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Schmuel Moran
Ministry of Agriculture, Plant Protection Department, Yafo, Israel

Chaim Keidar
Ministry of Agriculture, Plant Protection Department, Yafo, Israel

Yehuda Wolf
Ministry of Agriculture, Plant Protection Department, Yafo, Israel

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SHMUEL MORAN, CHAIM KEIDAR and YEHUDA WOLF, Ministry of Agriculture, Plant Protection Department, Yafo, Israel

ABSTRACT: Several methods were evaluated for protecting polyethylene irrigation pipes against pecking damage caused by the Syrian woodpecker (Dendrocopos syriacus). Only by burying the pipes in the ground damage was effectively prevented. Other methods studied, the use of the game repellent Arbinol, covering the pipes with polyethylene sheets, and growing a weed cover, though reducing the rate of the damage, proved not to be sufficiently effective as an economic solution of the problem.

INTRODUCTION

The Syrian woodpecker (Dendrocopos syriacus) (Hemp. & Ehr. 1833) is the only picid species in Israel, common in woods, orchards and gardens throughout the country. It has been known as a nuisance to almonds and nuts (Schmidt 1973, Winkler 1973), but most serious economic damage it causes by perforating polyethylene irrigation pipes (Wolf 1973).

In Israel, a country with a semi-arid climate, fanners use leakage-proof polyethylene pipe systems, mostly in plantations and orchards. These systems are automatically controlled, and save water as well as working days. Several methods of irrigation are practiced: sprinklers, sprayers and drip irrigation with various types of accessories. Two types of drip systems are mainly used: drip accessories inserted inside the pipe lines, and small drip accessories attached to holes drilled along the pipe lines*. All the above irrigation systems are installed permanently on the ground. An earlier method still being used in many orchards are sprinklers attached to movable polyethylene pipes.

The woodpeckers damage plastic pipes of all the above types of irrigation systems by pecking holes into them, 2-10 mm (mostly 5-8 mm) in diameter, usually well rounded (Moran 1977). The reduction of water pressure in the damaged pipes reduces the amount of water received by plants and thus interferes with their growth and crop production. Therefore the farmers have to spend many labor hours to repair or replace the damaged pipes.

The average daily pecking rate of a single bird was estimated to be 1/2 - 3 holes, fluctuating monthly and between years. The woodpeckers attack plastic pipes installed in parks and gardens, and in orchards and groves of various crops: pecan, deciduous fruit, citrus, mango, loquat and avocado. In the course of 6 years (.1969-1975) the damage spread to most of the fruit gardens and orchards vulnerable to woodpecker activity in Israel. The spread of the pecking activity is assumed to be the result of transmission of the "knowledge of boring pipes" rather than an outbreak of a pest population (Moran 1977).

To protect the pipes two approaches were considered feasible: control of the harmful birds and physical protection of the pipes. Control of the woodpeckers by poisonous agents was considered to be too hazardous, as nuts were used as bait material. Trapping the birds with rat snap traps (Clark 1976, Dudderar 1977, Koehler 1962) was tedious and not always successful (Moran, Keidar and Wolf, in preparation). Because of the above deficiencies, it was considered worthwhile to evaluate several methods of prevention of damage by physical protection of the pipes.

METHODS

The number of holes made by woodpeckers in irrigation pipes in the test plots was recorded by farmers while repairing the polyethylene irrigation pipes. In most cases the repairing and hole counting was conducted prior to irrigation.

The various types of crops and irrigation methods in the study plots are outlined in Table 1.

Burying the Pipes in the Ground

The plots, where the method of burying the pipes in the ground to protect them from woodpecker damage was studied, were distributed throughout the country (plots series A in Table 1). In 7 plots (A2 to A8) the irrigation pipes were buried several centimeters below the surface of the soil (Table 2c). The irrigation accessories were connected to the pipes by slender and flexible p.v.c. pipes and a tack connection (plots A1 to A4, A6 and A7), or were directly inserted into the pipes (plot A5). Plots A8 and A9 were irrigated by sprayers connected by a T connection to the irrigation pipe lines. In plots A1and A9 the pipes were covered by a thin layer of soil. In plot Al small stones were added to the above soil layer.

Covering with Polyethylene Sheets

The irrigation pipe lines were covered by long black polyethylene sheets, 40 cm wide, 0.06 mm thick. This study was carried on in a single 30 acre pear and apricot plantation (plots series B in

*The types of drip irrigation accessories described in Table 2c are not in wide use.

Table 1. Characteristics of the study plots.

Plot No.	Crop	Irrigation Method	Duration of Test in Months	Acreage	
				Treated	Control
A1	Peaches[1]	Sprayers	8	2.5	0
A2	Plums[2]	Sprayers	6	11	0
A3	Apricots[3]	Sprinklers & Sprayers	9	12	0
A4	Pears[5] & apricots	Sprayers	13	2.4	27
A5	Almonds[4]	Drip	6	5	0
A6	Apricots	Drip	12	8	0
A7	Oranges[6]	Sprayers	7	2.5	0
A8	Pecan[7]	Sprayers	6	2.5	2.4
A9	Oranges	Sprayers	6	2.2	2.0
B1-B7	Pears & apricots	Drip	19	2.8 to 30[8]	25.2 to 0[8]
C	Pecan	Sprinklers	3.5	1.5	1.5
D1	Pears	Drip	24	1.25	1.25
D2	Pecan	Sprinklers	8	0.07	0.03
D3	Apricots	Sprinklers	6	1.25	1.25
D4	Pears	Drip	4	0.5	8.0
D5	Pears	Drip	7	0.5	1.7

[1] *Prunus persica* (L.) Sieb. et Zucc.
[2] *P. domestica* L.
[3] *P. armeniaca* L.
[4] *P. amygdalus* Stockes
[5] *Pyrus communis* L.
[6] *Citrus sinensis* (L.) Osb.
[7] *Carya illinoensis* W.
[8] The treated area was enlarged stepwise on behalf of the control area, until the whole pipe system was covered.

Table 1). The plantation was divided into 7 plots of 4.8, 3.7, 5.0, 4.0, 2.0, 2.4, 8.1 acres respectively. The plantation was irrigated by a drip system. The covering of the pipes was executed in stages, plot by plot (and sometimes parts of plots), until the entire plantation irrigation system was covered (Table 3).

Protecting by Weeds

Pecan plantations in Israel are usually clean of weeds. For our observations a pecan plantation was chosen where treatment with germination preventing herbicides was omitted on part of the plot. The weeds were 10-20 cm high in the untreated part of the plot, while on the treated part the ground was exposed. The plot (plot c in Table 1) was located in the center of a 370-acre complex of pecan plantations and citrus groves populated by woodpeckers causing serious pecking damage to the irrigation pipes.

Repellent

Arbinol WS* (manufactured by Stähler, Stade, W. Germany) is a sprayable white game repellent, composed of taste and smell repellents applicable by an ordinary paint brush. It was found to have good adhesive properties to the surface of the polyethylene pipes.

The study was carried on in 5 plots (series D in Table 1), distributed throughout the country. In plots D1-D4 the repellent was applied to the pipes by paintbrush (Table 5), but on plot 4 part of the irrigation system (38 percent) was sprayed with Arbinol. In plot D5 an apparatus developed by M. Mindel was used for application of the material to the pipes. It was composed of 1 gallon cylindrical tank with two rounded openings in its extremities, padded with sponges, which enabled the irrigation pipe to pass through it. This method considerably reduced the time needed for application of the repellent to the pipes. While in hand application by paintbrush approximately one hour was needed for 30 meters of pipes, this same length was treated within 2-3 minutes with the aid of the Mindel apparatus. The quality of the treatment of the pipes with Arbinol did not vary whichever method of application was practiced.

*Reference to trade names does not imply endorsement by the Israeli Government.

Table 2. Burying polyethylene irrigation pipes in the ground to protect them from woodpecker damage.

2a. The number of holes per month in plot A4.

Period	Test Plot[1] Exposed Pipes	Test Plot[1] Buried Pipes	Control	Percentage of damage in Test Plot per Entire Plantation[2]
Nov. 1974-Apr. 1975	8		227	3.6
May 1975	2		259	0.8
June 1975	37		287	11.4
July 1975	46		222	17.1
August 1975	33		116	22.2
September 1975	0	0	153	0
October 1975	0	0	107	0
Nov. 1975-Feb. 1976	0	0	147	0
Mar.-Apr. 1976	2	0	177	1.4
May 1976	0	0	502	0
June 1976	0	0	220	0
July 1976	2	0	412	0.5
August 1976	7	0	157	4.3
Sept.-Oct. 1976	2	0	170	1.4
Total of Sept. 1975 to Oct. 1976	13	0	2045	0.64

[1]The pipes were buried in September 8, 1975. From that time and on only short sections of pipe were to become exposed as a result of irrigation drain and were usually covered soon after being discovered.

[2]Entire plantation = control plots + test plot.

2b. Monthly mean of the number of holes pecked per day in plots A8 and A9 during 1975.

Month	Plot A8 Treated	Plot A8 Control	Plot A9 Treated	Plot A9 Control
May	2.32	0.16	1.30	0.26
June	1.53	0.13	0.46[1]	0.23
July	1.35	0.87	0.10[1]	0.13
August	0[2]	?[3]	0[2]	0.50
September	0[2]	?[3]	0[2]	0.20

[1]Only parts of the irrigation pipes are buried in the ground.

[2]All the pipes are buried.

[3]Damage occurred, but holes were not recorded.

2c. Summary of the results.

Plot	Depth in cm	Occurrence of Holes after Treatment		
		Buried Pipes	Exposed Sections	Control Pipes
A1	0[1]	no	yes	-
A2	10	no	no	-
A3	1-2	no	yes	-
A4	2-3	no	yes	yes
A5	1-2[2]	no	no	-
A6	3-5[3]	no	no	-
A7	4-7	no	no	-
A8	10	no	no	yes
A9	0[1]	no	no	yes

[1]The irrigation pipes were installed on the surface and were covered by a thin layer of soil. In plot A1 it was mixed with small stones.

[2]The knob-type accessories were buried rather superficially to let the dripping water expose their tips.

[3]The capsule-type accessories were attached to the pipe lines and connected to the surface by slender p.v.c. pipes.

Table 3. Total number of holes pecked by woodpeckers in plastic irrigation pipes protected by polythylene sheets.

Period	Study Plots	Treated		Control	Monthly mean in whole plantation
		Exposed Pipes	Covered Pipes		
May 1972-August 1972	B1	188		230	104
September 1972-April 1973	B1*	258	1	1137	199
May 1973	B1*, B6*	184	9	367	550
June 1973-August 1973	B1,B2*,B6,B7*	920	54	88	354
September 1973	B(1-3),B(4-7)*	27	0	0	27
October 1973-December 1973	All plots	5	69		24

*Partially covered.

RESULTS

Burying the Pipes in the Ground

Although perforating data were recorded in plots A4, A8 and A9 only (Tables 2 a,b), it was found that perforation of the pipes ceased absolutely in all of the 7 plots (Table 2c). In plots A1, A3 and A4 the irrigation water washed away the soil on short sections of the pipes. The woodpeckers perforated the exposed sections, until they were covered again. This phenomenon was well recorded in plot A4 (Table 2a).

Covering with Polyethylene Sheets

Plot B1 was selected to be the first of the plots to be covered with polyethylene sheets (Table 3), as the number of the holes recorded during the early summer of 1972 was very high (82 percent of the total damage in the orchard, while the area of that plot was only 16 percent of the whole plantation acreage). During the first 8 months, when plot B1 was covered partially, the damage was reduced to 18.5 percent of the total pecking damage in the entire plantation. During the summer of 1973 the work of covering the pipes progressed at a faster rate than 1972, until it was concluded. Meanwhile the woodpeckers began pecking at the covered pipes in places where the sheets adhered to the pipes, showing the rounded shape of the pipes to the birds.

After the study was terminated, the sheets were neglected by the farmers. The irrigation pipes were exposed as a result of winds and agricultural activity in the plantations. The farmers did not replace the polyethylene sheets over the irrigation pipes to restore their protection.

Protecting Weeds

During the 4 month study period, only 2 holes were recorded in the weed-covered section of the plot (Table 4). One hundred two holes were counted in the exposed section.

Table 4. Number of holes perforated in irrigation pipes by woodpeckers in a weed-covered pecan orchard (Plot C, summer 1972).

Date	Ground Covered by Weeds	Exposed Ground
June 6	1	34
June 30	1	18
July 18	0	6
July 29	0	11
September 3	0	16
September 19	0	17
Total	2	102

Repellent

Pecking activity ceased immediately after treatment of the pipes with Arbinol and was resumed again only after several weeks to 4 months (Table 5). Later on, the damage rate was relatively high. During the period of damage resumption, the mean percentage of damage reduction was 28.6-66.7. It is of interest to note that during the second year of our observations (plot D1), the woodpeckers perforated the treated pipes only. During that year, the total damage rate in plot D1 was 4 holes only per 8 months.

Table 5. Perforation of woodpeckers in Arbinol treated polyethylene irrigation pipes.

Plot No.	Pipe Length in Meters Treated	Control	Method of application	Damage Interval in Months[1]	Total number of holes[2] Treated	Control	Mean perforating[2] Rate[3] Treated	Control	Percentage of Damage[2] Reducing[4]
D1	1100	1100	Paintbrush	2/3	41	122	0.07	0.21	66.7
D2	28	14	Paintbrush	1	10	28	0.27	0.46	41.3
D3	350	350	Paintbrush	1	16	37	0.27	0.63	57.1
D4	790	13700	Spray & Brush	3	10	132	0.20	0.28	28.6
D5	242	800	Mindel's[5]	4	1	12	0.04	0.12	66.7

[1] Interval after the treatment until new holes occurred.

[2] Damage occurred after the interval between damage and new damage resumption.

[3] Different units according to plot:
Plot D1 - Total number of holes per day
Plot D2 - Number of holes per day per 100 meters.
Plot D3 - Number of holes per day per km.
Plot D4 and D5 - Number of holes per day per acre.

[4] Calculated: $100\left(1 - \frac{\text{Mean Perforating Rate in Treated Pipes}}{\text{Mean Perforating Rate in Control Pipes}}\right)$

[5] M. Mindel apparatus (for details - see text).

DISCUSSION

The only method absolutely preventing perforation of the irrigation pipes by woodpeckers is undoubtedly by burying them in the ground. In plots where the pipes were covered by a thin layer of soil (plots A1 and A9) the farmer had to waste labor hours in replacing the soil above the exposed sections to prevent damage resumption. In cases where the pipes were superficially buried (1-2 cm) they were due to exposure by the irrigation water of the spray or sprinkler irrigation (plot A3). This phenomenon did not occur in drip irrigation (Table 2c, plot A5). Our recommendation to farmers is therefore to bury the irrigation pipes not less than 5 centimeters in the ground. The cost of the performance of this method is rather high, but it was preferred by farmers in most of the pecan orchards and citrus groves suffering woodpecker damage. The other methods described here solved the problem partially only. The method of covering the pipes with polyethylene sheets was neglected because of the high price of the sheets (approx. 10 percent of the price of the pipes), and the need for constant maintenance. Most of the farmers were not willing to let weeds grow in their orchards. Only a few grew a narrow strip of weeds along the pipe lines (30-40 cm high), and dried them up with contact herbicides. The dry weeds continued to protect the irrigation pipes for months.

The treatment by the repellent Arbinol had a relatively low effect. The immediate cessation of woodpecker pecking activity during first few weeks or months after the treatment is known to occur also when the pipes are treated by whitening agents (Moran, Keidar and Wolf 1973). On the other hand, after the resumption of woodpecker attacks the whitening agent had a short effect (few weeks) in comparison to Arbinol, which reduced the damage for a year. Economically, a repellent must completely stop the damage to the irrigation pipes to justify its cost. The investment in labor hours for inspection of the pipe systems before every irrigation, in order to find the holes and plug them, is almost the same for any level of damage. So the damage reduction by Arbinol is considered to be insufficient to justify its use.

The method of burying the pipes was found suitable for permanent irrigation pipe systems, where the irrigation accessories are connected by a short pipe to the buried pipe lines. On the other hand, most of the drip systems, must be located above the ground. Also movable irrigation systems cannot be stabilized by burying in the ground. These later irrigation systems have to be protected by any of the other methods described above.

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