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Comparative Effectiveness of Repellents for Rose-Ringed Parakeet and House Crow at University of Agriculture, Faisalabad, Pakistan

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ABSTRACT

Present paper provides information on the comparative effectiveness of the three repellents: mist nets, reflecting ribbons and distress sound player with respect to the five economically significant crops viz. maize, chickpea, sugarcane and sunflower for the two birds, *Psittacula krameri* and *Corvus splendens* at the mature crop stages. Mist nets are considered physical barrier on the various crops to maximally deter their damage and, therefore, act as the potential repellents against the birds. Present study was conducted from January through December, 2021 to determine the movements patterns of the rose-ringed parakeet and house crow impacted by the repellents at the students' farms of the University Campus. Observations were recorded in the two one-acre crops for eight hours, four each in the morning and afternoon durations, 05:30-9:30 am and from 13:30-17:30 pm, respectively. They were further differentiated for period of 30-min in the two observations hours for the controlled and repellent treated conditions. Apparently, the two crops, sunflower and maize, were significantly damaged by the rose-ringed parakeet in the controlled conditions. They depicted their means 506.43±2.54 and 537.57±5.52. Nonetheless, in the repellents treated conditions, the means were 242.29±4.95 and 273.14±5.86. Mean damage recorded for the crows in controlled conditions for the sunflower was 510.86±7.11 and for maize it was 464.43±3.20. It was, therefore, evident that the repellents sufficiently reduced the numbers of attacking birds on all the crops. Conclusively, the non-chemical measures should be considered obligatory in agriculture to decrease not only the bird depredations but also to maintain the ecosystem sustainability.

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HAK conceived the idea and designed the experiment. SM worked on the proposed research with mutual consultation of SA and MA.

Key words
Croplands, Ecosystem, Sustainability, Habitats, Forest plantations, Ecological friendly

INTRODUCTION

Birds are economically important pests, cause crop mutilation at various growth stages with resulting significant economic losses. Therefore, comparable damage appears to be serious at the various agricultural and horticultural interests (Elliott and Bright, 2007; Elser *et al*., 2019). Present depredations become largely debilitating to the farmers and stakeholders in the unprotected environments. As such significant economic losses have been recorded owing to their intermittent incursions (Ahmad *et al*., 2012a, b; Lindell *et al*., 2012; Anderson *et al*., 2013). Majority of the birds are also recognized as vectors of various zoonotic infections viz. avian influenza, chlamydiosis, avian trichomoniasis and salmonellosis (Davis *et al*., 2015) besides their destructive impacts on economically important crops viz. wheat, maize, sugarcane, sunflower, the mandarin orange, mango and few others, therefore, likely to cause severe economic losses (Khan *et al*., 2015; Batool *et al*., 2019; Klug *et al*., 2023).

The wheat crop is well recognized worldwide and is a significant food crop of Pakistan. It contributes more than 25% value-added chain (VAC) of agriculture in Pakistan with almost 28 million tons of export per year (World-Grain, 2020; IPAD, 2024). Importance of sunflower is also invaluable due to its oil production. It is cultivated over 22 million hectares worldwide (Khan, 2002; Skoric *et al*., 2006). Cultivation of sunflower (108 million tons), maize (6.3 million tons), sugarcane (46 million tons) and chickpea (238 million tons) also predominantly contributes in the agriculture of Pakistan with their substantial food and economics (FAO, 2017; GAIN, 2023; GOP, 2024). Undeniably, the rose-ringed parakeet *Psittacula krameri*, crow *Corvus splendens*, sparrow *Passer domesticus*, rock pigeon *Columba livia* and rosy starling *Pastor roseus*

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occur as significant bird pests of the croplands with variable feeding niches, causing considerable damage and economic losses (Khan *et al*., 2013; Klug *et al*., 2023; Hess *et al*., 2023).

Due to their pestiferous abilities, incorporation of bird-repellents like the metallic drums, pyro-technics and using the fearsome models in the fields, have been used to scare away the invading birds for different crops (Gilsdorf, 2002; Witmer *et al*., 2009). The traditional approaches are not sufficient to inhibit the depredations of birds on a variety of crops. Customarily, the repellents have provided benefits to inhibit not only the damage patterns but also economic losses for sustainability and to attain the sustainable developmental goals (Ahmad *et al*., 2012a,b; Linz *et al*., 2012; Hannany *et al*., 2019). Of these, mechanical measures to repel away bird pests includes reflecting ribbons (tapes), multi-mirror reflectors, hawk eye rotator, sound players with scary sounds, terrifying kites, scary balloons. Reflecting ribbons have been ecologically safe selection to be more effective (Hafeez *et al*., 2008; Khan *et al*., 2011).

Bird management for the farmlands is a complex mechanism and requires the ecologically viable methods to deter their sporadic infestations. Precision and regulated approaches should always be implemented to reduce their damage patterns (Seamans and Gosser, 2016). The repellents or deterrents in the modern time stress on their exact mechanisms, placement and environmental safety to scare and repel the attacking birds. Some of them can be somewhat expensive, while the others remain cost-effective and in the access to the farmers and stakeholders. Considering some of the repellents to be less cost-effective would prove beneficial resulting in large crop output (Clarke, 2004; Elliot and Bright, 2007; Seamans and Gosser, 2016). Various types of bird repellents *viz*. distress sound player, glossy ribbons, hawk eye rotators, fearsome bird models and large helical balloons have been developed to protect the crops without infringements to the environment. The results obtained with such management measures have been encouraging in improving the crop production and sustainability (Lindell *et al*., 2012; Ahmad *et al*., 2012a, b; Swaddle *et al*., 2016; Li *et al*., 2018).

Present study was designed to compare and contrast the controlled and repellent treated maize and sunflower crops in the designated agricultural sites for the probable reduced attacks of the rose-ringed parakeet and the house crow for the five economically important crops *viz*. wheat, maize, sugarcane, chickpea and sunflower for their relative effectiveness and management.

MATERIALS AND METHODS

Study sites

The present study was conducted at the Students' Farms of the University Campus located in the Faisalabad, Punjab, Pakistan. It occurs between 31.42°N latitude and 73.07°E longitude with an elevation of 184 m (Abdullah *et al*., 2017; Shakoor *et al*., 2018). This district covers the area 58.56 km^2 with the two rivers, Ravi and Chenab, on the northern and southern sides of Faisalabad. The Central Punjab contributes predominantly for the canal irrigation system (CIS) and various the excavated water channels (Punjab Portal, 2016). The district Faisalabad is enriched in several economically important crops with the differential old and tall trees comprises viz. *Salmalia malabarica, Dalbergia sissoo, Ficus benghalensis, Cedrella toona, Terminalia arjuna, Momordica charantia, Pinus roxburghii, Eucalyptus* species and few more (Khan *et al*., 2015; Batool *et al*., 2019).

Present investigations were only limited at the Students' Farms of the University Campus of the Faisalabad. Here, variety of agricultural and horticultural crops were cultivated and majority of them were; wheat, maize, sugarcane, fodders, sunflower, chickpea, citrus, guava, dates, mango, pomegranate and watermelon (Ahmad *et al*., 2019; Nazir and Mehmood, 2021).

Design and sampling

This study provided information for the infestations of rose-ringed parakeet and house crow in the untreated (controlled) and treated (repellents) management measures for both the birds for a period of one year, January through December, 2021. The main focus of the present study was to determine the population abundance and to reduce the impact of rose-ringed parakeet and house crow with the incorporation of the repellents *viz*. reflecting ribbons, distress sound players and mist nets. In all, five growing crops, wheat, maize, sugarcane, sunflower and chickpea were sampled in the selected one-acre experimental plots. Observations were recorded for four hours (30-min for each interval) in the morning and evening hours to assess the likely impact of the two birds on the stipulated crops during the total period of the investigations to adjudge the crop economics.

Implications of the repellents were incorporated at the mature stages. Repellents comprised the reflecting ribbons, distress sound player and mist nets, which were concurrently implicated for single acreage of crops for one week at the students farms of the agricultural research area. All observations continued without any hiatus distinctly as controlled and treated conditions. Numerical assessments were later made for both the crop states to record the

least depredated crops as impacted through the induced repellents with the treated crop profiles till the conclusion of the investigations.

Data analysis

The obtained numerical data were analyzed using the Minitab version 21 (Stroup, 2012) and was implicated with generalized liner model (GLM) test to assess their statistical significance along with the post-hoc test (Tuckey's test). For assessing their significant differences, incorporation of the Analysis of Variance was also applied wherein, the days of observations and selected crops were considered as variables and indicated highly effects of the numerical abundance of rose-ringed parakeets and the house crow on their daily basis crop visitations (Steel *et al*., 1997).

RESULTS

Present results depicted that in the morning time intervals, the average sunflower damage by the rose-ringed parakeets was 439.14±5.02; 132.43±2.51 and that for the maize it was 389.00±1.13; 146.14±3.61. For the wheat, yet again, the damage was 360.00±2.37; 124.00±1.86, for the chickpea it was 326.71±23.2; 91.14±11.4, nonetheless for the sugarcane crop it reflected 311.29±2.12; 62.71±0.68 in controlled and treated conditions (Table Ia). However, in the evening time intervals depredations were significantly reduced as compared to morning time intervals. During the evening durations, mean values in controlled and treated conditions for all the sampled crops were: 127.00±2.36; 117.43±1.99 for maize, 114.14±1.49; 101.00±3.01 for wheat, 109.86±2.61; 98.43±1.84 for sunflower, 93.43±3.31; 74.43±9.86 for chickpea and 87.71±1.04; 47.14±1.55 for the sugarcane, respectively. Perceptibly, the parakeets had left this crop well before the sunset (Table Ib). Similarly, the parakeets showed higher predilections for sunflower and maize crops for their overall day long predatory activities. The value for the sunflower was 537.57±5.52; 242.29±4.95, and for the maize was 506.43±2.54; 273.14±5.86. For the wheat, chickpea and that of the sugarcane values were 474.14±3.69; 225.00±4.04, 420.14±26.25; 165.57±21.25 and 399.00±1.98; 109.86±2.11 subsequently. Conclusively, treatments depicted strong statistical impact to reduce the parakeets crop movements per day in repellent treated crop fields (Table Ic).

Observations on house crow at the mature stages of the designated crops, evidently, proportion of crows which entered in the morning specific time intervals (30-min) were fairly high in the untreated or controlled crop conditions. However, with the inception of the repellents,

Table I. Analysis of variance (mean squares) for parakeets.

Source	Degrees of freedom	Mean squares		
		Entering	Leaving	Total
Days	6	574.0	87.1	980.0
Crop	4	23169.0**	6453.5**	50744.0**
Group	1	1128522.0**	1872.1**	1222321.0**
Crop x Group	4	3147.0**	1633.7**	2506.0*
Error	54	503.0	101.2	882.0
Total	69			

Table Ia. Crop and group interactions means for parakeet movements (entry) in diurnal hours.

Crop	Group		Mean
	Control	Treated	
Wheat	360.00±2.37bc	124.00±1.86ef	242.00±32.76B
Maize	389.00±1.13b	146.14±3.61e	267.57±33.73A
Sugarcane	311.29±2.12d	62.71±0.68g	187.00±34.49C
Chickpea	326.71±23.2cd	91.14±11.4fg	208.93±34.95C
Sunflower	439.14±5.02a	132.43±2.51e	285.79±42.62A
Mean	365.23±9.04A	111.29±5.69B	

Table Ib. Rose-ringed parakeet mean interactions recorded for leaving per day.

Crop	Group		Mean
	Control	Treated	
Wheat	114.14±1.49abc	101.00±3.01be	107.57±2.43B
Maize	127.00±2.36a	117.43±1.99ab	122.21±1.99A
Sugarcane	87.71±1.04ef	47.14±1.55g	67.43±5.70D
Chickpea	93.43±3.31de	74.43±9.86f	83.93±5.65C
Sunflower	109.86±2.61ad	98.43±1.84cde	104.14±2.21B
Mean	102.23±2.18A	91.89±5.24B	

Table Ic. Total movement patterns of the parakeets in the day long.

Crop	Group		Mean
	Control	Treated	
Wheat	474.14±3.69b	225.00±4.04d	349.57±34.65B
Maize	506.43±2.54ab	273.14±5.86d	389.79±32.50A
Sugarcane	399.00±1.98c	109.86±2.11f	254.43±40.12D
Chickpea	420.14±26.25c	165.57±21.25e	292.86±38.85C
Sunflower	537.57±5.52a	242.29±4.95d	389.93±41.10A
Mean	467.46±10.25A	203.17±10.90B	

the attacking behavior largely subsided as for wheat 331.57±2.51; 115.29±2.41. Minimum pillage was recorded on the chickpea 297.29±15.22; 91.29±13.88 and highest on sunflower 411.57±3.90; 117.57±2.98, indicating the predilection of the crows with sunflower. Similarly, maize 346.00±3.01; 130.86±3.00 and sugarcane 300.43±2.63; 55.29±0.87 also indicated reasonable occurrence of house crow. Overall, in the diurnal hours, significant results pointed out the statistical variance, and the effectiveness of the three repellents to inhibit the crow depredations (Table II). Information for the house crows in the evening time durations at the time of leaving the crops suggested that, invariably the proportion of crop pillage was least as compared to the morning hours which apparently described somewhat hurrying behavior of the crows to reach their roosts. For maize, wheat and sunflower crows indicated higher tenacities 118.43±0.48; 115.57±2.54, 115.86±1.62; 93.00±2.21 101.29±2.84; 99.29±3.35 as compared to average values of chickpea 92.00±0.72; 74.86±12.55 and sugarcane 87.29±1.51; 43.00±1.60 (Table IIa).

Table II. Crop and group interaction means for the house crow diurnal entrance.

Crop	Group		Mean
	Control	Treated	
Wheat	331.57±2.51bc	115.29±2.41ef	223.43±30.04B
Maize	346.00±3.01b	130.86±3.00e	238.43±29.90B
Sugarcane	300.43±2.63cd	55.29±0.87g	177.86±34.02C
Chickpea	297.29±15.22d	91.29±13.88f	194.29±30.23C
Sunflower	411.57±3.90a	117.57±2.98ef	264.57±40.84A
Mean	337.37±7.75A	102.06±5.34B	

Table IIa. House crow means recorded for the evening exits.

Crop	Group		Mean
	Control	Treated	
Wheat	115.86±1.62a	93.00±2.21bc	104.43±3.43AB
Maize	118.43±0.48a	115.57±2.54a	117.00±1.31A
Sugarcane	87.29±1.51bc	43.00±1.60d	65.14±6.23D
Chickpea	92.00±0.72bc	74.86±12.55c	83.43±6.49C
Sunflower	101.29±2.84ab	99.29±3.35ab	100.29±2.13B
Mean	102.57±2.28A	85.54±4.97B	

Considering the overall day long crow activities around the five crops described maximum infestation of crows for all crop's mature stages in the morning and evening durations. However, there occurred considerable decline for the crow visitations as recorded in the adjacent one-acre crops implicated by the three repellents. Cumulative depredatory patterns per day and their average statistical values indicated that sunflower 510.86±7.11; 218.86±5.68 and maize 464.43±3.20 were utmost preferred by crows. However, under the influence of day long activities of the crows, wheat 447.43±3.37; 208.29±3.40, chickpea 389.29±14.56; 166.14±26.42, and sugarcane 387.71±3.26; 98.29±2.09 showed less infestation in controlled and treated conditions (Table IIb). Ironically, the combined impact recorded on all the designated crops suggests that the mean numbers of birds for control 907.40±18.75 in the controlled situation remained highly significant for the crow depredations; nonetheless, their infestations were declined (390.89±21.07) for the repellent treated crops. Sunflower yet again hitherto was more depredated followed comparatively by maize, wheat, and, chickpea with sugarcane. Therefore, sunflower perpetually indicated higher influx of crop damage as compared to all other designated crops in untreated conditions, which was subsequently reduced with the incorporation of the ecologically friendly bird repellents (Table III).

Table IIb. Cumulative movement patterns of the crows in the day.

Crop	Group		Mean
	Control	Treated	
Wheat	447.43±3.37b	208.29±3.40de	327.86±33.24B
Maize	464.43±3.20ab	246.43±5.50d	355.43±30.39AB
Sugarcane	387.71±3.26c	98.29±2.09f	243.00±40.18D
Chickpea	389.29±14.56c	166.14±26.42e	277.71±34.17C
Sunflower	510.86±7.11a	218.86±5.68d	364.86±40.73A
Mean	439.94±8.66A	187.60±10.28B	

Table III. Crop and group interaction means for the overall number of birds (parakeets, crows) per day.

Crop	Group		Mean
	Control	Treated	
Wheat	921.57±6.99b	433.29±5.86d	677.43±67.85B
Maize	970.86±5.16ab	520.14±9.89d	745.50±62.73A
Sugarcane	786.71±4.21c	208.14±4.01f	497.43±80.28D
Chickpea	809.43±40.79c	331.71±47.59e	570.57±72.77C
Sunflower	1,048.43±12.51a	461.14±10.21d	754.79±81.81A
Mean	907.40±18.75A	390.89±21.07B	

For the assessment of bird entrance and leaving throughout the day for rose-ringed parakeets and house

crows is provided in the (Table IV). For their inclusive assessments with the Tuckey's test, indicated (t=8.59) for the parakeet, greater than (p-value 0.000), represented the statistically significant difference for the morning and afternoon durations. Seemingly, for house crow, it was apparent again of the statistical significant difference (P<0.01) for the morning and evening crow depredations on the crops. Therefore, their averages (219.71; 94.06) for the morning and evening time intervals, showed 8.27 t-value highly significant (P<0.01) and overall (t=11.94) displaying statistical significance for both the day long time durations.

Table IV. Comparison between cumulative numbers of entering and leaving birds per day.

		N	Mean	Std. deviation	Std. error mean	t value	P value
Parakeet	Entering	70	238.26	135.37	16.18	8.59**	0.0000
	Leaving	70	97.06	24.14	2.89		
House crow	Entering	70	219.71	124.78	14.91	8.27**	0.0000
	Leaving	70	94.06	24.29	2.90		
Total	Entering	140	228.99	130.05	10.99	11.94**	0.0000
	Leaving	140	95.56	24.18	2.04		

Results of this study suggested that the mean squares estimated from the Analysis of Variance that the existing crops and treatments were highly significant (P<0.01) for the both rose-ringed parakeet and house crow based on their day time crop visitations for the morning and evening hours (Table I). Moreover, it was also indicated regarding the statistical significance of food crops and treatments for the numbers of the parakeets during different diurnal hours of the day by the incorporation of the Tuckey's test (5% level). Of the five designated crops in this study, wheat, maize, sugarcane, chickpea and sunflower interactions between the control and treated crop conditions described the mean per day parakeet mean entering and exits were statistically significant based on the variations. The letters used after the standard errors indicates statistically significant differences. Means with the same letter are not significantly different from each other. Nonetheless, the letters A, B, C for each row represented of more significant results as in comparison with the similar letters, the no-significant in the present findings (Table Ia). Observations for the evening time durations of the rose-ringed parakeet in its regular visitations suggest that the mean values for various crops were found to be varied; therefore, showed that all the crops impacted the parakeets exits during the latter half of the day (Table Ib).

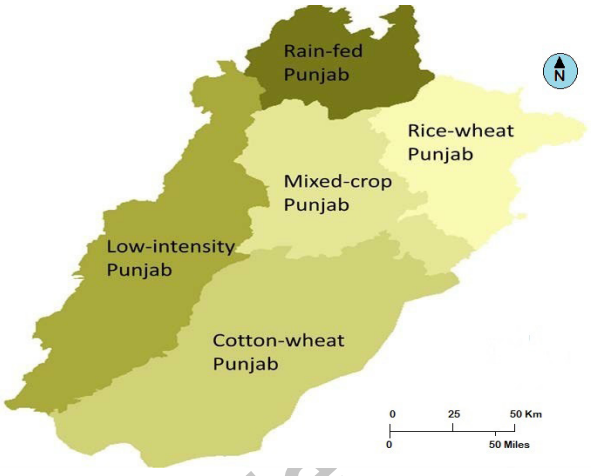

Fig. 1. Occurrence of agro-ecological zones of Punjab in Pakistan.
Source: Research gate.

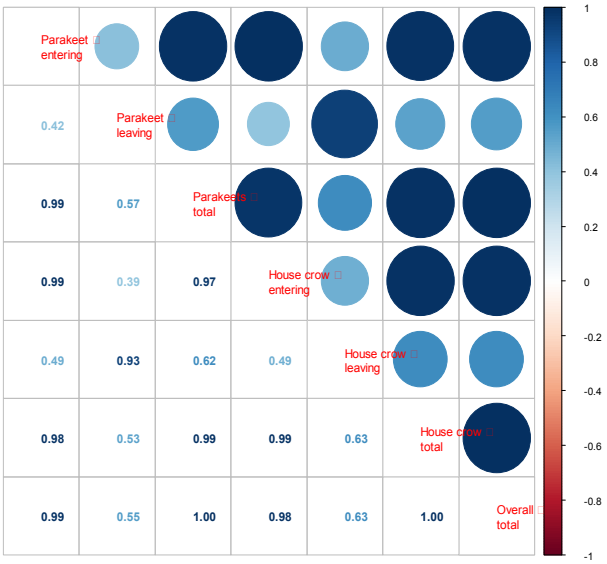

Fig. 2. Incidence of correlation for different variables between the rose-ringed parakeet and house crow.
This indicates a strong positive correlation, suggesting that as the number of birds' entrance increases in crops, the incidence of leaving birds also rises.

Pearson's correlation coefficients, therefore, provided valuable linear relationships for all the variables and moreover, indicated the positive and linear correlation, to assess its matrix for the experimental data analyses. It also seems mandatory to develop the expressive regression models for the differential variables also. The correlation matrix for the different variables for parakeets and crows, it was apparent that (Pearson's correlation coefficients)

for the variables and levels of significance adjudging the higher levels of correlation coefficient, and the lower coefficients at the significance levels. Therefore, the formulated correlation between the parakeet interference and leaving the crops was 0.409, considered statistically significant and moreover, that the number of parakeet's incursions in the crops was positively associated with their crop leaving trends (Fig. 2). Contrary to it the house crows which were recorded to enter and leave the designated crops was 0.953 which was highly significant ($P<0.01$) and specified strong correlation between the number of entering crows per crop to those of the leaving from crops. Results of the present study also discuss that the rose-ringed parakeets and crows occurred in good numbers at the Students Farms, University of Agriculture, Faisalabad. Undeniably, the agro-ecosystems throughout the province of Punjab comprise various sub-habitats viz. forest plantations, road side plantations, croplands, wide-spaced university and college campuses.

DISCUSSION

Predominantly, several economically important crops as maize, wheat, sunflower, chickpea and sugar cane are cultivated throughout the year over more than 12.70 million hectares (GOP, 2023). The agro-ecological zones throughout the Punjab province *viz*. rice-wheat zone, cotton-wheat zone, mixed-crop zone rain-fed zone and low-intensity zone have been devised for sustainable strategies and to promote diversified utilization national resources with the investment to harness agricultural value-added chain (Ahmad *et al*., 2019). Therefore, the agro-ecological zones have proved to be instrumental for acquiring sustainable agricultural growth throughout the province of Punjab, Pakistan. It was evident in that both birds seemed destructive on the five selected crops in the controlled conditions. Ironically, all these crops are also considered economically significant throughout the Punjab province and, therefore, contribute more than 75% as the value-added chain crop output (Iqbal *et al*., 2001; Rehman *et al*., 2015).

The data of this study provides information that in the controlled conditions, the damage patterns were fairly high due to their constant access to the food resources. There were two foraging peaks of the both parakeets and the crows to; during the early morning and yet again the late afternoon. During both these time intervals, the bird entrance and exits from the respective food resources were evinced at the dawn and once more at the dusk before going to their respective roosts. Considering the crop predilection of both the crows and parakeets regarding their designated habitat (the University Farms) sunflower remained significantly affected due to both the birds. However, in the repellent treated conditions, the depredations were significantly reduced. Apparently, maize and wheat were comparably impacted by the two birds and the least impairment was recorded on the sugarcane (Table Ic; Fig. 2). Logically, all the crops which were sampled in the present study were of one-acre in dimension and the observations recorded were at the mature stage. Therefore, in terms of preference, the sunflower appeared to be widely depredated in both the controlled and repellent treated conditions. Undeniably, wheat and chickpea were also largely destroyed by both the rose-ringed parakeet and house crow; nonetheless, the frequency of damage was largely reduced by the implications of three bird management measures *viz*. mist nets, reflecting ribbons and distress sound players. Present results also conform to the report of Ahmad *et al*. (2012a, b) showing similar findings on the damage patterns of rose-ringed parakeet on sunflower, guava, citrus and mango. Moreover, the reflecting ribbons and distress sound player proved to be reliable to reduce the bird damage. Similarly, the work done by Dolbeer *et al*. (1986); Beg *et al*. (1995) have also suggested on the strong efficiency of the reflecting ribbons against the blackbirds *Turdus merula* in the cultivations of North Carolina, USA against sunflower and sweet corn along-side of the rose ringed-parakeet in Central, Punjab, Pakistan. The data also indicated invariably the same findings for the five designated crops on the basis of the house crow visitations. Although comparing the tenacity of both birds for the food crops, evidently the damage patterns remained elevated for the parakeets, therefore, truly regarding it as noxious and opportunistic. Although, some management measures have been used to deter the bird depredations in the field, customarily, reliance on the old and traditional methods like the beating of metallic drums and gas exploders (Stevens and Clark, 1998) have been used with little success. Important consideration of using the repellents is to safeguard and protect the crop biosafety and maintain the crop sustainability for the self-perpetuating agricultural and horticultural systems, therefore, reducing the intensity of bird damage and economic losses (Hughes, 1996; Linz *et al*., 2011).

Situation in Pakistan particularly of Central Punjab with predominant multiple-cropping patterns existed for more than five decades (Taber *et al*., 1998) having incorporated the suitable ecological conditions for birds to restructure their roosts and nests closer to the food resources and, therefore, providing their tenacious management measures (Beg, 1978; Roberts, 1991). In view of this scenario, comprehensive and logical measures are required to combat the bird crop deterioration patterns. Although the existing devices like the distress players, reflecting ribbons,

mist nets and scare crows occur, nonetheless, their precise and rational application is largely unsuitable. Therefore, for the future research, it is imperative to implement the repellent measures on the significant crops intelligently not only to maintain the agro-ecosystems sustainability but also to obtain the desirable goals.

DECLARATIONS

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Statement of conflict of interest

The authors have declared no conflict of interest.

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