Rodent Management for Surface Drip Irrigation Tubing in Corn, Cotton, and Peanut

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ABSTRACT

Surface drip (SD) irrigation of field crops has been gaining interest in the farming community. However, rodent damage is one of the major drawbacks for SD acceptance. This research documents the cost of repairing drip tubing and effectiveness of several rodent control methods. Four sites were used to identify cost of repairing tubing. Treatments included untreated drip tubing, tubing that was lightly buried, sprayed with an insecticide or animal repellent, and edible rodenticide placed next to the tubing. Once a leak was found, it took an average of 4 minutes to repair the hole. Each repair had an average cost of $0.67 for labor and repair materials. This repair cost does not include time or transportation cost to find the leak. Rodent damage was the same in the untreated versus any chemical treatment tested. At Site 4, the animal repellent, Ropel®, did have less rodent damage (2392 holes/ha) compared with the untreated (6049 holes/ha) however, the damage was extensive enough that it was more economical to replace than to repair the tubing. There was less rodent damage to the thin-walled tubing compared with the thicker-walled tubing. Drip tubing that was slightly buried had the best rodent control (5 holes/ha) compared with all other treatments (1771 holes/ha). One disadvantage of burying the drip tubing is removal. Strip tillage along with burying the drip tubing showed excellent resistance to rodent damage and appears to be a cost effective management tool for SD.

Key Words: *Arachis hypogaea*, drip tubing, *Gossypium hirusutum*, irrigation, *Mus musculus*, *Reithrodontomys humulis*, repellent, rodent damage, *Sigmodon hispidus*, *Zea mays*.

Almost one million ha are irrigated in Georgia, Florida, and Alabama, with 36% being irrigated by overhead irrigation systems (NASS, 2003). Surface drip (SD) is used on over 85,000 ha with over 73,000 ha in FL alone (NASS, 2003). Both SD and subsurface drip irrigation (SDI) are used primarily for vegetable production in this tri-state area.

Surface drip and SDI systems are typically installed to irrigate high value crops. In recent years, drip irrigation has expanded, with good success on field crops such as corn (*Zea mays* L.; Lamm *et al*., 1997 and 2001, Mitchell, 1981; Mitchell and Sparks, 1982; Powell and Wright, 1993), cotton (*Gossypium hirusutum* L.; Bauer *et al*., 1997; Camp *et al*., 1997; Sorensen *et al*., 2004), and peanut (*Arachis hypogaea*, L; Jordan *et al*., 2002; Sorensen *et al*., 2001a,b; Zhu *et al*., 2004b).

The conversion of non-irrigated land to SD or SDI can be challenging for land owners, especially with the day-to-day management of these systems concerning rodent damage. Both SD and SDI are subject to rodent or other animal damage especially in crops where there is maximum crop cover such as peanut. Wildlife that can cause damage to SD tubing include the Hisbid cotton rat (*Sigmodon hispidus*), house mouse (*Mus musculus*), Eastern harvest mouse, (*Reithrodontomys humulis*), and White-tailed deer (*Odocoileus virginianus*). The cotton rat and harvest mouse had by far the greatest impact on SD tubing in these studies. Both the mouse and rat tended to chew on the tubing while deer step on the tubing cutting it with their hoof when moving across the field.

The result of holes in the tubing are obvious but also include loss of pattern and irrigation efficiency, drought stress to areas that no longer receive water, water logging around the hole, nutrient leaching, and on undulating topography, possible soil erosion. In addition to the inefficiency of the irrigation water and possible loss of yield and resultant revenue, there is the added cost associated with tubing repair. This would include the cost of the repair materials, which can be minimal, and labor, which could be substantial, depending on the time it takes to find and repair the holes.

There is very little information on rodent damage and control in peanut (Parshad *et al*., 1987) especially when irrigating with SD. Application of rodenticides as broadcast baits in a peanut field used for human consumption may not be an alternative. Various chemicals that are already registered for peanut should be selected. In this

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research, chemicals were selected that have an offensive smell or taste to humans. The objective of this research was to document the effectiveness of two insecticides, one animal repellent, one rodenticide, and shallow soil/plant debris cover on reducing surface tube damage from field rodents.

Materials and Methods

Four sites were selected where SD irrigation was used to irrigate peanut. Site 1 was on a Greenville fine sandy loam (Fine, kaolinitic, thermic Rhodic Kandiudults) with 0 to 1% slope. A SD system was installed two years prior to irrigate cotton (2003), strip-till corn (2004), and strip-till peanut (2005). The area was clean tilled and cotton (DP 555 BG/RR) was planted. Drip tubing (Roberts Irrigation Products, 57 L/hr, 0.20 mm wall thickness, and 30 cm emitter spacing; www.robertsirrigation.com) was installed in alternate row middles (1.83 m). Cotton was irrigated following recommendations from IrrigatorPro for cotton. Following cotton harvest, the drip tubing was not removed from the field and the cotton stalks were mowed and pulled (fall 2003). During the spring of 2004, a strip-tillage operation was performed to prepare the seed bed for planting. During the stalk pulling and strip-tillage operations, the drip tubing was partially covered with 1 to 3 cm of soil and cotton debris. Corn was planted (DK697) following best management practices for strip tillage corn production. Irrigation events were scheduled using IrrigatorPro for corn. Following corn harvest, the stalks were mowed (fall 2004) and the strip-tillage unit was used (spring 2005) to prepare the field for peanut. Peanut (Georgia Green) was planted following TSWV risk index (Brown et al., 2004) and crop production (Prostko, 2004) recommendations. During each growing season the number of holes and time required to repair holes in the tubing was documented. Prior to peanut harvest, the drip tubing was lifted out of the soil and placed on the soil surface and removed from the field. Total number of holes in the tubing was not recorded.

Site 2 was on a Faceville fine sandy loam (Fine, kaolinitic, thermic Typic Kandiudults) with 0 to 1% slope. This project was in cooperation with a long term cropping systems project described by Lamb *et al*. (2003) with six crop rotations, four irrigation regimes, and three replications per rotation. Surface drip tubing (Roberts Ro-Drip, 0.20 mm wall thickness) was placed in all crop rotations such that tubing was placed in cotton, corn, and peanut. There were two crop rotations that were planted to peanut, i.e., continuous peanut and corn-peanut rotation during the 2005 growing season. All land area was conventionally tilled and crops planted following best management practices. After each crop was planted, SD tubing was installed on alternate row middles using equipment modified to lay three laterals in one pass (Zhu *et al*., 2004a). Each sub-plot was 1.83 m wide and 61 m long. During the growing season, the number of holes and time to repair each hole was documented. Prior to each crop harvest, the drip tubing was removed and destroyed before the total number of holes could be counted.

Sites 1 and 2 were primarily used to document the cost of finding and repairing leaks that occurred in SD. Management was such that the number of leaks, type of leak (mechanical or biological), and time it took to repair the leak could be documented. Documentation also included the type and quantity of materials needed to repair the leak. When repairing leaks, costs include labor, thick walled tubing (1.2 mm wall thickness), stainless steel wire ties, wire-tie tool, extra SD tubing, scissors, and rubber boots.

Site 3 was on a Faceville fine sandy loam with 2 to 3% slope (same as above). The area received full conventional tillage in the fall. Accepted best management practices were followed (see previous) to plant peanut (Georgia Green) in the spring of the year (2005). Tube wall thickness was an added variable to test rodent control. In randomized plots, rodent repellent and insecticides were applied to the drip tube surface. There were three tube thicknesses, five chemical treatments, four field positions, and three replications per treatment. Irrigation drip tubing was installed using the same equipment describe earlier (Roberts Ro-Drip with 0.20 mm, 0.25 mm, and 0.38 mm tube thickness). Sub-plots were 1.83 m wide and 60 m long. The chemical treatments were untreated, Contrac Blox® (Bromadiolone: [3-[3-(4′-Bromo-[1,1-biphenyl]-4-yl)-3-hydroxy-1-phenylpropyl]-4-hydroxy-2H-1-benzopyran-2-one]), Ropel® (Benzyidlethyl (2.6 xylyl carbamoyl) Methyl Ammonium Saccharide and Thymol), Lannate LV (Methomyl), and Orthene (Acephate). Just prior to peanut canopy closure, insecticides and animal repellent were banded over the SD tubing. Lannate was banded at a concentration of 12.5 ml/L and applied at 25 L/ha. Ropel® was diluted to 50% and banded at 25 L/ha. Orthene concentration was 24 g/L and applied at the same rate as Ropel® and Lannate. Ropel® manufactures suggest that this chemical does not wash off with precipitation, which was one of the major criteria for selecting this product. Contrac Blox® was placed in a grid next to the drip tubing at 185 Blox®/ha. Three Contrac Blox® were monitored to determine when to re-apply the

Blox® if needed. Prior to harvest, the SD tubing was removed and holes were counted in 15 m sections (positions) for each tube thickness and treatment. Position 1 was adjacent a grass area while position 4 was adjacent a corn plot. Positions 2 and 3 were between positions 1 and 4.

Site 4 was adjacent to Site 3 with the same soil type and slope. This area received the same tillage and management practices as described for Site 3. This site had a non-irrigated and irrigation component such that only half the total plot was irrigated. Each irrigated plot had a non-irrigated plot on each side. Irrigation tubing was not installed until the middle of June to facilitate a tillage project. During tube installation all three laterals (designated outside east, middle, and outside west) were treated with Ropel®. As tubing (0.20 mm tube thickness) spooled off the roll, it passed through two rope wicks, top and bottom, which was attached to a chemical bath, thus, placing the repellent on both sides of the tubing. Ropel® was applied only at installation and not at row closure as with other sites. Both outside tubing locations (east and west) were adjacent a non-irrigated plot. There were three replications across the field. Sub-plots were 5.5 m by 60 m. No chemicals were applied to the other half of the irrigated treatment. Prior to harvest, the SD tubing was removed and holes were counted in 15 m sections (positions described earlier) in the field.

Data collected during the growing season at all four sites were: 1. Documentation of the number of holes that were fixed, 2) time it took for repair, and 3) equipment needed for each repair. In Sites 3 and 4 at the end of the growing season, all tubing was inspected in each treatment to identify total number of existing holes not repaired.

Site 1 will be used as a comparison since the tubing was covered and chemical treatment was not feasible. Site 2 was mainly used to determine cost to repair damaged tubing. Sites 3 and 4 were analyzed separately because of different treatments. The number of holes in each treatment was subjected to randomized block analysis of variance (ANOVA) procedures (Statistix8, 2003) with chemical treatment and tube wall thickness as treatments. Means were separated when ANOVA showed significant differences at the $P \leq 0.05$ level.

Results and Discussion

Precipitation recorded during the growing season (01 April to 01 October) totaled 727 mm as measured by an electronic weather station located onsite. Precipitation events were quite frequent such that only two time periods during the growing season had 15 days between events and four time periods with 9 days between events.

Table 1. Total number of leaks repaired at Sites 1, 2, 3, and 4 for various treatments of surface drip tubing with untreated, soil cover, animal repellent, insecticides, and a rodenticide. Site 1 had drip tubing in use for three years. Sites 2, 3, and 4 used tubing for one year. These values were used to identify time required per repair.

Treatments	Site	Crop		
		Corn	Cotton	Peanut
		Number of repairs		
No cover	2,3,4	0	1	73
Soil cover	1	20(10)†	3	3
Contrac Blox®	3,4	–	–	5
Ropel®	2,3,4	0	0	30
Lannate	2,3,4	0	0	8
Orthene	3,4	–	–	16

†The number in parenthesis was leaks caused by mechanical damage during stalk pulling and strip-tillage operations.

Visual inspection of drip tubing showed that most holes were started on the folded edge. It is most likely that if the drip tubing was full of water the mice and rats are unable to open their mouths wide enough to chew on the tubing edge. However, without frequent irrigations the drip tubing lays flat allowing the mice and rats to chew on the edges. Thus, less frequent irrigation events would give the rodents a longer opportunity time to gnaw on the tubing edge. These frequent precipitation events resulted in fewer irrigation events and possible washing off of the insecticide chemicals on the drip tubing thereby increasing the number of incidence of rodent damage.

Table 1 shows the total number of leaks for the various crops and conditions. Drip tubing at Site 1 (Table 1, Soil cover) was installed in 2003 on cotton and was covered during stalk pulling and strip tillage over the next two years. Mechanical damage occurred and was repaired in the spring of 2004 (corn) and 2005 (peanut) prior to planting. Table 1 shows that drip tubing covered with soil/plant debris had less damage than drip tubing installed with no cover, insecticides, repellents, or rodenticides over the life of the tubing in the field (three years versus one growing season). This site had a total of 20 leaks repaired with half of those caused by mechanical damage (Table 1). If we take into account only those leaks caused by biological activity, the total number of repairs for this site for three years extrapolated to an area basis was 5 repairs/ha per year.

Table 2. Total number of holes identified after harvest for tube thickness, field position, and treatment for Site 3. Column means followed by the same letter are not significantly different according to Tukey's HSD comparison test. Field position 1 was next to a grassy area and field position 4 was adjacent a corn field.

Tube Thickness	holes/ha	Field Position	holes/ha	Chemical Treatment	holes/ha
0.20 mm	800a	1	1963a	Untreated	1645a
0.25 mm	1884ab	2	2113a	Contrac Blox®	1495a
0.38 mm	2631b	3	1146a	Lannate	2367a
		4	1864a	Ropel®	1981a
				Orthene	1370a

There was little or no biological damage to the drip tubing in corn or cotton in Site 1 (2003 and 2004) or Site 2 (2005). There was major tube damage in peanut (Table 1) even with the tubing treated with a chemical or repellent. There were a total of 135 leaks repaired in peanut (Table 1), one in cotton, and zero in corn. These data indicate that rodent damage is minimal in corn and cotton compared with peanut. Rodents have a large number of predators and need cover to survive. Corn and cotton have very little crop cover for rodents to hide for protection during the growing season compared with peanut. It seems reasonable that the addition of a chemical or repellent to the drip tubing in corn or cotton would not be necessary or cost effective.

The time required to find and repair a drip tube leak can be variable. It is possible for a leak to occur and water move off-site resulting in extensive time required in finding the hole. Time data collected from these four sites indicate that it takes about 4 minutes to repair any given leak (repair time data not shown). This repair time does not include the time it takes to find the leak. The best way to find or locate a leak was to check the flush end of the tubing. If the flush end had no pressure then a leak was in that row. By walking across the end of the field opposite the supply side, a manager could quickly identify which rows had leaks.

Site 3 and 4 were situated with a grassed border area on the north (Position 1) and a corn field to the south (Position 4). Current data (Table 1) show that corn or cotton had less rodent damage than areas with full plant canopy cover. Therefore, it was suspected that the tubing closer to the corn field, position 4, would have less damage than tubing close to the grassy area, position 1. Table 2 shows no difference with field position whether close to the grassy area or the corn field. However, Site 4 (Table 3) shows more damage closer to the grass area and less damage next to the corn field. It is unclear as to why this would occur with both Sites 3 and 4 adjacent each other. Two possible explanations would be that: 1) drip tubing at Site 4 was installed about 45 days after that of Site 3; and 2) a mechanical tillage operation was performed in Site 4 to facilitate another project which may have frightened the rodents and moved them out of this area. These two operations, late tube installation and tillage, could have reduced the total opportunity time for rodents to be in the field and gnaw the tubing.

Another hypothesis was that thicker walled tubing would help reduce rodent damage. Site 3 shows less damage to the thinner walled tubing compared to the thicker walled tubing (Table 2). The thicker walled tubing had over three times more damage compared with the thinner walled tubing. Rats and mice have incisors that need to be sharpened. They also have the tendency to chew to exercise their jaw muscles and possibly to relieve nervousness caused by constant predator pressure. Peanut was rotated from corn which does not leave very hard substances in the field for rodents to chew. It would seem plausible that without any hard substrate in the peanut field on which to chew, rodents would move to the thicker tubing looking for a material on which to chew for exercise, keep their incisors sharp, or nervousness (personnel communication: Dr. Terrell Salmon, Wildlife Damage Specialist, UC-Davis).

The spraying of chemical on the drip tubing was to create a hostile environment such that mice would not inhabit the area near the SD tubing. By

Table 3. Total number of holes identified after harvest for tube location, field position, and chemical treatment for Site 4. Column means followed by the same letter are not significantly different according to Tukey's HSD comparison test. Field position 1 was next to a grassy area and field position 4 was adjacent a corn field.

Tube Location	holes/ha	Field Position	holes/ha	Chemical Treatment	holes/ha
Outside west	2280a	1	6603b	Untreated	6042b
Middle	4560a	2	4186ab	Ropel®	2392a
Outside east	5812a	3	4535ab		
		4	1545a		

Table 4. Economic values for labor, repair equipment, rodenticides, insecticides, and animal repellents. Tubing installed in alternate row middles (1.83 m apart). About 15 cm of blank tubing is used for a repair splice for each hole.

Input	cost/unit	cost/ha
	$	
Labor	8.00/hr	
Drip tubing wall thickness		
0.20 mm	0.054/m	296.00
0.25 mm	0.071/m	388.22
0.38 mm	0.107/m	583.04
Blank tubing (1.2 mm)	0.295/m	
Stainless steel wire ties	0.025 ea	
Contrac Blox®	0.21 ea	38.92
Orthene	19.30/kg	11.37
Lannate	12.02/L	3.71
Ropel®	7.10/L	35.25

spraying the drip tubing just before canopy closure may also allow a short time period for the peanut canopy to cover the tubing for added protection and reduce the opportunity time for precipitation to wash the chemical off of the tubing. By creating this hostile environment with chemicals, rodent activity should decrease. However, there was no difference in the number of holes counted in any of the chemical treatments compared with the untreated tubing. At Site 4, the Ropel® did have less rodent activity (2392 holes/ha) than the untreated (6042 holes/ha) and about the same number that was found in Site 3 (1981 holes/ha). This can possibly be attributed to late installation of the tubing and that Ropel®, according to label, does not wash off during precipitation events, thereby repelling the rodents and increasing the rodent damage on the untreated tubing.

The rodenticide was not an effective control method. The cost per unit area for the rodenticide was the highest of all the chemicals selected (Table 4). Cost and poor efficacy of rodent control indicates this rodenticide should not be used for rodent control. In addition, the active chemical is not registered for use in peanut. It is possible that during harvest portions of the Contrac Blox® could be of big enough size to make it though the combining process and eventually into storage, and end up peanut used for human consumption. Therefore, this is not a recommended practice for rodent control.

A comparison of all four experimental sites indicates that a light covering of soil/plant debris on drip tubing can reduce rodent damage to an acceptable level. The cost associated with repairing drip tubing at Site 1 peanut (Table 1) would be 3 repairs (12 min), 9 wire ties, and about 1.0 m of blank tubing. The total cost for these 3 repairs would be \$3.68/ha with the major cost attributed to labor or about 78% of the total cost. If we were to repair the holes found at Site 3 for the control treatment and 0.20 mm tube thickness (Table 2), the total cost would be \$503/ha. The cost to repair was more than the replacement cost (\$394/ha) of the SD tubing. The breakeven point of when to repair versus when to replace would be about 500 holes/ha. This value does not include transportation cost within the field.

Tubing (0.20 mm tube thickness) installed on a 1.83 m spacing would cost about \$300/ha (Table 4). Site 1 had drip tubing in the field for three years. Amortized over the three years, tubing cost would be \$100/ha. Total repair cost for the three years was \$24.71/ha or \$8.24/ha for each year. Thus, annual cost for the irrigation system would be about \$108.24/ha per year. Repair costs for Site 3 (data not shown) with 91 repairs/ha was \$151/ha with a total irrigation cost of \$451/ha per year since the tubing was only used one year. These data indicate that light soil/plant debris covering over the tubing can be cost effective if tubing can be left in the field longer than one year.

Conclusions

There was very little rodent damage to drip tubing in corn or cotton. In peanut, a light covering of soil or plant debris will keep rodents from damaging the drip tubing to acceptable levels. Spraying the tubing at canopy closure (peanuts) did not work with the two insecticides tested. The animal repellent, Ropel®, did seem to have less rodent damage on drip tubing at one of the sites but was not consistent across multiple sites. The rodenticide, Bromadiolone (Contrac Blox®), had no effect on reducing rodent damage. Since none of the insecticides, repellents, or rodenticides were effective in controlling rodent damage, the expense of purchasing and applying these chemicals would not be an option. Thicker walled tubing had over three times more damage than the thinner walled tubing implying that thinner wall tubing may be a better choice. Overall, lightly burying the tubing may be the only option available to reduce rodent damage in peanut fields. However, this light soil cover on the drip tubing may not be an option if clean tillage is the normal farm practice such that drip tubing would need to be destroyed and replaced each year. If the tubing could be installed and not removed for three to four years such as with strip tillage, this system would be a more cost effective irrigation system for installation and repairs.

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