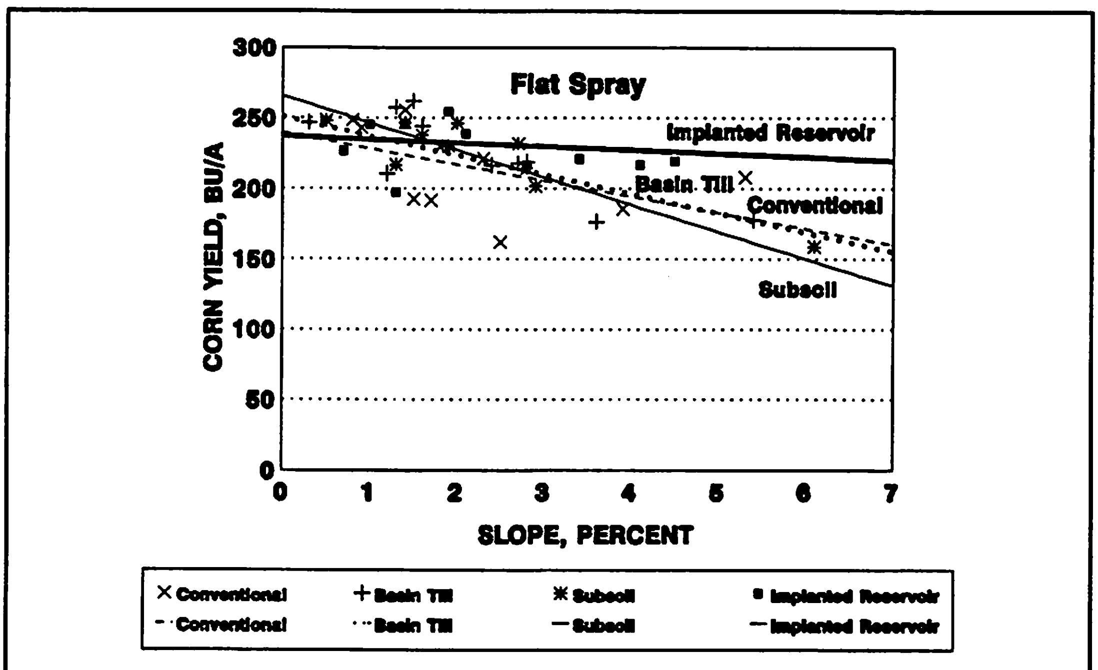

Figure 2. Predicted and actual corn yield (1990-1991) as a function of ground slope for LEPA nozzles in the flat spray mode. Spray/mode tillage study at the Southwest Research-Extension Center, Garden City, Kansas.

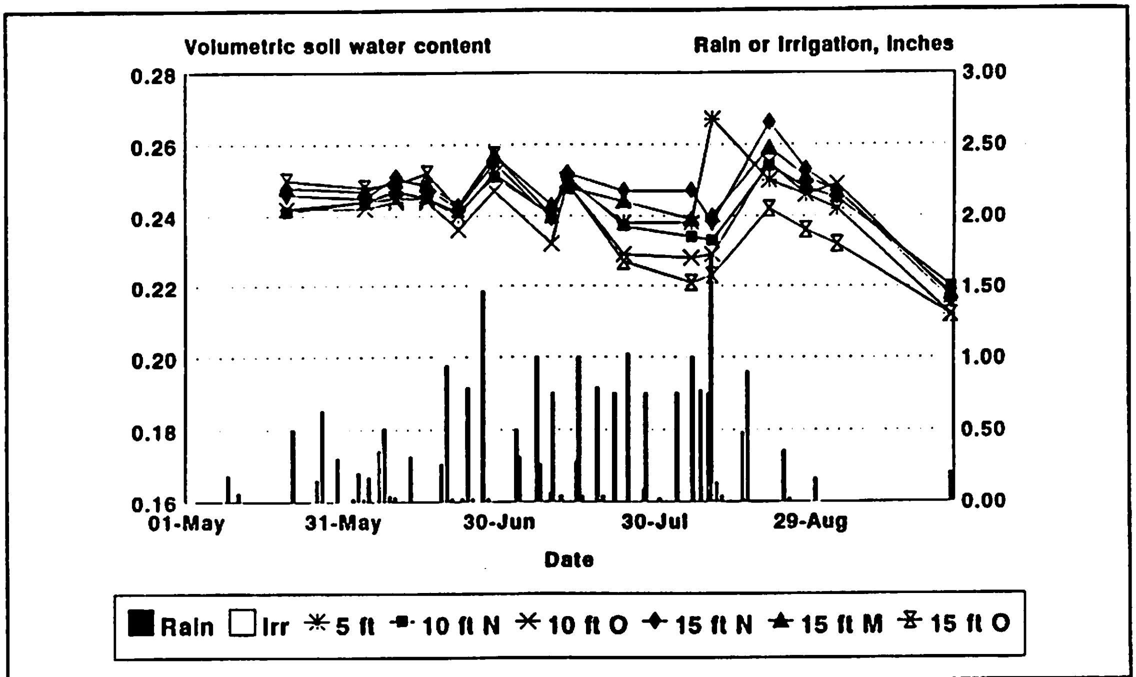

Figure 3. Average soil water content of the upper 5 feet of soil verses time for various locations for in-canopy nozzles spaced 5, 10 and 15 feet. Data taken at the Southwest Research-Extension Center, Garden City, KS in 1992.

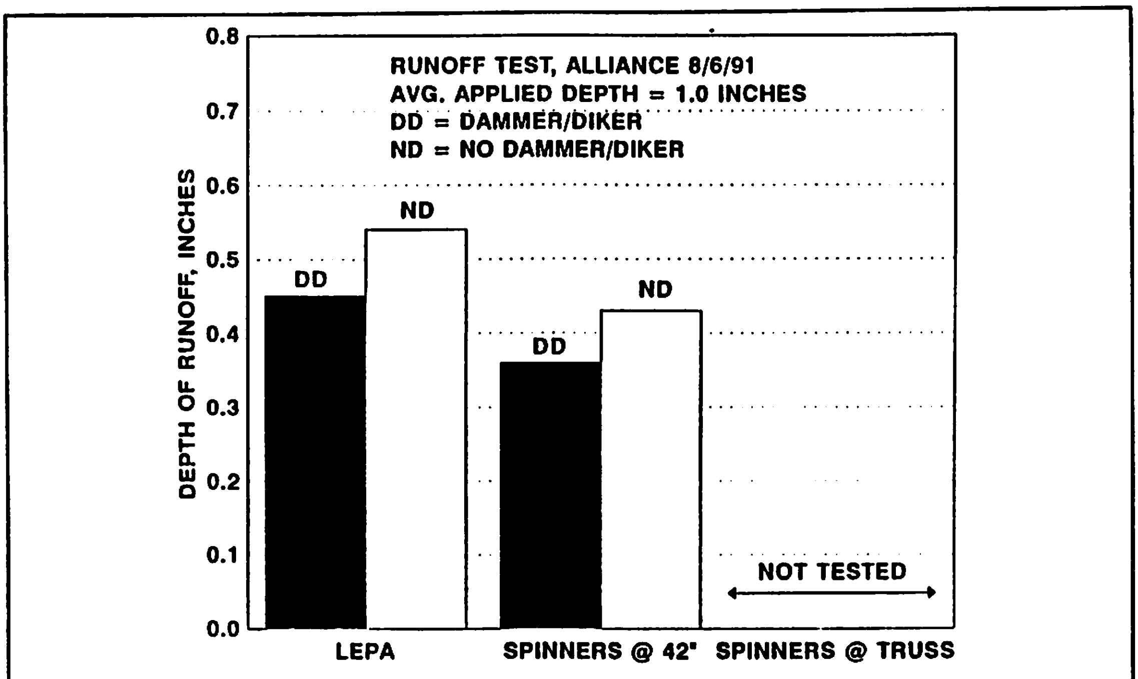

Figure 4. Runoff measured for an 1.0 inch irrigation at Alliance, NE.

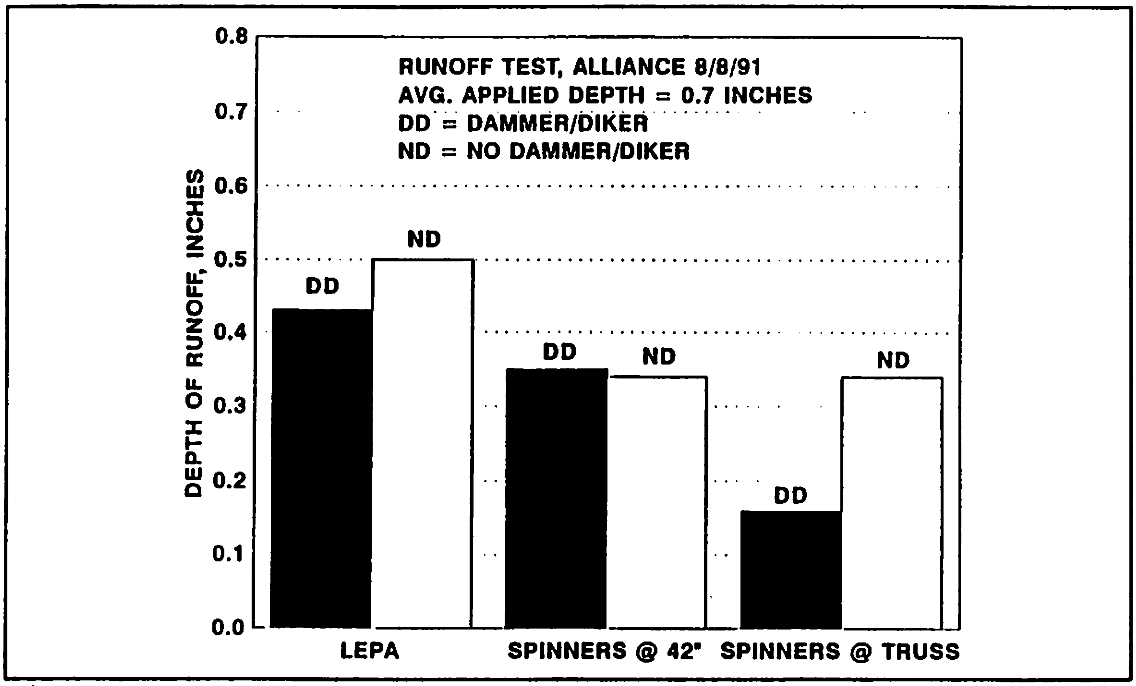

Figure 5. Runoff measured for an 0.7 inch irrigation at Alliance, NE.

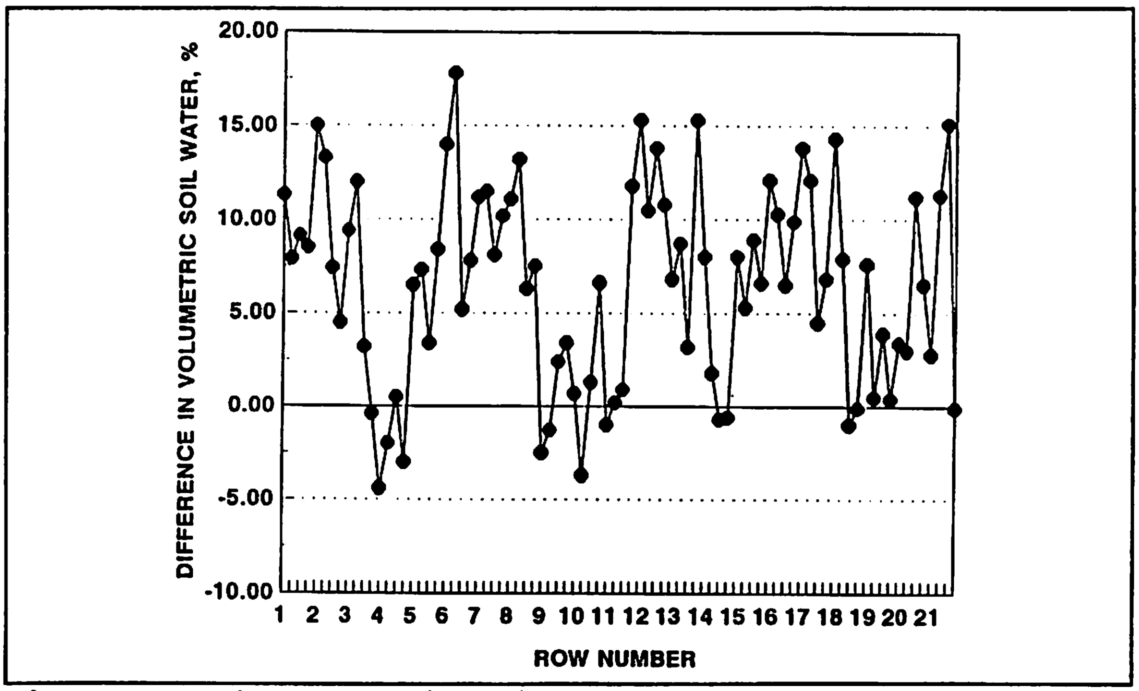

Figure 6. Difference in soil water content before and after an irrigation when Nelson Spinners are placed 42 inches above the soil and are spaced 14 feet along the pivot lateral.