THE POTENTIAL OF COMPOUND U-12171 AS AN AVIAN REPELLENT

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ABSTRACT: Tests of the effectiveness (primarily reduced plant damage) of U-12171 to repel linnets from, or reduce the amount of feeding damage on, Gem hybrid broccoli suggest that: 1) concentrations above 1.50 lb./acre deterred avian depredations whereas lower concentrations did not; 2) the "hop-scotch" feeding pattern of linnet groups may have contributed to repellency since high concentrations in one area may act as a barrier to other areas; and 3) U-12171 efficiency may be markedly affected by chemical coverage of the plant, the number of applications made, and application timing relative to crop maturity.

An intensive and specialized agriculture has expanded food production but has also compounded depredations by pest birds. Losses to avian depredation must somehow be reduced if ever-increasing needs for agricultural products are to be met despite increased costs of production. One plausible method of reducing loss is to treat crops with nontoxic chemical compounds that reduce their palatability to pest birds. Nontoxic agents are desirable for both humane and environmental considerations. The chemical U-12171 (a butyramide compound provided the The Upjohn Company; also known as DRC 3324) therefore came under study in 1974 by the University of California in cooperation with The Upjohn Company, Kalamazoo, Michigan; the Asgrow Seed Company, Salinas, California; and the Ventura County Department of Agriculture. Reported here are the results of an investigation on its avian repellency characteristics as affecting the feeding patterns of the linnet (house finch), Carpodacus mexicanus, on Gem hybrid broccoli plants.

THE STUDY AREA

The potential of U-12171 to repel linnets was studied on two adjacent 15-acre fields of Gem hybrid broccoli near Oxnard, Ventura County, California. Field 1 and Field 2 were treated with U-12171 on different dates but at comparable stages of plant maturity. Each field was divided into five 3-acre "test plots" (Table 1). Each test plot contained six "beds" consisting of two rows of broccoli. The plots were separated from each other by a 6-ft.-wide strip of bare ground created by removing two beds of pollinator plants.

Table 1. Spatial relationship (east to west) of 3-acre test plots of Gem hybrid broccoli in two adjacent fields. Test plots 1-5 in Field 1, and test plots 6-10 in Field 2. Shown are the respective U-12171 treatments (pounds of active ingredient/acre), the milled pounds of broccoli seeds, and the total percentage of the broccoli plants damaged by linnets. See text for date, time, and method of U-12171 application and Tables 3 and 4 for details of plant damage assessment.

PLOT NO.	U-12171/ACRE	POUNDS OF SEED	% PLANTS DAMAGED
1	1.50	760	98
2	0.50	437	93
3	0.75	350	94
4	1.00	315	97
5	0.00	265	90
6	0.00	143	97
7	1.00	114	98
8	2.00	251	68
9	3.00	213	38
10	1.50	318	55

The broccoli fields were bounded to the north by strawberry; to the northeast and east by pepper, tomatoes, and beans; and to the west by pea and squash crops. The linnets often perched on telephone lines along the north boundary and used a grove of Eucalyptus trees to the south for roosting and staging.

METHOD OF U-12171 APPLICATION

U-12171 was applied to the broccoli with ground spray equipment in a water solution in various concentrations at 100 gallons per acre and a pressure of 110-150 psi. Spreader-applicator X-77 was added (1 pint per 100 gallons solution) to increase retention of the chemical on the plants. Coverage by the spray included whole pods to a depth of six to eight inches below the canopy and partial coverage of the under-foliage. All applications were made by the Santa Clara Chemical Company, Santa Clara, California. The chemical solutions were measured and mixed by Mr. Henry Hayes, Asgrow Seed Company, and Ms. Jan Holcomb, University of California (who collected much of the field data reported here).

U-12171 was applied in Table 1 between 9:00 and 11;30 a.m. on 25 June in the concentrations given in Table 1. Ambient air temperature was 72° F., with a 2-5 mph westerly wind and clear skies. U-12171 was first applied to Field 2 on 6 July, but very heavy rains on 14-15 July likely washed it from the plants, so that application is not included in Figure 1. Instead, the U-12171 application to Field 2 is based on total amounts applied equally in two subsequent applications: 1) on 23 July between 1:30 and 3:00 p.m. (weather clear; air temperature 80°F.; and a 3-5 mph westerly breeze); and 2) on 27 July between 8:00 and 9:45 a.m. (weather foggy, calm; air temperature about 67°F.).

CHARACTERISTICS OF LINNET FLOCKS USING THE BROCCOLI FIELDS

Population Size Estimates

The population size of linnets feeding on the broccoli was estimated by periodically counting the birds flushed from the various test plots as a function of disturbance made by the observer while walking transects through the bare strips of ground separating adjacent plots. The numbers in both fields increased as the broccoli crop reached maturity but then decreased at or near the time of harvest (Table 2). Field 1 generally contained considerably more birds than Field 2, but both were exploited consistently by the linnet population.

Linnet Feeding Patterns

At about sunrise, linnets (usually in 6-to-8-bird flocks) began to move from their roosting site in the Eucalyptus grove into weeds along the southern border of the fields and subsequently into the crop. An additional influx was usually observed about 1/2 hour after sunrise. Further, there were constant flights between the broccoli and the grove throughout the day.

Table 2. Size of linnet populations occupying two 15-acre fields of Gem hybrid broccoli in Ventura County, California. Population size is based on counts of linnets flushed from the broccoli fields during the morning period of feeding activity. The time given indicates when the census was initiated.

DATE	FIELD 1		FIELD 2		BOTH FIELDS
(1974)	Time	Number	Time	Number	Number
25 June	8:00	290			
10 July	8:30	560[a]	8:00	7	567
12	8:30	590			
16			9:30	130[b]	
17	8:30	510	8:00	85	595
18			8:30	65	
22	7:15	270	9:00	305[c]	575
25	7:30	260	7:30	180	440
29	7:45	285	7:15	2	287
30	7:30	260	7:00	0	260
8 Aug			9:15	160	
9			8:00	190	
20			7:30	115	

a) Test Plots 1 and 2 contained about 2/3 of the observed population.

b) Test Plots 6 and 7 contained about 3/4 of the observed population.

c) Test Plots 6, 7, and 8 contained about 2/3 of the observed population

Linnet activity usually peaked between 8:30 and 10:00 a.m., underwent a mid-day lull, and peaked again between 4:00 and 6:00 p.m. This bimodal activity pattern persisted during the study in Field 1, and also in Field 2 until 27 July, when the final application of U-12171 was made. After that application, the morning activity peak was virtually nonexistent and the few linnet feeding groups observed were in the lowest U-12171 concentration (Test Plot 7, 1.00 lb. AI/acre) or in the untreated control (Test Plot 6). That pattern persisted until the broccoli in the adjacent field had been harvested, whereupon the bimodal activity pattern was resumed in Field 2.

As crop maturity progressed, the size of individual linnet feeding groups in both broccoli fields changed from 1-7 bird groups initially numerous, to fewer groups that were much larger, 40-60 birds. That may represent the recruitment of juveniles to the population. The change in group size did not appear to influence feeding activity and behavior.

EFFECTS OF U-12171

Net Crop Yield

The net crop yield (milled pounds) of seeds in 1974 could not be used in a detailed assessment of repellent effects on a test-plot basis since relative plant density was not determined with sufficient accuracy, nor did net yield of the various plots directly reflect linnet damage to the plants. For example, the 760-lb yield from Plot 1 was by far the greatest although essentially every plant (98%) in the plot was damaged by linnets. Conversely, Plot 9 sustained relatively low (55%) plant damage but the net yield was only 213 lb. Table 1 shows net yields relative to U-12171 concentrations on the various test plots, along with the amount of plant damage.

The difficulties in comparing crop yields with U-12171 concentrations were compounded by the considerable differences between the plots in plant density, size, and vigor. Further, inundation and "wash-out" of broccoli plants in Plots 7 and 8 reduced their respective effective acreages by about 25 and 35 percent. Hence, net yield does not appear to be a reasonable indicator of U-12171 effectiveness in this study. All the same, the collective yield from all treated plots does suggest some repellent effect, for yield averaged 112 lb./acre in the eight treated plots and only 68 lb./acre in the two untreated plots. Thus, damage of individual plants may represent repellent effects more accurately.

Extent of Damage to Plants

Two 50-sq-ft areas in each test plot were randomly selected as "sample sections". Periodically from U-12171 application to plant harvest, each plant in the sample sections was examined for damage, rated as: zero (none), low (1-25% of seed pods with damage), medium (26-75% seed pods damaged), and high (76-100% of seed pods damaged).

Plant damage levels in Field 1 are given in Table 3. U-12171 was applied to this field on 25 June, 22 days before harvest. At that time, appreciable numbers of linnets were already feeding on the relatively mature plants in this field (Table 2). Damaged plants were few on 1 July but increased rapidly in numbers thereafter (Table 3). The U-12171 concentrations applied to Field 1 seemed to

Table 3. Damage levels on Gem hybrid broccoli plants in Field 1 as a function of linnet activity through time. Ratings indicate: zero, low (1-25%), medium (26-75%), and high (76-100%) of maturing seed pods damaged or destroyed by linnets. Method of assay was repeated inspection of individual plants located in two 50-sq-ft sample sections in each of the 3-acre test plots. Total number of plants/test plot assayed is indicated by N. The percentage of damaged broccoli plants is indicated by %. See text for method of U-12171 application.

	DAMAGE LEVEL	1 JULY	2 JULY	6 JULY	9 JULY	17 JULY
TEST PLOT 1	Zero	17	14	4	1	1
1.50 lbs of	Low	30	31	11	8	1
U-12171/acre	Med	12	10	39	35	33
(N = 59)	High	0	4	5	15	24
	(%)	71	76	93	98	98
TEST PLOT 2	Zero	56	38	23	9	5
0.50 lbs of	Low	9	21	20	18	11
U-12171/acre	Med	5	11	24	32	32
(N = 70)	High	0	0	3	11	22
	(%)	20	46	67	87	93
TEST PLOT 3	Zero	47	37	17	9	5
0.75 lbs of	Low	20	28	22	17	6
U-12171/acre	Med	9	11	27	28	30
(N = 77)	High	1	1	11	23	36
	(%)	38	52	78	88	94
TEST PLOT 4	Zero	33	28	8	5	2
1.00 lbs of	Low	27	29	22	15	4
U-12171/acre	Med	3	6	24	21	26
(N = 63)	High	0	0	9	23	31
	(%)	48	56	86	94	97
TEST PLOT 5	Zero	43	37	15	8	7
0.00 lbs of	Low	24	29	25	13	8
U-12171/acre	Med	4	5	21	35	29
(N = 71)	High	0	0	10	15	27
	(%)	39	48	79	89	90

exert no overt repellent effect. In fact, at harvest the percentage of damaged plants was lowest (90%) in Plot 5 (untreated) and highest (90%) in Plot 1(most heavily treated with U-12171; 1.50 lb./acre). Plot 1 was nearest to the linnet roosting and staging area, so the higher damage there may have been a function of location. This is somewhat substantiated by the very high damage levels on Plot 1 in early July relative to damage levels sustained in the other test plots in Field 1.

As mentioned, the first application of U-12171 to Field 2 was washed from the plants by heavy rains. Further applications in equal amounts on 23 and 27 July doubled the initial amounts on each test plot in Field 2. The initial application was 34 days before harvest, before linnet activity was appreciable in this field (Table 2). The late-July treatment reduced linnet feeding substantially in Field 2 (Table 4). Damage was much less in plots with higher concentrations (1.50, 2.00 and 3.00 lb./acre)

Table 4. Damage levels on Gem hybrid broccoli plants in Field 2 as a function of linnet activity through time. Ratings indicate zero, low (1-25%), medium (26-75%), and high (76-100%) of maturing seed pods damaged or destroyed by linnets. Method of assay was repeated inspection of individual plants located in two 50-sq-ft sample sections in each of the 3-acre test plots. Total number of plants/test plot assayed is indicated by N and the percentage of damaged broccoli plants by %. See text for method of U-12171 application.

	DAMAGE LEVEL	8 JULY	11 JULY	16 JULY	18 JULY	22 JULY	25 JULY	27 JULY	29 JULY	31 JULY	9 AUG
TEST PLOT 6	Zero	62	46	41	30	19	9	6	4	2	2
0.00 lbs of	Low	11	25	25	35	41	44	33	24	20	18
U-12171	Med	0	2	7	8	12	19	32	39	40	41
(N = 73)	High	0	0	0	0	1	1	2	6	11	12
	(%)	15	37	44	59	74	88	92	95	97	97
TEST PLOT 7	Zero	43	40	33	31	29	24	16	12	1	1
1.00 lbs of	Low	6	8	10	9	11	14	16	10	12	8
U-12171/acre	Med	0	1	5	8	8	10	15	25	32	36
(N = 49)	High	0	0	1	1	1	1	2	2	4	4
	(%)	12	18	33	37	41	51	67	76	98	98
TEST PLOT 8	Zero	66	65	57	57	50	35	24	24	24	22
2.00 lbs of	Low	3	4	9	9	14	22	28	28	25	25
U-12171/acre	Med	0	0	3	3	4	11	15	15	18	20
(N = 69)	High	0	0	0	0	1	1	2	2	2	2
	(%)	4	6	17	17	28	49	65	65	65	68
TEST PLOT 9	Zero	57	56	56	56	54	54	47	47	47	47
3.00 lbs of	Low	3	4	4	4	5	5	12	12	12	20
U-12171/acre	Med	0	0	0	0	1	1	1	1	1	3
(N = 60)	High	0	0	0	0	0	0	0	0	0	0
	(%)	5	7	7	7	10	10	22	22	22	38
TEST PLOT 10	Zero	75	71	71	71	71	41	36	36	36	34
1.50 lbs of	Low	1	5	5	5	5	34	29	26	33	12
U-12171/acre	Med	0	0	0	0	0	1	11	14	17	29
(N = 76)	High	0	0	0	0	0	0	0	0	0	1
	(%)	1	7	7	7	7	46	53	53	53	55

than in Plots 6 and 7 (0.00 and 1.00 lb./acre). Damage on those last plots was as great as in Field 1. Even before the second application (when U-12171 concentrations were only half the final levels in each plot), damage was inversely proportional to the level of U-12171 applied. Perhaps the strongest evidence that U-12171 is a linnet repellent is the stabilized damage levels subsequent to the 27 July application, which gave total concentrations as high as 1.50, 2.00, and 3.00 lb./acre (Fig. 1). It might be argued that this apparent repellent effect in certain plots in Field 2 might result from the feeding in Field 1, where damage was indeed heavy (Table 3). However, there were considerable numbers of linnets in Field 2 (Table 1), and heavy damage did occur in the control test plot and the lowest U-12171 concentration (Table 4). Thus, it seems likely that the differential amounts of damage in the various plots of Field 2 were a direct result of the level of U-12171 applied.

The efficacy of U-12171 as a linnet repellent may also relate to the location of the treated area relative to roosting-staging sites and to other areas of U-12171 treatment. Plots 1 and 10 were each treated with 1.50 lb./acre and were at extreme ends of the two fields (Fig. 1). The total percentage of damaged plants was much greater in Plot 1 (98%) than in Plot 10 (55%). The differential may be a function of the high (2.00 and 3.00 lb./acre) concentrations separating Plot 10 from the rest of the field (Fig. 1). Thus the feeding pattern of linnet groups ("hop-scotch" movements of short distance, perhaps only 5-10 feet) would result in the highest U-12171 concentrations becoming an effective barrier protecting the plants in Plot 10, whereas no such concentrations were present to protect Test Plot 1.

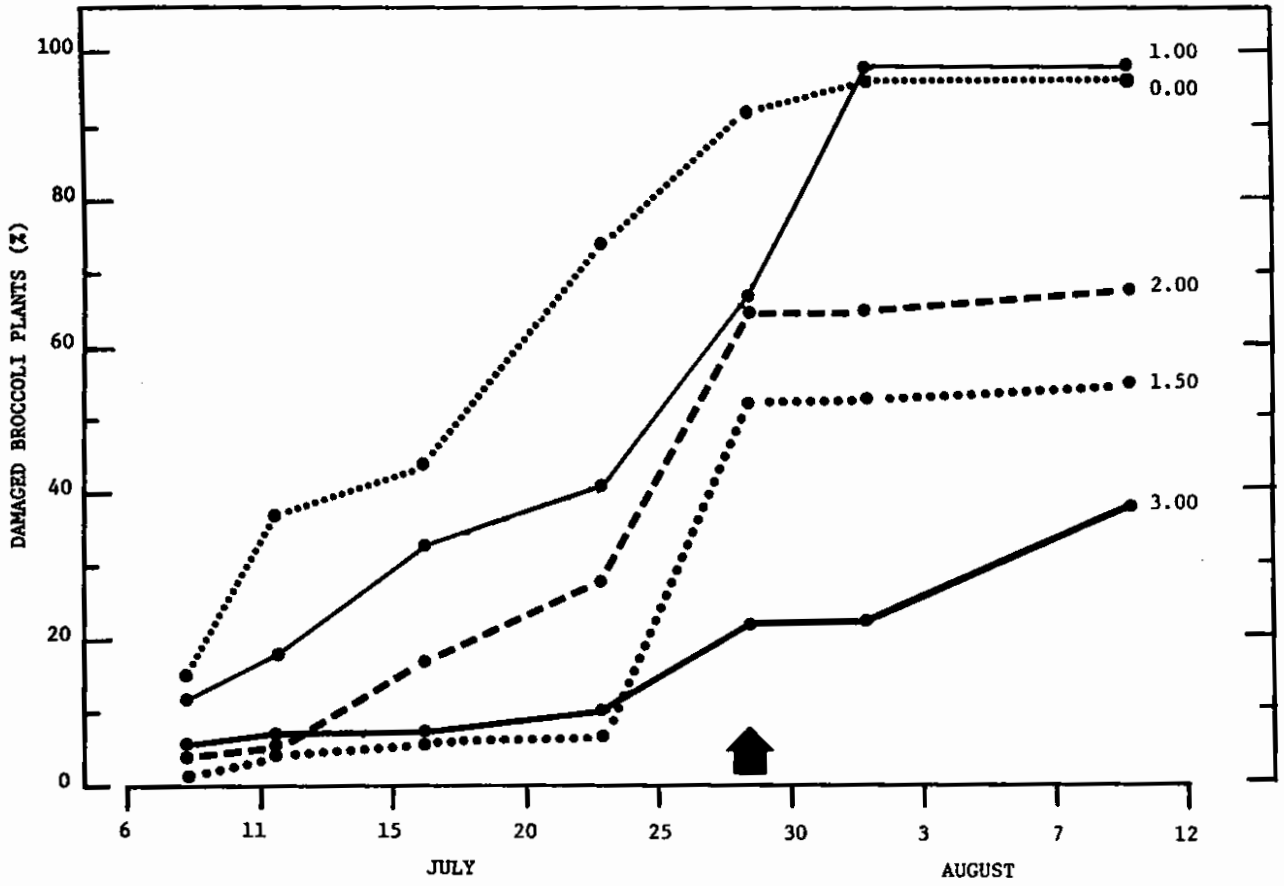

Figure 1. Chronology of damage to Gem hybrid broccoli plants resulting from linnet feeding activity relative to levels of U-12171 applied to 3-acre test plots in Field 2. See Table 3 for detailed analysis of damage levels, dates of assay, numbers of plants assayed, and the text for description of assay methods. First application of U-12171 was on 6 July 1974, and the final, indicated by the arrow, on 27 July.