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A study on the role of cultural management on the population dynamics of Dubas bug, *Ommatissus lybicus*

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Abstract

Cultural control is one of the oldest methods for insect pests' management. To elucidate the role of cultural activities on population fluctuations of Dubas bug (*Ommatissus lybicus* Bergevin), 12, 19, and 29 date palm plantations were chosen as sampling plots in Abadan, Behbahan and Bam, respectively. Samplings were done using the cluster random method. Population densities were estimated by leaf sampling and yellow card installations. The impact of management activities was evaluated by direct observations and interviews with plantation owners and extension service officers. Results showed that the efficiency of management factors in population reduction was of different values so that the pattern of cultivation including intercropping and planting space, nutrition management, and other activities including leaf pruning, basal offshoot removal, and chemical control were effective in population reduction.

Keywords: Cultural management, date palm, Dubas bug, pest control

مطالعه نقش مدیریت زراعی بر تراکم جمعیت زنجرک خرما *Ommatissus lybicus* Bergevin

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چکیده

کنترل زراعی یکی از قدیمی‌ترین روش‌ها برای مدیریت حشرات آفات است. برای بررسی نقش فعالیت‌های زراعی در نوسانات جمعیت زنجرک *Ommatissus lybicus*، تعداد ۱۲، ۱۹و ۲۹ نخلستان به‌ترتیب در شهرستان‌های آبادان، بهبهان و بم انتخاب شدند. نمونه‌برداری با استفاده از روش تصادفی خوشه‌ای انجام شد. تراکم جمعیت با استفاده از نمونه‌گیری از برگ و تله کارت زرد تخمین زده شد. شاخص‌های انجام فعالیت‌های مدیریتی زراعی با مشاهدات مستقیم و مصاحبه با نخل‌داران و کارشناسان خدمات ترویجی ارزیابی شد. نتایج نشان داد که کارایی عوامل مدیریتی زراعی در کاهش جمعیت زنجرک خرما از تأثیر مختلفی برخوردار بود، به‌طوری که الگوی کشت شامل فاصله کشت و میانه کاری، مدیریت تغذیه و سایر فعالیت‌ها از جمله هرس برگ، حذف پاجوش و کنترل شیمیایی در کاهش جمعیت مؤثر بودند.

واژه های کلیدی: خرما، زنجرک، کنترل آفات، مدیریت زراعی

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Introduction

Insect pests, diseases, and weeds are the main yield reduction factors of date palms. More than 40 species of insect pests, 24 diseases, and 16 species of weeds were identified in date palm plantations (Al Sarai and Al Alawi, 2015; Mokhtar *et al*., 2010; Al Sarai and Al Alawi, 2015). Dubas bug (DB) is one of the most important date palm insect pests in Iran. This insect has been detected in most palm growing areas of Iran where it injures both male and female date palm trees with the same intensity. During the active period, DB nymphs hatch and feed on the nutrient sap of the leaf (Mokhtar *et al*., 2010). Nymphs pass through five growth instars 8, 9, with adult female DB grows to 5–6 mm and males to 3–3.5 mm in length (Blumberg, 2008). Two population generations of DB are produced each year. The summer generation of nymphs appears during mid to late April. While feeding, the insect produces honeydew on the leaflets and accumulates on top of the leaf a shining droplet full of sugar and other constituents. This becomes the onset of the mainstay problem by the development of pathogenic infection (black sooty mold on the foliage), further damaging the leaf parts via chlorosis (Al-Kindi *et al*., 2017). Regarding the importance of DB an integrated pest management (IPM) approach seems to be necessary for overcoming its damages.

The most prevalent method for DB control is chemical control which technically faces several limitations. The height of trees, low efficiency of ground sprayers, and ineffectiveness of aerial control are the most important limitations in control of the pests and diseases of palm trees in Iran (Latifian, 2017).

Pests are not considered as an enemy of crops in new IPM approaches, but they are considered as management factors necessary to be incorporated into the cultural system management. The cultural methods emphasize the environmental manipulation to reduce its attractiveness for pests, diseases, and weeds (Al Sarai and Al Alawi, 2015).

Adult and nymphs of DB feed on plant sap and excrete sweet and sticky substances on the leaf surfaces and sometimes on the fruits of palm trees. The leaflets of infested trees are gradually dried out and fruits become wrinkled, decolored, and small, so consequently lose their market acceptability (Al Shidi et al., 2018). DB is a bivoltine insect with a summer and a winter generation. Hatching duration in summer generation is shorter than that of winter generation, so the latter is controlled easier (Shah *et al*., 2012).

Limited studies are available on the role of cultural management in the intensity of damages caused by pests and diseases in date palm groves (Al-Jboory, 2007; Latifian *et al*.,2012). Latifian *et al*., showed that the efficiency of the combination of management components including cultural, economic, and extensional on the reduction of damages to palm trees are different depending on the type of pest, disease, and weeds active in the agricultural system. Economic management factors are the most efficient with a rate of 99.59% followed by those of cultural and extensional with 61.22 and 46.68% respectively. Depending on control values, cultural factors are hierarchically divided into three categories: (1) leaf pruning, (2) pruning of petioles, discarding the bunch remaining, and chemical control (3) remaining factors including cropping pattern, irrigation, fertilization, sanitation, bunch covering, bunch shaping, basal offshoot removal, and weed control.

Materials and Methods

Kernel Screening Assay (KSA)

Cluster or regional random sampling was used for sampling. For this purpose, the sampling community was plotted and one sample was randomly selected from each plot (Southwood, 1975). Each sample was a date palm plantation with an area of at least one hectare. 30 samples in Khuzestan province (11 plots in Abadan and 19 plots in Behbahan) and 29 in Bam (Kerman province) were considered. The sampling areas are shown in the maps in Figure 1.

Data collection methods

The chosen groves were marked and their coordinates were recorded. Data and information were collected from each grove in two ways, including the following (Matsukura and Matsumura, 2010):

Population estimates of DB in groves

In each grove, 10 date palm trees were randomly selected and marked. In each tree, leaves were selected from 3 different directions and 3 leaflets from each leaf were randomly selected. Before picking the leaves and transferring

them to the laboratory, the numbers of nymphs and adult insects were counted and recorded. The eggs were counted under the stereomicroscope in the laboratory and recorded for each leaflet. Sticky traps were also used to estimate the population density of the mobile stages of the insect. The traps were 40 × 30 cm polyethylene cards with an absorption spectrum of 593 nm. The surface of the cards was smeared with standard tangle foot adhesive with near a month of durability. Three cards were installed at the lower, median, and higher parts of each palm tree. (Machacek, 1949).

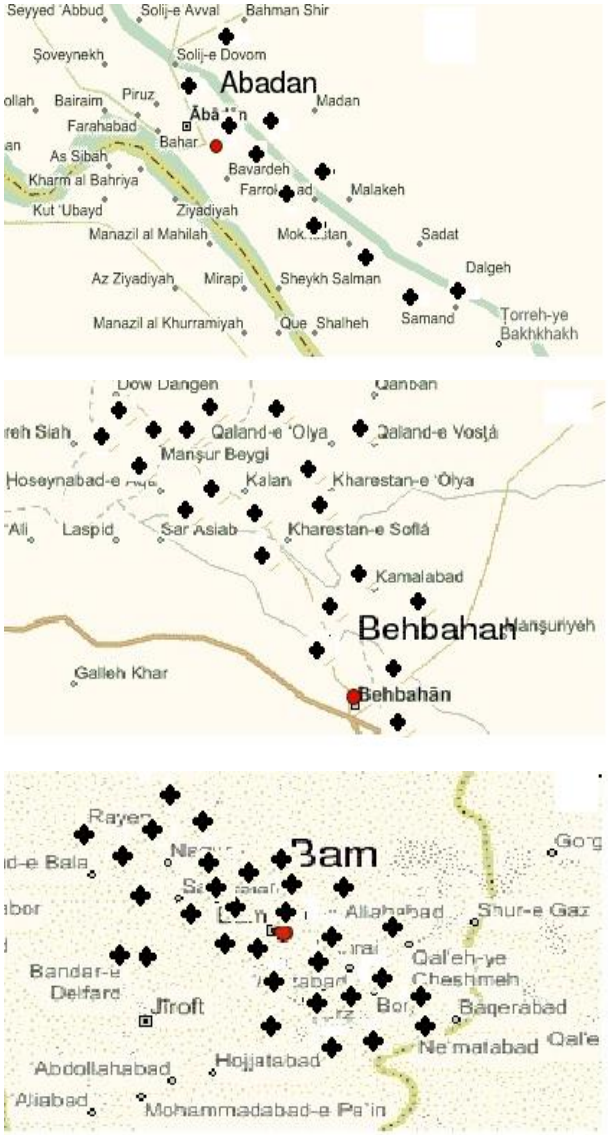

Fig 1. The maps of the sampling areas in Khuzestan (Abadan and Behbahan) and Kerman provinces (Bam).

Assessment of cultural management factors of palm groves

Different management factors and the percentage of activities in each grove and each area were assessed by the realization of the activities and interviewing the grove owners and officials of the regional agricultural service centers.

Data analysis methods

Multivariate regression was used to analyze the data. The population density of DB was considered as a dependent variable and other variables mentioned in the research theory were considered as independent variables. Before the implementation of regression analysis, correlation analysis was performed in Rank Correlation mode and Kendall mode, and variables that had significant correlation with DB population density were considered in regression analysis. To perform these analyzes, according to the specific form of the data of this research, the following steps were performed (Suarez et al., 1999; Zuki, 1992):

First, all quantitative and qualitative variables were adjusted using factor analysis to make subsequent analyzes easier.

Using factor analysis, variables that are correlated with each other were considered as a single factor. The linear composition factor of variables with correlation was as follow:

Factors expressing quality transformed to quantitative variables and were used in the regression. It should be noted that qualitative variables (zero and one) were first estimated as interval variables and then entered the analysis process.

Then the regression of factors related to the studied variables was performed. After performing this regression and obtaining the estimated factors, these factors were estimated as a variable dependent on the population density of DB in the form of a regression equation. The value of each of the cultural management factors in the overall DB control program was calculated as follows (Suarez et al., 1999).

$$w = \sum_{n=9}^{i=1} riBi$$

Equation 1

In this equation, W = value of crop control method, B = factor coefficient in multivariate regression model and r = factor correlation coefficient with DB population density.

After calculating the control value of each cultural factor, the obtained data were compared with each other by analyzing the variance (ANOVA). Then, using the SNK test the mean values of cultural methods were compared.

Results

Description of different factors of cultural management in palm groves

Significant differences have been observed among different cultural management indicators. Also, in each region, there is a significant difference in the method of cultural management (Table 1).

Comparison of *Ommatissus lybicus* population density in research areas

The results showed a significant difference among the three regions in terms of changes in DB density ($F= 4.87$, $df= 52$, $p<0.01$), (Fig 2). Results showed that the lowest and highest population densities were in Abadan and Bam, respectively.

The effect of crop management indices on the population density of *O. lybicus*

Step 1: Evaluation of the degree of correlation

Population density of DB in three regions had significant correlations with management indices of planting distance, intercropping, fertilizing and manuring, pruning (leaves, basal and high offshoots), and chemical control of pests.

Step 2: Multivariate regression model of the impact of crop management factors

Among the various factors of crop management, indices of planting distance, intercropping, fertilization, pruning (leaves, high and basal offshoot removal), and chemical control of pests had a significant correlation with the population density of DB, the results of which are shown in Tables 3. The Cultural management operations in Abadan, Behbahan, and Bam regions, reduced the population density of DB 16.52%, 14.61%, and 14.83%, respectively. These models were significant in Abadan, Behbahan, and Bam regions at one percent level with coefficients of determination of 66.7, 51.9, and 54.3 percent, respectively.

Value of cultural management factors in *O. lybicus* Control

The value of each of the crop management factors in the general cultural control program of DB was calculated using equation 1 (fig. 3).

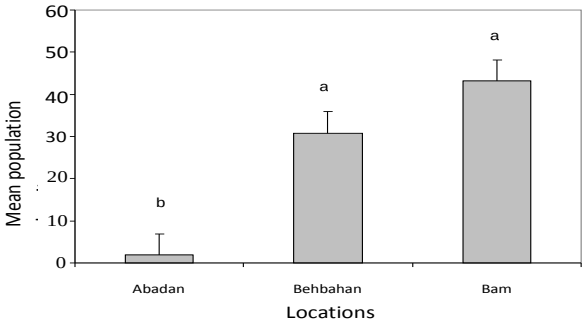

Fig 2. Comparison of *Ommatissus lybicus* population density in sampling areas in Khuzestan and Kerman provinces.

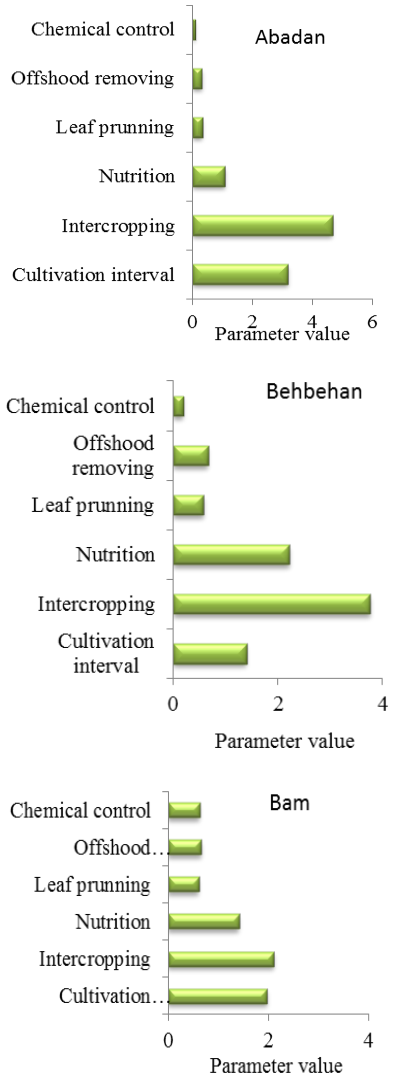

Fig 3. The value of each of the crop management factors in the general cultural control program of *Ommatissus lybicus.*

Table 1. Quantitative changes in the operation of various indicators of cultural management in Abadan, Behbahan, and Bam regions.

Locations Management factors	Performance (amount/percent)			Locations Management factors	Performance (amount/percent)			Locations Management factors	Performance (amount/percent)		
Abadan	**Mean**	**Max.**	**Min.**	**Behbahan**	**Mean**	**Max.**	**Min.**	**Bam**	**Mean**	**Max.**	**Min.**
No. of varieties	4.2	7	2	No. of varieties	3.1	5	2	No. of varieties	3.6	5	2
Planting distance	5*5	8*8	2*3	Planting distance	5*5	8*8	4*3	Planting distance	5*5	8*8	3*3
Intercropping (%)	49	80	0	Intercropping (%)	42	63	0	Intercropping (%)	17.1	100	0
No. of plowing	0.42	2	0	No. of plowing	0.26	0	1	No. of plowing	0.32	1	0
Fertilizer (Kg/Tree)	0.58	2	0	Fertilizer (Kg/Tree)	0.47	3	0	Fertilizer (Kg/Tree)	3.24	5.35	0
Manure (tons per ha)	0.35	2	0	Manure (tons per ha)	0	0	0	Manure (tons per ha)	0.98	2	0
Irrigation interval (Day)	7.4	15	3	Irrigation interval (Day)	6.8	35	7	Irrigation interval (Day)	17.8	25	7
Leaf pruning	20.68	73	0	Leaf pruning	9.68	12	0	Leaf pruning	6.7	7	0
Basal offshoot removal	49.9	90	12	Basal offshoot removal	42.9	90	5	Basal offshoot removal	96.4	100	70
High offshoot removal	0	0	0	High offshoot removal	47.9	90	10	High offshoot removal	92.4	100	0
Bunch remaining removal	23.1	90	0	Bunch remaining removal	37.1	90	5	Bunch remaining removal	24.4	100	0
Bunch shaping	45	100	0	Bunch shaping	35	90	0	Bunch shaping	54.6	100	0
Bunch stalk tying up	56.1	90	0	Bunch stalk tying up	36.8	80	5	Bunch stalk tying up	93.6	100	0
Leaf to bunch ratio adjustment	8.12	20	0	Leaf to bunch ratio adjustment	13.7	50	0	Leaf to bunch ratio adjustment	21.6	100	0
Covering	10.7	40	0	Covering	7.1	50	0	Covering	92	100	0
Fruit thinning	0	0	0	Fruit thinning	0	0	0	Fruit thinning	0	0	0
Disease control	0	0	0	Disease control	0	0	0	Disease control	6	100	0
Pest control	37.8	90	0	Pest control	57.6	80	0	Pest control	38.4	100	0
Weed control	0	0	0	Weed control	0	0	0	Weed control	0	0	0

Table 2. Correlation of different factors of crop management with changes in the population density of *Ommatissus lybicus* in Abadan, Behbahan, and Bam regions.

Locations Management factors Abadan	Correlation coefficient (r)	t(N-2)	Locations Management factors Behbahan	Correlation coefficient (r)	t(N-2)	Locations Management factors Bam	Correlation coefficient (r)	t(N-2)
No. of varieties	0.002	0.01	No. of varieties	0.07	0.31	No. of varieties	-0.07	0.33
Planting distance	-0.57	0.82*	Planting distance	-0.55	0.24*	Planting distance	-0.58	1.42
Intercropping (%)	-0.61	2.57*	Intercropping (%)	-0.7	4.05*	Intercropping (%)	-0.52	1.09*
No. of plowing	-.006	0.13	No. of plowing	0.27	1.116	No. of plowing	-0.28	1.42
Fertilizer (Kg/Tree)	0.61	0.24	Fertilizer (Kg/Tree)	0.17	0.74	Fertilizer (Kg/Tree)	-0.54	0.26*
Manure (tons per ha)	-0.52	0.04*	Manure (tons per ha)	-0.52	0.5*	Manure (tons per ha)	-0.52	0.58*
Irrigation interval (Day)	0.28	0.14	Irrigation interval (Day)	0.44	2.01	Irrigation interval (Day)	-0.06	0.27
Leaf pruning	-0.57	1.17*	Leaf pruning	-0.57	1.62*	Leaf pruning	0.7	0.33*
Basal offshoot removal	-0.55	1.02*	Basal offshoot removal	-0.58	0.29*	Basal offshoot removal	-0.58	0.4*
High offshoot removal	0.14	0.46	High offshoot removal	0.17	0.73	High offshoot removal	-0.52	0.61*
Bunch remaining removal	0.07	0.63	Bunch remaining removal	0.09	0.37	Bunch remaining removal	0.12	0.54
Bunch shaping	0.06	0.31-	Bunch shaping	0.13	0.53	Bunch shaping	0.05	0.06
Bunch stalk tying up	0.03	0.27	Bunch stalk tying up	-0.04	0.14	Bunch stalk tying up	0	0
Leaf to bunch ratio adjustment	0.09	0.08	Leaf to bunch ratio adjustment	0.2	0.83	Leaf to bunch ratio adjustment	0.06	0.13
Covering	-0.07	0.11	Covering	0.16	0.65	Covering	-0.13	0.02
Fruit thinning	0.03	0.38	Fruit thinning	-0.15	0.63	Fruit thinning	0.02	0.06
Disease control	0	0	No. of varieties	0.07	0.31	Disease control	0	0
Pest control	-0.68	1.39*	Planting distance	-0.55	0.24*	Pest control	-0.69	0.69*
Weed control	0	0	Intercropping (%)	-0.7	4.05*	Weed control	0	0

. * significantly correlated

Based on the results, among the various management factors, the cultivation pattern factors have higher effects. Nutrition and pruning management factors were less important in DB control.

The Value of crop management factors in the reduction of *O. lybicus* population density

The results showed that the value of the cultural management factors in reducing the population density of DB have a significant difference at one percent level (f=12.43, df=10). The effects of the mean values of different cultural factors in the three regions were compared by the SNK method (fig. 4).

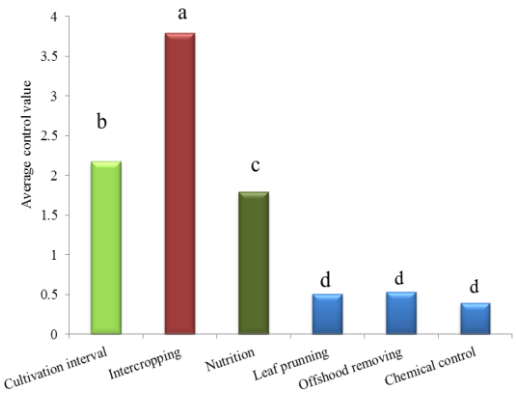

Fig. 4. Comparison of mean values of different cultural indices in *Ommatissus lybicus* management.

The results showed that the planting pattern [intercropping (a) and planting distance (b)], fertilization management (C), and pruning management [leaf pruning and offshoot removal (d)] and pest control (d) affect control of DB.

Discussion

In this study, intercropping with an average value of 3.79 had the greatest effect on reducing the population density of DB in three regions. Other research has shown that intercropping is effective in reduction of the damage severity of spider mites, lesser and greater date moths but increases the damage of mealybugs and leaf spot disease.

Planting density and spacing is also one of the selection patterns that can affect the severity of pests and diseases of dates. In general, sampled groves can be divided into two groups based on density and planting distance, including trees with a planting distance of fewer than 5 meters and between 5-10 meters. The control value of this factor was 2.18 on average and following the intercropping operation, it had the greatest effect on reducing the density of DB. Studies showed that the damage severity of spider mites, termites, rhinoceros beetles, long-horned beetles, mealybugs, inflorescence rot, and leaf spot disease in orchards with planting distance less than 5 m were higher than its severity in orchards with a planting distance of 5-10 meters. However, regarding lesser and greater date moths, the severity of damage was higher in groves with a planting distance of 5-10 meters (Matsukura and Matsumura, 2010).

Following planting pattern nutrition management including fertilization by chemical and organic methods and irrigation had the greatest effect on reducing the population density of DBs so that the average value in crop control was 1.79. Studies showed that proper fertilization and nutrition of groves have been effective in reducing the severity of most pests and important diseases of dates. Only in the case of

Table 3. Correlation of different factors of crop management with changes in the population density of *Ommatissus lybicus* in Abadan, Behbahan, and Bam regions.

Regions														
Abadan					Behbahan					Bam				
Factors	**T**	**SE**	**Value**	**P-Value**		**T**	**SE**	**Value**	**P-value**		**T**	**SE**	**Value**	**P-Value**
Fixed value	0.51	9.72	59.5	0.006	Fixed value	1.02	16.5	116.06	0.032	Fixed value	0.06	2.95	8.16	0.009
Planting Distance	-0.7	8.32	-5.57	0.03	Planting Distance	0.81	5.4	-2.54	0.043	Planting distance	-1.17	0.19	-3.39	0.02
Intercropping	-0.81	4.31	-7.63	0.04	Intercropping	-1.95	8.3	-5.35	0.007	Intercropping	0.33	0.31	-4.04	0.007
Manuring	-0.37	9.22	-2.05	0.007	Chemical Fertilization	-0.23	2.7	-4.26	0.008	Chemical Fertilization	-0.52	0.01	-2.6	0.006
Leaf pruning	-0.38	3.39	-0.57	0.007	Leaf pruning	0.16	0.39	-1.01	0.009	Organic Fertilization	0.61	0.27	-1.17	0.05
Basal shoot Removal	-0.27	0.53	-0.56	0.03	Basal shoot Removal	-1.29	0.88	-1.14	0.002	Leaf pruning	0.75	0.17	-1.13	0.04
Pest control	0.63	0.41	-0.14	0.05	Pest control	0.36	0.19	-0.29	0.007	Basal shoot removal	0.91	0.02	-1.2	0.03

mealybugs fertilization increased to a small extent the severity of its damage (Matsukura and Matsumura, 2010). Our research showed that fertilization and proper nutrition had the greatest effect in reducing the severity of leaf spot disease followed by xylophagous pests including termites, rhinoceros, and long-horned beetles, and date palm spider mite, respectively. The effect of this factor on the severity of damage of lesser and greater date palm moths, mealybugs, and inflorescence rot was small and non-significant.

Among different pruning management methods, offshoot removal and leaf pruning had significant effects on reducing the population density of DB. The average value of basal offshoot removal operations in date palm control was 0.53. Studies have shown that the removal of basal offshoots is effective in reducing the severity of pests and important diseases of date palms and in no case has shown an increasing effect on the severity of their damage (Latifian, 2012). The effects of this factor on the severity of damage of rhinoceros and long-horned beetles were highest, but its effects on the severity of damage of other pests and diseases were less. The mean value of the leaf pruning effect in DB control was 0.51. Other studies had shown that leaf pruning operations were effective on the severity of leaf spot, termite, rhinoceros, and long-horned beetles, respectively, but its effect on the severity of spider mites, lesser and greater date palm moths damage, and inflorescence rot disease is less (Latifian, 2001).

The average value of chemical control operations in palm leafhoppers control was 0.39. This indicates the efficiency of the chemical control was insufficient to reduce the population and damage of the pest. Studies have shown that the effect of chemical control operations on reducing the severity of spider mites, lesser and greater date palm moths, and termites was significant, but its effect on the severity of other pests and diseases was small and non-significant (Latifian, 2001).

Research on the effects of cultural management methods on other leafhoppers in agricultural and horticultural systems has also shown the success of the application of these methods. For example, the use of leaf and branch pruning is one of the cultural control methods of grape leafhopper, *Erythroneura elegantula* Osborn (Matsukura and Matsumura, 2010; Hoffman and Hogg, 1992). In another study on *Cicadulina bipunctata*, Melichar changing planting time as a cultural control method had an important role in reducing pest damage to alfalfa plants (Hoffman and Hogg, 1992). In a similar study, the effects of cycle and depth of irrigation on population changes of active leafhoppers in alfalfa agroecosystem have been studied. A set of studies was done in the form of applied and survey researches by which the value of various factors of grove management was determined as a method of cultural control in reducing the population of date palm leafhoppers (Matsukura and Matsumura, 2010; Hoffman and Hogg, 1992).

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