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Protecting agricultural crops from attacking of crested lark, *Galerida cristata* (L.) using insecticide and fungicide repellents

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Abstract
The bird crested lark (*Galerida cristata* L.) causes significant damage to many field crops, especially during the sowing stage. So a field experiment was conducted to investigate the efficacy of an insecticide and a fungicide as well as their mixture as repellents to *G. cristata* from seed depredation during the seeding stage at the experimental farm of the National Research Center, El-Moghra, Matrouh governorate, Egypt during 2023/2024 season. Safflower (*Carthamus tinctorius* L.), quinoa (*Chenopodium quinoa* Willd.), triticale (*Triticosecale* sp.), and sugar beet (*Beta vulgaris* L.) seeds were treated with methomyl (Lannate®) and tolclofos-methyl (Rizolex-T®) at a rate of 1 and 3g/1 Kg seeds, respectively, in addition to the mixture of both with half dose of each. The results showed that the insecticide and fungicide worked well as bird repellents to protect crop seeds from the crested lark bird during seeding stage. Lannate resulted in the lowest empty holes across the four-plant species, with reductions in empty holes of 13.33%, 22.22%, 26.67%, and 14.44% for the abovementioned plant species, respectively followed by Rizolex-T and the combination of Lannate and Rizolex-T which induced similar rates of low ingestion, with no significant differences. On the other hand, in untreated control plots, *G. cristata* ingested more seeds, with percentages of 83.33%, 86.67%, 98.89%, and 82.22%, for the four-plant species, respectively. Thus, applying these chemical repellents proved to be highly efficient in protecting the four agricultural crops, and could be dependable as an element of integrated pest management (IPM).

Keywords: Wild bird, pesticides, repellents, crop depredation

Introduction

Bird pest infestations cause significant economic damage to crops all over the world, with estimates from 0.25% to 0.80% of the total agricultural production losses (Weatherhead *et al.*, 1982) [1]. In Egypt, the crested lark (*Galerida cristata* L.) is regarded as one of the most economic vertebrate pests in agricultural lands, particularly in newly reclaimed ones, and it causes damage to various crops by feeding on seeds during the sowing stage (Wilson 1993 [2] and Metwally, *et al*., 2009) [3]. This bird pest is extensively distributed in the region of El-Maghrah and seriously damages valuable crops at the sowing stage (Al-Hussaini, 1938 [4]). In many countries, the agricultural environment allows normal crop productions, but some countries suffer from adverse effects, such as seed predation by various birds (Schackermann *et al*., 2015) [5]. Bird pests cause enormous seasonal damage to agricultural crops, and represent a significant global economic problem, particularly for the growers who neglect pre-treat seeds with repellent insecticides (Klosterman *et al*., 2013) [6].

Chemical repellents are often classified as primary or secondary repellents (Sayre and Clark, 2001) [7]. Birds usually avoid primary repellents because they upset their peripheral chemical sensors. Pre-plant seed treatments are highly frequently required to protect seeds and pre-emergent seedlings from bird predation while maintaining seed germination (DeLiberto and Werner, 2016) [8]. Seed treatments with insecticidal and fungicidal products are a widespread practice; as number of substances, including methyl anthranilate, anthraquinone, and thiram have previously been used as bird repellents (Moran, 2001[9]; Kennedy and Connery, 2008 [10]; Cummings *et al.*, 2002 [11]; Mason, 1990 [12]; Mason and Primus, 1996 [13]; Avery and Decker, 1991 [14] and Scott and Michael, 2017 [15]).

The current study was carried out to investigate the efficacy of some insecticides and fungicides in repelling the crested lark (*Galerida cristata*) away from feeding on seeds of safflower, quinoa, triticale, and sugar beet during the sowing stage.

Materials and methods

Experimental site and objectives

The current field experiment was conducted at the experimental farm of the National Research Center, El-Maghrah, Matrouh governorate, northern coast of Egypt (about 440 km north west of Cairo) during 2023/2024 winter season. The objective was to evaluate the efficacy of an insecticide and a fungicide as well their mixture in repelling the crested lark (*Galerida cristata* L.) away from attack of four crops.

Experimental design

This experiment was laid out in a complete randomized complete block design (RCBD) with four treatments; (three pesticide treatments, as well as an untreated control) in three replicates. Thus, the experimental area was divided into 12 plots (each plot measured 7 × 12 m, with four ridges) for each crop.

Pesticides

Three seed treatments, as well as untreated check were as follows:

1. Seeds treated with methomyl (Lannate® 90% SP) at a rate of 1 g/ 1 Kg seeds.
2. Seeds treated with tolclofos-methyl (Rizolex-T® 50% WP) at a rate of 3g/1 Kg seeds.
3. Seeds treated with a mixture of methomyl (Lannate® 90% SP) and tolclofos-methyl (Rizolex-T® 50% WP) with a half dose from each/1 Kg seeds.
4. Untreated control

Seeds of the abovementioned plants were dipped in water combined with used chemicals for 5 minutes, then screened and covered with plastic sheet for about three hours, depending on the material, to allow the surface water be absorbed before drying outdoors.

Seed distribution and planting

Seeds of safflower (*Carthamus tinctorius*), quinoa (*Chenopodium quinoa*), triticale (*Triticosecale* species), and sugar beet (*Beta vulgaris*) were planted using the hand planter on the 15th of October in 2023. Each plot contained 30 holes, as three holes per ridge, and 10 seeds per hole. The holes were marked with very short sticks, to monitor and count the ingested seeds by the bird, crested lark

Data recorded

A. Percentage of empty holes

Number of empty holes due to ingesting of the seeds by the crested lark was daily counted from one up to seven days after sowing. Percentages of empty holes were calculated as follows:

Empty holes were calculated from the first to the seventh day after each treatment to determine the percentage of empty holes per 30 seeds. From the 1st up to the 7th day, the number of empty holes was determined for each day.

$$\text{Percentage of empty holes (\%)} = \frac{\text{Number of empty holes}}{\text{Total number of sown holes (30)}} \times 100$$

B. Reduction percentage of empty holes due to crested lark feeding

After sowing stage, the holes were inspected, and the empty ones were calculated in each plot from 1st up to 7th days after application. According to Guo *et al.* (2013) [16], the reduction percentage in empty holes due to repellent treatments was calculated as follows: Reduction % = ((Total number of empty holes in control - Total number of empty holes in treatment) / Total number of empty holes in control) × 100.

Statistical analysis

Data were subjected to analysis of variance (ANOVA) and to "F" test. To compare means of the different treatments, a computer program (Costat Software, 1988 [17]) was used to calculate the least significant differences (L.S.D.) at the 0.05 level, and means were also compared using Duncan's Multiple Range Test (Duncan, 1955 [18]).

Results

Percentage of empty holes due to crested lark feeding crested lark

Results presented in Tables (1 to 4) show the effect of the tested compounds as repellents to protect the seeds of *Carthamus tinctorius*, *Chenopodium quinoa*, *Riticosecale* species, and *Beta vulgaris* from attacks of the crested lark, *Galerida cristata*, during the sowing stage of 2023/2024 season.

Results in Table (1) showed that all plots treated with Lannate had the lowest number of empty holes of *Carthamus tinctorius* seeds, with a total of 4 empty holes and a percentage of 13.33%, followed by Rizolex-T, and Lannate + Rizolex-T mixture, with values of 7.33 and 6.67 empty holes and percentages of 24.44 and 22.33%, respectively, with no significant differences among the three treatments. In contrast, the untreated control had the highest number of empty holes (25.00 holes/30 holes and percentage of 83.33%.

Table 1: Efficiency of Lannate and Rizolex-T and their mixture as repellents for the crested lark, *Galerida cristata*, on the safflower, *Carthamus tinctorius* crop

Treatment	Rate (g)/ 1 Kg seeds	Number of empty holes as indicated by days post-treatment/ 30 sown holes							Total	%
		1st day	2nd day	3rd day	4th day	5th day	6th day	7th day		
Lannate	1	1.33^{b*}	0.67^{b}	0.33^{a}	0.33^{a}	0.67^{a}	0.67^{b}	0.00^{b}	4.00^{b}	13.33^{b}
Rizolex-T	3	2.33^{b}	2.00^{b}	0.33^{a}	1.00^{a}	0.33^{a}	1.33^{b}	0.00^{b}	7.33^{b}	24.44^{b}
Lannate + Rizolex-T	0.5 + 1.5	2.00^{b}	1.33^{b}	0.33^{a}	1.00^{a}	0.67^{a}	1.33^{b}	0.00^{b}	6.67^{b}	22.22^{b}
Untreated control	-	8.00^{a}	5.33^{a}	1.67^{a}	1.67^{a}	2.67^{a}	4.00^{a}	1.67^{a}	25.00^{a}	83.33^{a}
LSD0.05		2.24	1.88	1.72	2.03	3.31a	1.88	1.96	8.03	26.75

* Means in each column followed by the same letter (s) are not significantly different at the 0.05 probability

Also, the listed results in Table (2) showed that Lannate treated plots had the lowest empty holes of *Chenopodium quinoa* seeds, with a value of 6.67 empty holes and a percentage of 22.22%, followed by Rizolex-T and Lannate + Rizolex-T mixture, with values of 7.33 and 9.00 empty holes and percentages of 24.44 and 30.00%, respectively, with no significant differences. In contrast, the untreated control had the highest total number of empty holes (26.00/ 30 sown holes) and percentage of 86.67%.

Table 2: Efficiency of Lannate and Rizolex-T as a bird repellent for the crested lark, *Galerida cristata*, on quinoa, *Chenopodium quinoa* crop

Treatment	Rate (g)/ 1 Kg seeds	Number of empty holes as indicated by days post-treatment/ 30 sown holes							Total	%
		1st day	2nd day	3rd day	4th day	5th day	6th day	7th day		
Lannate	1	2.00^{b}	1.33^{b}	0.67^{a}	0.33^{a}	2.00^{a}	0.00^{b}	0.33^{b}	6.67^{b}	22.22^{b}
Rizolex-T	3	2.33^{b}	2.00^{b}	0.33^{a}	1.00^{a}	0.33^{a}	1.33^{ab}	0.00^{ab}	7.33^{b}	24.44^{b}
Lannate + Rizolex-T	0.5 + 1.5	2.00^{b}	1.33^{b}	1.00^{a}	0.67^{a}	2.00^{a}	1.33^{ab}	0.67^{ab}	9.00^{b}	30.00^{b}
Untreated control	-	8.00^{a}	5.33^{a}	1.67^{a}	1.67^{a}	2.67^{a}	3.33^{a}	3.33^{a}	26.00^{a}	86.67^{a}
LSD0.05		2.55	1.88	2.11	1.88	3.07	2.82	3.12	8.30	27.66

* Means in each column followed by the same letter (s) are not significantly different at the 0.05 probability

Data in Table (3) revealed that triticale plots treated with the insecticide, Lannate had the lowest number of empty holes (8.00 empty holes/ 30 sown holes), which means 26.67% empty holes out of total. The corresponding results of Rizolex-T fungicide as well as the mixture of insecticide and fungicide were 11.33 and 10.00 empty holes/30 sown holes, with percentage of empty holes of 37.78 and 33.33%, respectively. No significant differences were detected among the three treatments. These treatments exhibited significant differences with untreated control, which had 29.67 empty holes/ 30 sown holes, and 98.89% reduction in number of seeded holes.

Table 3: Efficiency of Lannate and Rizolex-T and their mixture as repellents for the crested lark, *Galerida cristata*, on triticale, *Triticosecale* sp. crop

Treatment	Rate (g)/ 1 Kg seeds	Number of empty holes as indicated by days post-treatment/ 30 sown holes							Total	%
		1st day	2nd day	3rd day	4th day	5th day	6th day	7th day		
Lannate	1	2.00b	2.00b	1.67b	0.67b	0.33b	0.67a	0.67a	8.00b	26.67b
Rizolex-T	3	1.33b	2.00b	2.00b	1.67ab	1.00b	1.33a	2.00a	11.33b	37.78b
Lannate + Rizolex-T	0.5 + 1.5	1.67b	1.67b	1.67b	1.33ab	1.00b	1.00a	1.67a	10.00b	33.33b
Untreated control	-	8.33a	7.33a	5.00a	2.67a	3.67a	1.33a	1.33a	29.67a	98.89a
LSD0.05		3.39	1.54	1.22	1.72	2.61	2.11	1.88	9.86	32.86

* Means in each column followed by the same letter (s) are not significantly different at the 0.05 probability

Results in Table (4) display the effects of repellent compounds against the crested lark in sugar beet fields. The most effective was Lannate, followed by Lannate + Rezolex-T mixture, with 14.44 and 25.56 empty holes/ 30 sown holes, indicating into 14.44 and 25.56% empty holes/ 30 sown holes, out of total 30 ones. The third rank of repellence efficiency was that of Rezolex, with 30.00% empty holes out of total. As in the previous results, no significant differences were detected among the three treatments. In the untreated plots 82.22% of holes were free from sugar beet seeds that were ingested by this predatory bird.

Table 4: Efficiency of Lannate and Rizolex-T and their mixture as repellents for the crested lark, *Galerida cristata*, on sugar beet, *B. vulgaris* crop

Treatment	Rate (g)/ 1 Kg seeds	Number of empty holes as indicated by days post-treatment/ 30 sown holes							Total	%
		1st day	2nd day	3rd day	4th day	5th day	6th day	7th day		
Lannate	1	1.00b	1.00b	0.67a	0.67a	0.67a	0.33a	0.00b	4.33b	14.44b
Rizolex-T	3	1.33b	2.00b	1.67a	0.67a	1.33a	2.00a	0.00b	9.00b	30.00b
Lannate + Rizolex-T	0.5 + 1.5	1.33b	1.67b	1.33a	0.67a	1.33a	1.33a	0.00b	7.67b	25.56b
Untreated control	-	8.33a	7.33a	2.67a	2.33a	1.33a	1.33a	1.33a	24.67a	82.22a
LSD0.05		2.98	1.54	2.37	2.37	1.96	1.88	1.09	12.06	40.19

* Means in each column followed by the same letter (s) are not significantly different at the 0.05 probability

Reduction percentage in empty holes due to the repellents

Results in Table (5) show the reduction percentage in empty holes of seeds of the four abovementioned crops due to feeding of crested lark bird after applying with different treatments as repellents. Among the treatments, Lannate demonstrated the highest efficacy in reducing seed consumption, with a remarkable 84.00% reduction in *Carthamus tinctorius* and 82.45% in *Beta vulgaris*. Rizolex-T came second, showing significant effects, achieving reductions in empty holes ranging from 61.18% to 71.81% across the four-crop species. The combination of Lannate + Rizolex-T yielded moderate results, with reductions between 65.38% and 73.32%. Overall, the data highlight the effectiveness of the tested compounds as bird repellents, contributing to the protection of crops from avian ingestion during seed stage.

Table 5: Reduction percentage in empty holes of winter crops due to chemical treatments as repellents to the bird, crested lark

Treatment	Rate (g)/ 1 Kg seeds	*Carthamus tinctorius*		*Chenopodium quinoa*		*Riticosecale* species		*Beta vulgaris*	
		Empty holes							
		Total No.	Reduction%	Total No.	Reduction%	Total No.	Reduction%	Total No.	Reduction%
Lannate	1	4.00b*	84.00a	6.67b	74.35a	8.00b	73.04a	4.33b	82.45a
Rizolex-T	3	7.33b	70.68a	7.33b	71.81a	11.33b	61.81a	9.00b	63.82a
Lannate + Rizolex-T	0.5 + 1.5	6.67b	73.32a	9.00b	65.38a	10.00b	66.30a	7.67b	68.91a
Untreated control	-	25.00a	0.00b	26.00a	0.00b	29.67a	0.00b	24.67a	0.00b
LSD0.05		8.03	29.76	8.30	35.16	9.86	29.83	12.06	20.87

* Means in each column followed by the same letter (s) are not significantly different at the 0.05 probability.

Discussion

It has been demonstrated that applying insecticide and fungicide treatments to crop seeds can protect them from predation of crested lark, *Galerida cristata*. Many techniques, which focused on insecticidal and fungal repellents, have been developed to prevent birds from damaging agricultural seeds during the seeding stage. According to Niekerk (2009) [19], these birds reduced sunflower yields in South Africa by 12.7%, resulting in $ 11.00 million loss in income. In North America, red-winged blackbirds alone caused $5.4 million yearly loss in sunflower crops, with localized damage being especially severe (Peer *et al.*, 2003 [20] and Shwiff *et al.*, 2017 [21]). Despite human efforts to chase seed predatory birds away, village weavers and african mourning doves caused over 60% seed loss in sorghum fields (Hiron *et al.*, 2014 [22]). The overall yearly economic damage from birds in the United States surpasses $4.7 billion, indicating the scale of the problem (Shwiff *et al.*, 2017 [21]). Localized damage can be economically devastating for individual producers, particularly in areas with high bird populations during important growth seasons (Peer *et al.*, 2003 [20]). Also, the seed repellent minimized chemical hazards allowing effective pest management while maintaining seed viability (DeLiberto and Werner 2024) [23]. The use of insecticide and fungicide seed repellents shows promise in protecting seeds from birds, concerns about the environmental impact and potential harm to non-target species remain. Balanced effective pest control with ecological considerations is crucial for sustainable agricultural practices, and developing Integrated Pest Management (IPM) programs.

Conclusion

The current results demonstrate the effectiveness of different compounds as bird repellents for various plant species. Overall, across all plant species studied, Lannate demonstrated the lowest seed consumption among other treatments compared to untreated control and thus was the most effective treatment, followed by the mixture of Lannate and Rizolex-T, or Rizolex-T alone, without significant differences.

Ethics approval and consent to participate

None of the authors of this article have conducted any research with humans or animals.

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Declaration of competing interest

The authors declare that they have no known conflicting financial interests or relationships that might have influenced the work presented in this publication.

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