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Review Article
Integrated Pest Management of Date Palm Fruit Pests: A Review

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Abstract

The spider mite (*Oligonychus afrasiaticus*) and the lesser date moth (*Batrachedra amydraula* Meyrick) are considered as the most significant pests of date palm in Iran. The objective of this study was to review of the Integrated Pest Management (IPM) tactics such as the use of biological control in combination with resistant cultivars, cultural and chemical control were implemented. It is speculated that the pest threats status and compare it with other studies for solving these pests using integrated pest management strategies. Augmentation of biological control were conducted by releasing the predator *Stethorus gilvifrons* and entomopathogenic bacteria, Bacillus thuringiensis for date mite and the lesser moth respectively. Agricultural practices including soil tillage, fertilization, irrigation, pruning, resistant cultivars, bunch covering and cluster arrangement played have an important share in completion of biological control. The cultivars resistance levels set integrated other control methods with biocontrol. Combining the forecasting model based on meteorological models and pest monitoring based on geostatistical models had been practically utilized as a computer program for decision-making system in date IPM. The socio-economic and extension factors have to be considered for expected adaptation level of date IPM. This program must be economically considered to optimize date production and to minimize pesticides pollutions. Biological control should be considered as the backbone of date palm IPM program.

Key words: Date palm, fruit feeder pests, biological control, integrated pest management

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Date palm is an important economic product crop in different countries[1]. Various biotic and abiotic factors such as pests, diseases and weather conditions affected the plant health. Climate change and irregular use of chemical pesticides are affecting pests and their natural enemies in the date palm agricultural ecosystems[2]. Date's fauna are different in date palm cultivation in Iran. Khuzestan province with 10 species and Khorasan province with two species have the strongest and weakest pest fauna respectively[2]. Date palm cultivation is in large quantity. Dates production is dependent on its international marketing and consumers. The international phytosanitary standards must be observed for dates export. One of the most important observes is the level of pest infestation[3]. This issue has a significant impact in integrated pest management programs. The IPM programs become more complicated when diverse pests increased in each region[4]. But two date palm fruit feeder pests including spider mite (*Oligonychus afrasiaticus* McGregor) is not only fruit feeder however it is sucking pest on leaves, fronds and fruits and the lesser date moth (*Batrachedra amydraula* Meyrick) present in most date palm cultivation orchards in Iran. The spider mite sucks the cell sap of immature fruits tissue. The natural colors of fruits were changed to pale yellow or gray by mite's nutrition. Damaged fruit were cracked and their juices were ejected from them. The fruit peel will be hard and dry. Date palm bunches and fruits surfaces are cover by dusts when the spider mite outbreaks. The damaged fruits are used for feeding livestock by date palm gardeners. The damage caused by this pest sometimes reached up to 70%[5,6].

The lesser date moth eats unripe fruit. This pest feed on the embryos and it cuts the connection between fruits and their stalks so causing drying and the loss of date fruits. Damage of this pest has increased in date palm plantations in the recent years in Iran. The damage was between 30-70% by various generations of the pest larvae. A significant reduction or even completely eliminate pesticide usage in date palm plantation ecosystems is possible by application of the biological control based IPM[7].

Various factors such as monoculture systems, climate change and miss use of pesticides have been affected the relations between date palm pests and their natural enemies[8,9].

Date palm pests are initially an ecological problem rather than a chemical problem, so unprincipled use of costly chemical pesticides is a failed strategy. Resurgence of key pests such as date palm spider mite and the lesser date moth, disrupting the natural balance, resistance to pesticides are problems caused by chemical control[2].

Date palm pest controls have usually been done by the application of insecticides in previous years. But due to the negative aspects of chemical control programs, attention has been given to the IPM in recent years[10].

BASIC APPROACH IN DATE PALM INTEGRATED PEST MANAGEMENT DESIGN

Integrated Pest Management (IPM) is a pest control method in which the different control strategies are used to supply maximum healthy products and minimum chemical pesticides application. Attention to agricultural extension and education is required for reducing the risk of chemical pesticides in this method[11]. The information about pest biology, ecology, sampling and monitoring with combine elements plant resistance, chemical and biological control are required for developing integrated pest management approaches[12].

The results of studies on the date palm pest management program have shown that the method of biological control (main axis) in combination with other control method is a good program plan for date palm pest management in Iran. Resistant cultivars have the ability to tolerate pest damage without limits for natural enemies. Cultural control maintains a balance between pests and natural enemies. Chemical control used only in cases where biological control is not effective.

BIOLOGICAL CONTROL BASED INTEGRATED MANAGEMENT OF DATE PALM SPIDER MITE

Main based: Biological control

Augmentation biological control: Augmentation biological control was done by inoculated release of Coccinellid predator *Stethorus gilvifrons* Mulsant. This is the most important and active ladybird predators in Iran date palm plantations. Assessments conducted in laboratory and field conditions have shown that it has very high performance for date palm spider mite biological control. The predatory ladybird consumes all life stages of the mite but it preferred the adult for hunting[13].

The ladybirds with less than 2-3 days old were used to release for biological control of date palm spider mite. First, the infected clusters were covered by mesh fabric and ladybirds were released under them. After a week, mantles

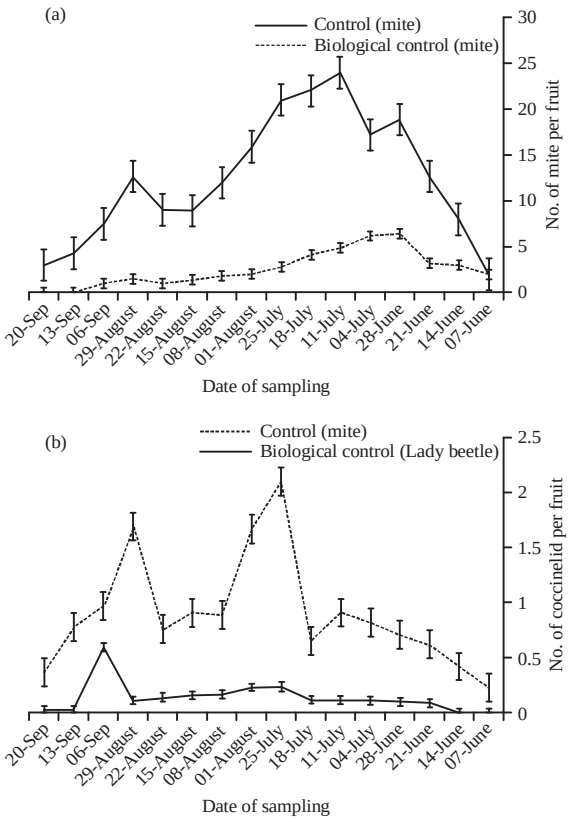

Fig. 1(a-b): Comparison the population fluctuation of date palm spider mite on (a) Natural and (b) Biological control condition

had been opened up to the establishment of ladybird run on the normal condition of date palm plantations. The highest performance control and lowest fruit damage occurred in simultaneous release with mite appearance at a density 3 coccinellid per square meter. Results of field experiments showed that the highest correlation coefficient occurred in terms of release coincided with the appearance of spider mite predator of maximum release, so, they had density depend reaction and lady beetle establishment were observed. At least maximum release with mite appearance in date palm plantation and continued for 2 weeks had high performance near 90%. The economic and environmental performance of this release method was in good condition (Fig. 1)[14].

Conservation biological control: Several natural enemies of date mite (*O. afrasiaticus*) have been identified such as the ladybug *Stethorus punctillum* (Weise) and mite predators such as *Phytoseiulus persimilis*, *Neoseiulus californicus*, two species of phytoseiidae mites such as *Amblyseius* and *Typhlodromus*[15] specie of hétéroptères Anthocoridae (*Anthocoris*) and two ladybug species (*Pharoscymnus ovoideus* Sicard and *P. numidicus* Pic)[10,16].

Anystis baccarum is one of the effective predators of the date palm spider mite that it can feed on all active stages of spider mite. Results of experiments about the effects of some selective acaricides showed that Hexythiazox has not only the lowest negative effect on predator but also the highest positive effect on pest control. So it is more suitable for application in IPM[17].

Intercropping of date palm plantations affected the in the population growth predatory mite. Because it increased production and distribution of nectar and pollen sources, secondary prey and vegetation grounds of activity for the mite predator[18].

A predatory mite's species from the family Bdellidae, genus *Spinibdella* observed on mite pest population. Studies showed that predator population density was low. Other predatory mite form family Caligonellidae, genus *Molothrognathus* is active in Iran date palm plantations. But these predatory mites are very inactive and do not appear to have considerable effect in pest population control[19].

FIRST SUPPLEMENTARY STEP: CULTURAL CONTROL

Date palm production efficiency can be increased by implementing the advanced cultural control practices. Using of this techniques need to thorough understanding of whole management practices and their effects on the population date palm pests. The correct enforcement cultural control such as tillage, fertilization, irrigation and bunch management reduce the spider mite damages[20].

Weed control: The mite can migrate from one date palm to other or grasses as *Cynodon dactylon* L. and *Lolium* sp.[21]. These weeds have important role in the life history of date palm spider mite[22].

Pruning bunch-remained: Date spider mite population overwintered in the bunch remains and transferred to plantations in the spring season. So the pruning of remained bunch-reduced hibernated pest population on future generations[22].

Tillage: The tillage of date palm plantations had significant effects on date palm spider mite population decline by removing wintering weeds hosts and microclimatic changes in the garden[20].

Bunch covering: The date spider mites could be migrated from one date palm bunch to another by ballooning method during May and June. So date palm bunches could be protected from secondary infection by bunch covering[20]. Similar results were founded for spatial distributions of *Oligonychus pratensis* on Deglet Noor bunch[21].

Irrigation: Greater heat and a midsummer drought caused *O. afrasiaticus* population growth in fruits[23]. Date palm fruits resistance against *O. afrasiaticus* was reduced by decreasing the amount of fruit moisture associated with increasing fruits sugar concentration[21,24]. Date palm plantations irrigation has significant population reduction role by decreasing temperature and increasing humidity[25].

Intercropping: The intercropping systems reduced the population and damages of date palm pests. Intermediate cultivation in date palm plantations increased biodiversity and ecological stability. As a result of this, the natural enemies' activity increased and pests' populations reduced[26-28]. Some intercropping factors such as economy aspect, soil fertility, land equality ratio, environment condition and crop cooperation have impact on the pest population is reduced[18].

SECOND SUPPLEMENTARY STEP: CULTIVARS RESISTANCE

Iranian native date palm cultivars were clustered to 4 groups based on Spider mite infestation as very susceptible cultivars including Liloei, Berhee, Zahedi, Deiri, Ashkar and Berim, susceptible cultivars including Halavi, Beliani, Sovidani, Hadak, Shkar, Bent Alsabae, Dagalzard, Khazravi and Sayer, semi-resistance cultivars including Bobki, Chabchab, Mashtom, Jahromi, Amobahri, Dagalsorkh, Fersi and Hadal and resistance including Khasab, Hamravi, Hasavi, Ashagh, Jozi and Gantar[29].

Cultivars characteristics of *Oligonychus* mite's hosts are also effective the efficiency of other control methods including biological and cultural control[21]. So the susceptibility of the date palm cultivars is effective the formation of integrated pest management program.

Recent genome sequencing in date palm indicates that stress resistance genes are present in the chromosomal regions where the density of single-nucleotide polymorphisms is comparatively low. Advanced techniques like gene silencing or RNA interference (RNAi), aiming at delivering durable multiple resistance traits towards important date palm pests. Genetically improved transgenic date palms have potential to development cultivar resistance strategies for future management approaches[30].

THIRD SUPPLEMENTARY STEP: CHEMICAL CONTROL

According to conducted research recommended specific acaricide for integrated management of a palm mite are: (1) Hexythiazox EC 10% (0.5 mL L^{-1}), (2) Fenazaquin SC 20% (0.5 mL L^{-1}) and (3) Fenpyroximate (0.3 mL L^{-1}). Hot-spot treatments replaced acaricides except at high infestations were applied in date palm plantations. Specific acaricides are important element of integrated control of date palm spider mite which is based on combination of biological and cultural control. Therefore, it is very important to study the effects of acaricides on its predator[7].

BIOLOGICAL CONTROL BASED INTEGRATED MANAGEMENT OF DATE PALM LESSER MOTH

Main based: Biological control

Augmentation biological control: Augmentation biological control was done by inoculated release of entomopathogenic bacteria *Bacillus thuringiensis* (BT). This entomopathogenic bacterium is a unique bacterium in that it shares a common place with a number of chemical compounds which are used commercially to control insects important to agriculture. The results of laboratory experiment of larvae infection on different concentrations showed that the pathogenic isolate of bacterium had the ability to cause disease on the lesser moth larva. The first symptoms was found as brown rot and black on cuticle of the larva's body. The external symptoms of the disease on larvae were appeared 2-3 days after the death of larvae by breaking down the body cuticle. The pathogenesis ability of different concentration was varying so that the LD_{50} was equal[31] to 2.15×10^8 CFU mL^{-1}.

The results of field experiments were conducted by Krustaki bacterial isolate showed that simultaneous release at same time of the appearance of the lesser moth and maximum release level (10 times more than LD_{50} concentration) given 2 days and continued for a week was the best condition of BT mass release. The minimum infestation was recorded on maximum release. The lowest average growth rate and the highest average reduction of injury growth rate were recorded on this treatment (Fig. 2)[32].

Sustainable IPM programmers including employing treatments with *Bacillus thuringiensis* were implemented by the Ministry of Agriculture in Iraq on targeting lesser date

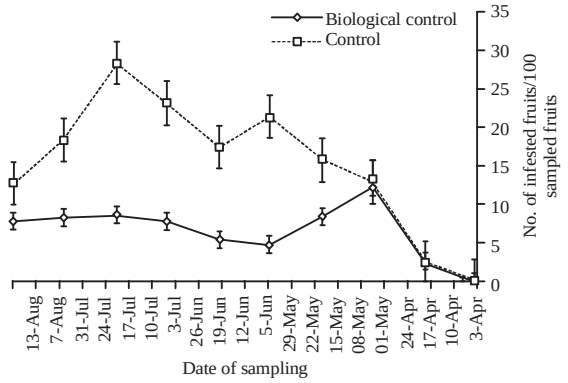

Fig. 2: Seasonal fluctuations of the lesser moth injury severity on biological control and natural conditions

moth, 80% decreases in infestation levels, respectively. The IPM interventions included solar light traps and hand collection of borers, application of neem based (Azadirachtin) sprays against Dubas and biological control of the lesser date moth[33].

Bioassays of some botanical extracts, granulosis virus, paraffinic summer oil, *B. thuringiensis* toxin and plant extracts (matrine) were conducted against the first generation of lesser date moth. This study was done at several sites during two campaigns (2004 and 2005) in Saudi Arabia. Results showed that the efficacy of all tested biopesticides was improved if good sanitation was applied in the orchard by removing over-wintering larvae in fruit stalks and dry fruits[34].

Results of other study showed that efficacy of the egg parasitoid, *Trichogramma evanescens* and the bio-pesticide bacteria, *Bacillus thuringiensis kurstaki* (Btk) in reduction of lesser date moth, *Batrachedra amydraula* infestations were studied during seasons of 2011 and 2012. The result showed that the release of egg parasitoid by rate of 500 and 1,000 parasitoids/palm tree achieved 55.06 and 67.45% reduction in infestation percentage, respectively. Meanwhile high reduction in infestation was achieved by Btk (78.65%) at dose rate of 6 g Btk powder per kilogram talc powder[35,36].

Conservation biological control: Several species of parasitoid wasps, including *Apanteles* sp., *Bracon brevicornis*, *Phanerotoma ocularis*, *Microbracon hebetor* and *Hymenobosmina* sp., have affective roles in the natural control and population dynamics of date palm lesser moth. Conservation biological control method is an effective step for increasing the efficiency of these natural enemies in IPM program. In this study, several methods have been proposed for the protection and improvement the performance of these natural enemies[37].

Adult parasitoid wasps feed on flowers nectars and pollens around date palm plantations such as genus *Cyanthillium* and *Asclepias*. Maintaining these plants naturally or artificial planting are very effective in conservation and increase performances of the parasitoid wasps[38].

The parasitoid wasps are extremely sensitive to organophosphate and pyrethroid insecticides. Therefore, they should not be used for date pest control unless it will be necessary and in a controlled way[38].

FIRST SUPPLEMENTARY STEP: CULTURAL CONTROL (SANITATION)

The effects of cultural management on the lesser date moth infestations were studied[9].

Pruning bunch-remained: Some of the lesser date moth hibernated population overwinter on bunch remains and transfers to warehouse by infested fruits. Thus pruning bunch-remained decreased overwintering locations and therefore, pest population will be reduced on future generations[9].

Bunch covering: The lesser date moth lying on bunch is prevented by bunch covering and reduced the pest damage. The larvae are able to migrate to another date palm bunch. The bunch covering also prevents spread of the lesser moth infection[9].

A study was conducted during the two subsequent seasons of 2001 and 2002 in El-Beheira Governorate, Egypt, to evaluate the efficiency of some agricultural practices on the incidence of the lesser date-moth, *B. amydraula* on some date-palm varieties, i.e., Sammany, Hayany and Halawy. In an attempt to explain such variations in the infestation by *B. amydraula*, determinations of wax contents as well as the histological studies of the green fruits of each variety were conducted. Results revealed that tolerance of Sammany to the infestation was due to relatively higher wax content (0.420 g/10 fruits) than that of either Hayany (0.220 g/10 fruits) or Halawy (0.320/10 fruits), respectively[39].

SECOND SUPPLEMENTARY STEP: CULTIVARS RESISTANCE

Iranian native date palm cultivars clustered in 4 groups based on moth very susceptible including Dagalsorkh, Bentalsabae, Diry, Raim, Jahromy, Sayer, Gantar, Dagalzard and

Berhee. Susceptible cultivars including Hamravi, Bobaki, Sovidani, Berim, Halavi, Belyani, Zahedi, Khazravi, Fersi and Hadal. Semi-resistance cultivars including Ashkar, Jozi, Khasab and Amobahri. Resistance cultivars including Hasavi, Liloei and Mashtom[40].

THIRD SUPPLEMENTARY STEP: CHEMICAL CONTROL

As a supplementary step a number of specific larvicides were recommended for integrated management of a date palm lesser moth including: (1) Hexaflumuron (2 mL L^{-1}) (0.6 cc L^{-1}), (2) Benzophosphate (2 mL L^{-1}) and (3) Chlorpyrifos-methyl (2 mL L^{-1})[7]. These insecticides are considered recommendable for use in integrated control operations with *B. thuringiensis* and provided that due regard is given to the environmental implications of their use.

Decision making in date palm IPM: One of the most important problems of date spider mite and the lesser moth control is accurate decision making system including forecasting and monitoring[5,23]. Forecasting is a management system used to predict the occurrence or change in injury of plant pests. At the field scale, these systems are used by date palm growers to make economic decisions about pest control treatments. Forecasting systems are based on assumptions about the pests interactions with the host and environment were designed. It is speculated that combining the forecasting model based on meteorological models and pest monitoring based on geostatistical models had been practically utilized as a computer program for decision-making system in integrated pest management[23,40].

Geographic Information System (GIS) based techniques and threshold based sampling plans could serve as vital tools to assess the performance of area-wide IPM programs in date palm. The GIS tactics used to determine the spatial-temporal distribution of RPW in food baited pheromone traps installed[41-43].

Socio-economic and extension factors affected date palm IPM: Generally, researchers and extension agents are often frustrated by slower than expected adoption levels for agricultural innovations such as date palm IPM. Slow rates of adoption cause a loss of potential benefit of IPM program to date palm growers and the public. This is a main reason why so much attention has been given to try and understand what drives adoption of new technology among date palm growers[44]. Sixty five growers were studied to effects socio-economic and extensions factors on date palm IPM. Results showed that land holding, the ratio of irrigated to total land, number of fertilized trees to number of growers, yield per tree, percentage of yield which be sold, crop benefit and ownership of tractor have negative and significant effects on pests injuries and positive effects on growers motivation to pests control. Four factors including irrigated to total land, value of crop benefit, number of fertilized trees to number of growers and non-agricultural employment had the most effective approach on date pests control program, respectively. On the other hand, extensions factors including availability to agriculture service centers were more important than promoter visitation and education and extenuation class on date palm pests control[45].

DATE PALMS PEST MANAGEMENT PROGRAM AND ITS EXECUTION CHALLENGES

IPM program plan: A substantial and rapid change is necessary in order to achieve ecological and economic approach of date palm pest control[7]. The integrated date palm pests control plan recommended is showed in Fig. 3.

Execution challenges: There are different challenges for implementation of biological based IPM in date palm plantations. The most important challenges are climatic factors, establishment of biological control agents in release site, a viability of biological control agents and economic mass productions of them.

Climatic factors: Understanding of the fluctuations in of the date palm pests and their natural enemies and the effect of climatic factors is necessary for operating the proposed models for integrated date palm pest management[4]. Climate change is adversely impacting human societies. The Intergovernmental Panel on Climate Change (IPCC) has estimated that by 2100 the global mean surface temperature will increase by 1-3.5°C from the 1990 level[46]. According to FAO over one third land area of the world is desert which mainly occurs due to prevailing weather patterns and over-exploitation by inappropriate land use. The desert of the world indicated that lands occupy 6.31 billion hectare or nearly half of the earth's land area. This situation leads to overgrazing, deforestation and faulty irrigation practices that in turn could cause deterioration in the soil fertility and crop productivity. The relationship between desertification and climate change, combined with biodiversity loss, degradation of land and water shortage makes farming in the dry lands of the world increasingly difficult and challenging[47].

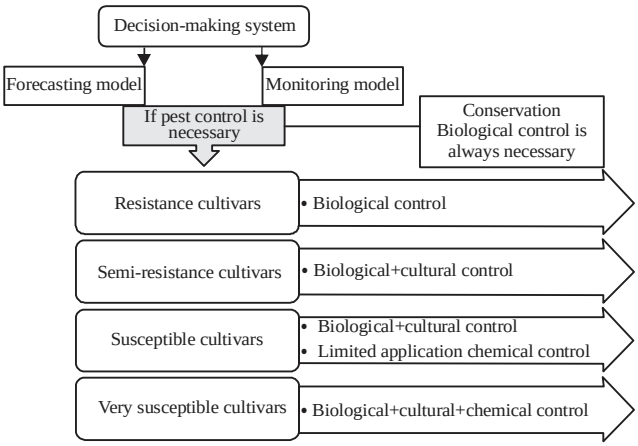

Fig. 3: Program plant for date palm fruit feeders pests management control

Population of date palm pests and their natural enemies are affected by bioclimatic changes[2,48]. The influences of these changes on natural enemies are much more than the pests[49]. For example, the optimum temperature, low temperature threshold and high temperature threshold of the lesser moth were 33.83, 16.10 and 39.87°C, respectively. It can be concluded that temperatures lower than 16 and higher than 40°C cause 100% mortality[50]. On the other hand, the optimum temperature for the development of its parasitoid Trichogramma evanescens (Westwood) ranged between 22 and 27°C. The upper development threshold temperature was 38.4°C and the lower was 11.14°C. Results also showed that the highest parasitism rate was 94.4% recorded at 25±2°C[51].

Establishment of biological control agents: Although research results have shown that biological control agent offers in this document are the convenient ability for establishment. But there are some problems to reach suitable efficiency of the control. The size of the release area is very effective for the success BT and *S. gilvifrons* to biological control of the lesser moth and spider mite[14,32]. The average level of date palm growers ownerships are about 0.4 ha in Iran. Therefore, government support is essential for the practical and coordinating implementation of biological control.

Economic accessibility of biological control agents: Date palm biological control agents must be developed in the public sector and need economic assessments at an early stage. Living biological controls frequently escape and they may be disrupted by pesticides or date palm cultural practices. So economic accessibility of biological control agents are very important for adaptation of this method. Based on the model findings and taking into account the net return on investment and total expenditure that carried out over a period of 18 years, the rate of returns on investment for biological control of spider mite and the lesser moth were 61.9 and 29.4, respectively. Among the experts participating in this study were 78 and 76% of respondents strongly agree or agree with the possibility of combining chemical, cultural and cultivar resistant control with pests biological control of date palm pests[51].

CONCLUSION AND FUTURE RECOMMENDATIONS

This review shows that biological control is the backbone of the integrated pest management program in date palm orchards which was based on three control methods including cultural control, cultivars resistance and chemical control (in compulsory conditions) and these were incorporated. Integrated Pest Management (IPM) is a framework of decision-making and action tools designed to maintain and improve date palm orchards health. Pests monitoring ensures early detection of potential problems. Combined control strategies with elimination of the economic and social problems, a sound basis on which to decide for control. But more studies on practical application of the IPM in this area are recommended as follows:

- Determination of the standard methods for assessing damage rate and population density of date plant fruits pests
- Determination of the economic thresholds of date palm fruit pests and sequential sampling models for decision making in the release of biological control agents
- Population dynamics and the role of other biotic and abiotic factors on the effectiveness of date palm pest's biological control

- Evaluation of potentials of environmental management and ecological engineer in increasing the efficiency of date palm pest biological control
- Methods of economic biological control agents mass production
- Development of classical biological control methods is necessary by transferring of natural enemies technology exchange between date palm cultivation countries

SIGNIFICANCE STATEMENTS

The results of this review found that date palm integrated pest management with a focus on biological control and integrated with crops management and chemical control economically optimizes the quantity and quality of the product and minimizes pesticides pollutions effects. Elimination of the socio-economic barriers along with application forecasting and monitoring are effective in IPM efficiency improvements.

REFERENCES

1. FAOSTAT., 2012. Food and agricultural commodities production. http://faostat.fao.org/site/339/default.aspx.
2. Latifian, M., 2000. The bioecology of date palm pests. Date Palm and Tropical Fruits Research Institute, pp: 24.
3. Anonymous, 1985. Codex standards for dates. CODEX STAN, pp: 6.
4. Latifian, M., 2001. The models used for integrated pest's management. Date Palm and Tropical Fruits Research Institute, pp: 25.
5. Latifian, M. and M. Zare, 2003. The forecasting model of the date lesser moth (*Batrachedra amydraula*) based on climatic factors. J. Agric. Sci., 2: 27-36.
6. Latifian, M., S. Ahmadizadeh and P. Nikbakht, 2005. Host preference of date lesser moth (*Batrachedra amydraula* Meyr) to Khuzestan native cultivars of date palm. J. Seeds Plantlet, 20: 215-223.
7. Latifian, M., 2001. Management Factors Roles in Pest and Disease Control. Date Palm and Tropical Fruit Research Institute, Iran, pp: 32.
8. Latifian, M. and M. Zaerae, 2009. The effects of climatic conditions on seasonal population fluctuation of date palm scale *Parlatoria blanchardi* Targ. (Hem.: Dispididae). Plant Protect. J., 1: 277-286.
9. Latifian, M., 2012. The effects of cultural management on the lesser date moth (*Batrachedra amydraula* Myer) infestation. Emirates J. Food Agric., 24: 224-229.
10. Blumberg, D., 2008. Review: Date palm arthropod pests and their management in Israel. Phytoparasitica, 36: 411-448.
11. FAO., 1966. Proceedings of the FAO Symposium on Integrated Pest Control, Rome, October 11-15, 1965. FAO-UN, Rome, Italy. Part 1, pp: 91, Part 2, pp: 186 and Part 3, pp: 129.
12. Abrol, D., 2013. Integrated Pest Management: Current Concepts and Ecological Perspective. 1st Edn., Academic Press, USA., ISBN: 9780123985293, Pages: 576.
13. Latifian, M., 2012. Voracity and feeding preferences of larvae and adult stages of *Stethorus gilvifrons* Mulsant. (Coleoptera: Coccinellidae) on larvae and adult of *Oligonychus afrasiaticus* McGregor (Acarina: Tetranychidae). Int. J. Agric. Crop Sci., 4: 540-546.
14. Latifian, M. and G.R. Kajbafevala, 2016. Studying the efficiency of *Stethorus gilvifrons* inoculate release for Date palm spider mite (*Oligonychus afrasiaticus*) biological control in field condition. Ministry of Jahad-E-Agriculture, Research and Education Organization, Date Palm and Tropical Fruits Research Institute, Iran, pp: 75.
15. Gerson, U., A. Venezian and D. Blumberg, 1983. Phytophagous mites on date palms in Israel. Fruits, 38: 133-135.
16. Bass Haih, G., 1999. Studies on the occurrence of the date palm dust mite *Oligonychus afrasiaticus* (McGregor) (Acarin: Tetranychidae) and its natural enemies on different date palm varieties in Wadi Hadramout. M.Sc. Thesis, University of Aden, Yemen.
17. Latifian, M. and M. Arbabi, 2004. Study on effects of different pesticides on population of *Anystis baccarum* predatory mite of date palm spider mite (*Oligonychus afrasiaticus*) in Khozestan province. Proceedings of the 3rd National Congress on the Development in the Application of Biological Products and Optimum Utilization of Chemical Fertilizers and Pesticides in Agriculture, July 2004, Karaj, Iran, pp: 562.
18. Rahnama, A. and M. Latifian, 2013. Intercropping relative efficiency and its effects on date palm pests and disease control. Int. J. Agric. Res. Rev., 3: 617-623.
19. Daneshvar, H., H. Bayatasadi and G. Kajbafvala, 2001. Faunistic study date palm mite predators *Oligonychus afrasiaticus* in Khuzestan. Plant Protection Institute, Iran, pp: 30.
20. Latifian, M., A.A. Rahnama and M. Amani, 2014. The effects of cultural management on the Date spider mite (*Oligonychus afrasiaticus* McG) infestation. Int. J. Farm. Allied Sci., 3: 1009-1014.
21. Palevsky, E., O. Ucko, S. Peles, S. Yablonski and U. Gerson, 2004. Evaluation of control measures for *Oligonychus afrasiaticus* infesting date palm cultivars in the Southern Arava valley of Israel. Crop Protect., 23: 387-392.

22. Latifian, M., A.A. Rahnama and H. Sharifnezhad, 2012. Effects of planting pattern on major date palm pests and diseases injury severity. Int. J. Agric. Crop Sci., 4: 1443-1451.
23. Latifian, M., 2014. Date palm spider mite (*Oligonychus afrasiaticus* McGregor) forecasting and monitoring system. WALIA J., 30: 79-85.
24. Al Dosari, S. and A.G. Ali, 2007. Susceptibility of date palm fruit cultivars to the natural infestation by *Oligonychus afrasiaticus* (Mcg.) (Acari: Tetranychidae) in relation to their chemical composition. Assiout Univ. Bull. Environ. Res., 10: 1-7.
25. Ben Chaabane, S. and B. Chermiti, 2009. Characteristics of date fruit and its influence on population dynamics of *Oligonychus afrasiaticus* McGregor (Acari: Tetranychidae) in the Southern of Tunisia. Acarologia, 49: 29-37.
26. Bucher, G.E. and H.H. Cheng, 1970. Use of trap plants for attracting cutworm larvae. Can. Entomol., 102: 797-798.
27. Javanshir, A., A. Dabgh-Mohamadinasab, A. Hamidi and M. Gholipour, 2000. Intercropping ecological. Mashhad University, Iran, pp: 217.
28. Trenbath, B.R., 1993. Intercropping for the management of pests and diseases. Field Crops Res., 34: 381-405.
29. Latifian, M., S.S. Marashi, S. Ahmadizadeh and P. Nikbakht, 2007. Host preference of date palm spider mite, *Oligonychus afrasiaticus* (McGregor), to native date palm cultivars of Khuzestan. J. Seeds Plant Improv., 23: 245-255.
30. Al-Mssallem, I.S., S. Hu, X. Zhang, Q. Lin and W. Liu *et al*., 2013. Genome sequence of the date palm *Phoenix dactylifera* L. Nat. Commun., Vol. 4. 10.1038/ncomms3274.
31. Latifian, M. and G.R. Kajbafvala, 2015. Pathogenicity of *Bacillus thuringiensis* against three important date palm insect pests. Arab. J. Plant Prot., 33: 323-329.
32. Latifian, M., M. Omidbakhsh, M. Amani and E. Rahkhodaei, 2016. Studying the efficiency of bacterium *Bacillus thuringiensis* inundative release for the Date lesser moth (*Batrachedra amydraula*) biological control in field condition. Ministry of Jahad-E-Agriculture, Research and Education Organization, Date Palm and Tropical Fruits Research Institute, Iran, pp: 44.
33. Al-Jboory, I.J., 2007. Survey and identification of the biotic factors in the date palm environment and its application for designing IPM-Program of date palm pests in Iraq. Univ. Aden J. Nat. Applied Sci., 11: 423-457.
34. Habib, D.M. and S.H. Essaadi, 2007. Biocontrol of the lesser date moth *Batrachedra amydraula* Meyrick (Cosmopterigidae=Batrachedridae) on date palm trees. ActaHortic, 736: 391-397.
35. Alrubeai, H.F., B.S. Hamad, A.M. Abdullatif, H.Z. Ali and A. Abed, 2014. Efficacy of *Trichogramma evanescens* and *Bacillus thuringiensis kurstaki* to control lesser date moth *Batrachedra amydraula* Merck. J. Agric. Sci. Technol. B, 4: 281-284.
36. Karampour, F., 2010. Collection, identification and application potential determination of natural enemies of *Batrachedra amydraula* Meyr. Acta Hortic., 882: 1045-1051.
37. Latifian, M., 2015. Conservation of parasitoids wasps in Date palm plantations. Technical Report, Date Palm and Tropical Institute, Iran, pp: 15.
38. Harhash, M., A.K. Mourad and S.M. Hammad, 2002. Integrated crop management of the lesser date moth *Batrachedra amydraula* Meyr. (Lepidoptera: Cosmopteridae) infesting some date-palm varieties in Egypt. Commun. Agric. Applied Biol. Sci., 68: 209-221.
39. Latifian, M. and N.E. Soleyman, 2009. Study of the Lesser moth *Batrachedra amydraula* (Lep.: Batrachedridae) distribution based on geostatistical models in Khuzestan province. J. Entomol. Res., 1: 43-55.
40. Al-Shawaf, A.M.A., S. Al-Abdan, A.H. Al-Abbad, A.B. Abdallah and J.R. Faleiro, 2012. Validating area-wide management of *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae) in date plantations of Al-Hassa, Saudi Arabia. Indian J. Plant Protect., 40: 255-259.
41. Faleiro, J.R., A.B. Abdallah, J.A. Kumar, A. Shagagh and S. Al Abdan, 2010. Sequential sampling plan for area-wide management of *Rhynchophorus ferrugineus* (Olivier) in date palm plantations of Saudi Arabia. Int. J. Trop. Insect Sci., 30: 145-153.
42. Massoud, M.A., A.A. Sallam, J.R. Faleiro and S. Al-Abdan, 2012. Geographic information system-based study to ascertain the spatial and temporal spread of red palm weevil *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae) in date plantations. Int. J. Trop. Insect Sci., 32: 108-115.
43. Latifian, M., A. Ahmadi and H. Pezhman, 2006. A study of the extension factors affecting suitable control of date palm pests and diseases. Iran. J. Agric. Sci., 37: 155-163.
44. Masoud, L., A.A.R. Ahmadi and H. Pezhman, 2006. The effects of socio-economic factors in control of date palm pests and diseases in Khuzestan province. Scient. J. Agric., 29: 75-83.
45. Cannon, R.J.C., 1998. The implications of predicted climate change for insect pests in the UK, with emphasis on non indigenous species. Global Change Biol., 4: 785-796.
46. Lal, R., 2001. Potential of desertification control to sequester carbon and mitigate the greenhouse effect. Climate Change, 51: 35-72.
47. Latifian, M., 2014. Study the effects of dusts phenomenon on date palm important pests and diseases. Int. J. Res. Agric. Sci., 2: 8-15.

48. Wang, X.Y., Z.Q. Yang, H. Wu and J.R. Gould, 2008. Effects of host size on the sex ratio, clutch size and size of adult *Spathius agrili*, an ectoparasitoid of emerald ash borer. Biol. Control, 44: 7-12.
49. Shayesteh, N., A. Marouf and M. Amir-Maafi, 2010. Some biological characteristics of the *Batrachedra amydraula* Meyrick (Lep: Batrachedridae) on main varieties of dry and semi-dry date palm of Iran. Proceedings of the 10th International Working Conference on Product Protection, June 27-July 2, 2010, Portugal, pp: 151-155.
50. Mohammad, J.K., R.F. Al-Jassany and A.S.A. Ali, 2015. Influence of temperature on some biological characteristics of *Trichogramma evanescens* (Westwood) (Hymenoptera: Trichogrammatidae) on the egg of lesser date moth *Batrachedra amydraula* Meyrick. J. Biol. Control, 29: 125-130.
51. Latifian, M. and S. Ahmadizadeh, 2016. Study the economic efficiency (Cost-benefit) of biological control of pests of date palm. Final Report, Date Palm and Tropical Fruits Research Institute, Iran, pp: 78.