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Date palm spider mite monitoring system

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A B S T R A C T

The spider mite (*Oligonychus afrasiaticus* McGregor) is an important injurious Pest of date palm. This research was carried out to decision making system in integrated pest of date palm in Abadan, Khoramshhar, Shadegan, Ahwaz, Mahshar and Behbehan regions of Khuzestan province by climatic and geoststistical models from 2008 to 2012. Samples were taken randomly from 10 trees located in one date palm orchards of any villages then the percent injury of date palm pest evaluated. Results showed that the spider mite damages reached to the peak values in July. Forecasting model of damage factors including have been significant at level 1 percent. Variography of distribution on different sites were studied based on Spherical, Exponential, Linear, Linear to sill and Gaussian models and their Kringing maps were driven. The model nuggets for spider mite for Abadan & Khoramshhar, Shadegan, Ahwaz, Mahshar and Behbehan regions were 11.6, 21.2, 11.8, 11.4 and 12.4 kilometers respectively. These results show that errors of the pest damage estimation were low at the distances less than within sampling space. Effective ranges of variograms were 12.4, 12.7, 8.2, 6.5 and 7.2 respectively which indicated the population distribution in region. Sills of models were 0.91, 0.74, 0.67, 0.75 and 0.96 respectively that at the distances more than these thresholds, correlations between the data of damages are at the lowest level and could be monitored. Combining both intelligent model based on meteorological and dispersion index pests on geostatistic has provided possible practical operation of the system of decision making in the form of a computer program.

1. Introduction

Date Palm spider mite *Oligonychus afrasiaticus* McGregor is the most important pest of date fruit. Dates bunches were been dusty and low quality when mite outbreaks. As result, the Date fruits were fallen out before ripening. This mite activities exposed to direct sunlight at 45°C and it was been passed in the palm shaded parts by its pin web. The pest ovi position and population density have decreased when the weather was cold. The mite injury started at humidity 14.7%.The spider mite damage is reduced up to 50% by relative humidity increase over the 21.3% (Latifian, 2000).

One of the most important problems of Dates spider mite control is lack of accurate decision-making system including forecasting and monitoring (Latifian, 2001). 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 growers to make economic decisions about pest treatments for control Russo *et al*., 1993; Russo 2000).Forecasting systems are based on assumptions about the pest's interactions with the host and environment. The objective is to accurately predict when the three factors - host, environment, and pest - all interact in such a fashion that pest can occur and cause economic losses (Schub, 1996). Simultaneously by development of agricultural meteorological from 1950 to forecasting, different methods depending on the application climate variables had been designed (Huntingford *et al*., 2005).

Simulation approaches offer flexibility for testing, refinement, and sensitivity analysis as well as field validation of developed model solver a wide range of environmental conditions. Thorough descriptions of cropping systems being managed or studied are needed to explain the interactions among pests, plants and the environment (Colbach, 2010).

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Systems models or other prediction schemes can be used with appropriate biological, environmental, economic or other inputs to analyze the most effective management actions, based on acceptable control, sustainability and assessment of economic or other risks (Strand, 2000)

Understanding the spatial dynamics of insect pests of crops can assist in developing ecologically based management practices. For example, if spatial distributions are consistent among years, predictions may be used for future distributions (Park and Tollefson 2006). Geostatistics have been used in plant pest management to analyze the spatial distribution of plant pest, mainly at plot or field scales. They have also been used in a regional risk assessment program for the management of plant pests (Story *et al.,* 1994, Ellbsury *et al.,* 1998). Geostatistical methods had been used for solving ecological problems during 1950 and 1960 and it has been implicated of solving ecological integrated pest management in many cases in recent years (Goovacts, 1997).According to the background of studies, the forecasting and monitoring system of date spider mite were designed based on weather and geostatistical models for Khuzestan province in this research.

2. Material and Methods

This study were conducted in Abadan, Khorramshahr, Shadegan, Ahvaz, Behbehan and Mahshahr the cities in Khuzestan province of Iran during the years 2008 to 2012 for 5 years. Khuzestan is in the southwest of the country, bordering Iraq's Basra Province and the Persian Gulf. Its capital is Ahvaz and it covers an area of 63,238 km^2.The abundance of water and fertility of soil has transformed this region into a rich and well-endowed land. All the standard meteorological data have been collected in the local station and used for simulating models.

2.1. Estimation of spider mite damage

The percentage of Date spider mite damage was estimated by selected a Date plantation from any village randomly and samplings had been done during the season. 10 palm trees were selected randomly in each plantation. 85 garden Dates were sampled in the area each year. Three clause fruits were harvested from each tree. Then amount of total, healthy, infected and the percentage of damages fruits were calculated.

2.2. Forecasting models

Forecasting models were simulated such as Andrewartha and Brich model (Andrewarth and Brich, 1953). For this purpose, the correlation coefficients between damages and weather data were calculated at first. Maximum damage was simulated as a function of climatic factors in a multivariate regression model. The coefficients of climatic factors were estimated in different months during the pest hibernation. Multiple stepwise regression analysis was performed for simulating and reducing the number of model factors. Curve Expert software (version 1.3, Hyams, 2010) was used for statistical analysis and simulation models. The forecasting models were simulated for each area separately. The parameters were used for simulating models including the average spring temperature (X_1), the average summer temperature (X_2), the number of months with rainfall (X_{20}), average humidity of summer (X_{30}) and the average moisture April (X_{33}) (Latifian and Zare., 2003).

2.3. Monitoring model

Geostatistical methods were used for simulating monitoring models. Geostatistical method is based on the spatial variables theory (Story *et al.,* 1994 and Wright *et al.,* 2002). Spatial correlation between samples can be described as a mathematical model Known as the variogram (Ellbsury *et al.,* 1998). If it is assumed that the total number of each pair of samples N (h) located at the distance h, then:

$$\hat{\gamma}(h) = \frac{1}{2N(h)} \sum_{i=1}^{N(h)} [Z(xi) - Z(xi+h)]^2$$

$\hat{\gamma}(h)$ is called Semi variance in the above equation. The values of semi variance are plotted on the vertical axis for different distances to selected be the best models. The obtained curves were drowning by this method known as variogram (Journel *et al.,* 1978). Some of variogram models (eg, Gaussian and spherical) had and others such as linear models hadn't limit threshold level. This means that variogram values were increased by increasing distance between samples (h) but not to fixed extent (Katheriene, 2001). The distance after which semivariance is constant known as *range of effects* and showed by R. The effect range is interval more than it; samples are independent and not affected to each other. This parameter determines the characteristics correlation and allowable interval sampling distance. So the lag distance at which the semivariogram (or semivariogram component) reaches the sill value. Presumably, autocorrelation is essentially zero beyond the range.

Most of variograms don't show rapid changes at very short distances so much semi variance not zero at the base of variogram curve. So in theory the semivariogram value at the origin should be zero. If it is significantly different from zero for distance very close to zero, then this semivariogram value is referred to as the nugget. The nugget represents variability at distances smaller than the typical sample spacing, including measurement error (Goovaets, 1997).

The variogram model parameters can be used to estimate the distribution of insects. All interpolation algorithms estimate the value at a given location as a weighted sum of data values at surrounding locations. Almost all assign weights according to functions that give a decreasing weight with increasing separation distance. Kriging is a commonly used method of interpolation (prediction) for spatial data. The data are a set of observations of some variable(s) of interest, with some spatial correlation present (Katheriene, 2001).

3. Results

The pest injury has started around June every year, and its severity was increased gradually by warming weather. So that the pest injury increased to a maximum on July and August and then reduced gradually. The injury was stopped in September at the same time that fruit ripening occurs and the fruits enter the phonological date stage.

3.1. Forecasting model

The relationships between climatic factors and date spider mite injury as correlation coefficients can be seen in Table 1. According to this table, The parameters x_1, x_2, x_{20}, x_{30}, x_{23} and x_{33} and has been moderate to strong correlation with Date spider mite injury. So they can be used in modeling of date spider mite injury forecasting.

Table 1: The correlation analysis between Date palm spider mite injury and climatic parameters

Regions	Climatic parameters	t(N-1)	Coefficient of correlation	Significant Level
Ababan and Khoramshahr	X_1	-1	-0.5	0.39
	X_2	1.29	0.6	0.28
	X_{20}	0.75	-0.4	0.50
	X_{30}	-1.29	-0.6	0.28
	X_{33}	-0.35	-0.52	0.74
Shadegan	X_1	0.54	-0.53	0.62
	X_2	1	0.5	0.39
	X_{20}	0.54	-0.41	0.62
	X_{30}	1.29	-0.6	0.28
	X_{33}	-0.17	-0.54	0.87
Mahshahr	X_1	-1	-0.5	0.39
	X_2	0.08	0.51	0.93
	X_{20}	0.19	-0.51	0.86
	X_{30}	0.54	-0.63	0.62
	X_{33}	1.69	-0.7	0.18
Ahwaz	X_1	0.35	-0.52	0.75
	X_2	-0.75	0.4	0.50
	X_{20}	-0.75	-0.54	0.50
	X_{30}	0.35	-0.62	0.74
	X_{33}	0.17	-0.71	0.87
Behbehan	X_1	0.86	-0.57	0.45
	X_2	0.86	0.45	0.45
	X_{20}	0.86	-0.49	0.45
	X_{30}	1.56	-0.67	0.21
	X_{33}	0.17	-0.51	0.87

The results of multiple stepwise regression models were registered to Table 2. According to this table, the date spider mite injury forecasting models were simulated as follows.

Abadan and Khoramshahr:

$$I = 3.58X_{20} - 0.43X_{30} + 1.23X_{33} - 94.96$$

Shadegan:

$$I = 1.5X_{20} - 0.18X_{30} + 0.04X_{33} - 16.66$$

Behbehan

$$I = 13.6X_{20} - 0.96X_{30} + 2.57X_{33} - 27.66$$

Mahshahr:

$$I = 0.97X_{20} - 0.24X_{30} + 0.42X_{33} - 35.65$$

Ahwaz:

$$I = 5.88X_{20} - 0.51X_{30} + 0.25X_{33} - 29.75$$

Based on the results, the regression models in all areas and in Behbehan were significant level 1% and 5% respectively. In all models, the detection error and explanation coefficient of forecasting models were greater than 0.7 and less than 25 percent respectively. These results reflect that the models can be implicated for local date palm care network.

3.2. Monitoring models

The date palm spider miteinhury distribution variographic were fitted based on of spherical, exponential, linear, Gaussian and Sill models in Khuzestan province. The model will be selected if it had greater determination coefficient. Larger Rss model will be selected if the model coefficients are equal. Selected models are shown in Figure 1. Results of variograhy analysis showed suitable trend in Khuzestan province monitoring model simulation. The model nuggets for spider mite for Abadan & Khoramshhar, Shadegan, Ahwaz, Mahshar and Behbehan regions were 11.6, 21.2, 11.8, 11.4 and 12.4 kilometers respectively. These results show that errors of the pest damage estimation were low at the distances less than within sampling space. Effective ranges of variograms were 12.4, 12.7, 8.2, 6.5 and 7.2 respectively which indicated the population distribution in region. Sills of models were 0.91, 0.74, 0.67, 0.75 and 0.96 respectively that at the distances more than these thresholds, correlations between the data of damages are at the lowest level and could be monitored.

Kriging maps of Date palm spider mite injury distribution is drawing for any studied regions of Khuzestan province in Figure 2. The Kriging maps are digital so that three attributes of the point including longitude, latitude, and the percent spider mite injury can be readable by stopping on each point. According to Kriging maps, four groups of regional mite infestation can be considerd for Khuzestan province which includes the following groups:

The first region that includes Date palm plantations are low risk and the degree of infestation less than 10%.

The second region that includes Date palm plantations are moderate risk and the degree of infestation 11-20%.

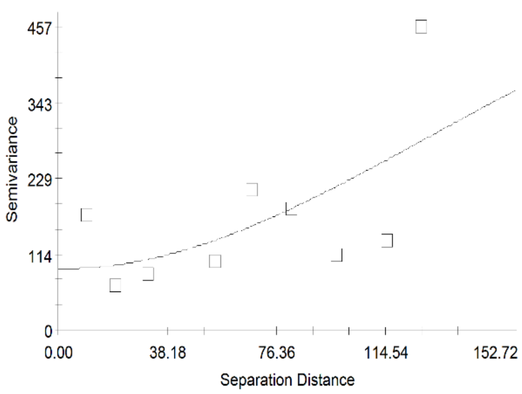
The third region that includes Date palm plantations are high risk and the degree of infestation less than 21-30%.

The fourth region that includes Date palm plantations are very high risk and the degree of infestation more than 31%.

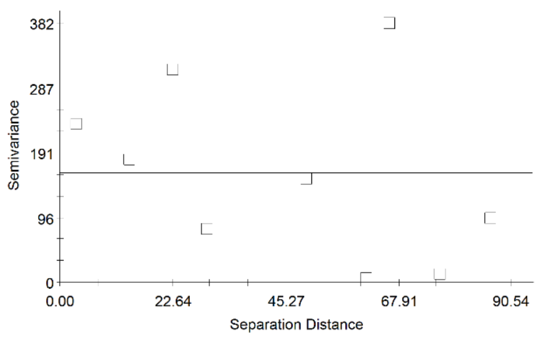
In all monitoring models the error detected coefficient greater than 0.7 and distinguish error less than 25 percent. These results showed that the spider mite injury monitoring models are applicable on the region date palm care network.

Table2: Regression analysis of Date palm spider mite injury forecasting models

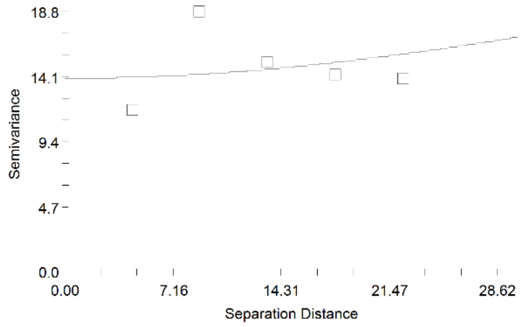
Regions	Parameters	Coefficient	Standard Error
Ababan and Khoramshahr	Intercept	-94.96	0.08
	X20	3.58	0.49
	X30	-0.42	0.28
	X33	1.23	0.74
Shadegan	Intercept	-16.66	0.66
	X20	1.05	0.44
	X30	-0.18	0.07
	X33	0.04	0.03
Mahshahr	Intercept	-35.65	0.62
	X20	0.97	0.38
	X30	-0.24	0.36
	X33	0.42	0.25
Ahwaz	Intercept	-29.75	0.51
	X20	5.88	0.53
	X30	-0.51	0.55
	X33	0.25	0.40
Behbehan	Intercept	-27.66	0.81
	X20	13.6	0.65
	X30	-0.96	0.12
	X33	2.57	0.28



Abadan and Khoramshahr



Shadegan



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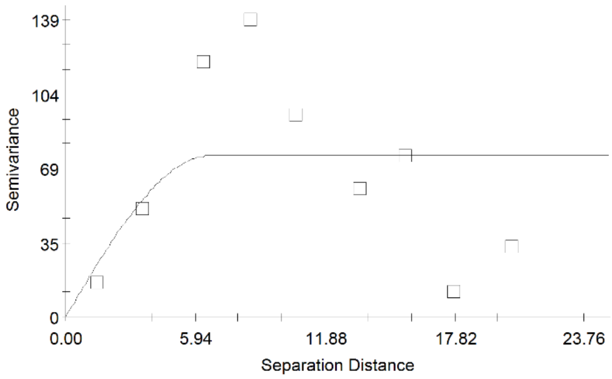

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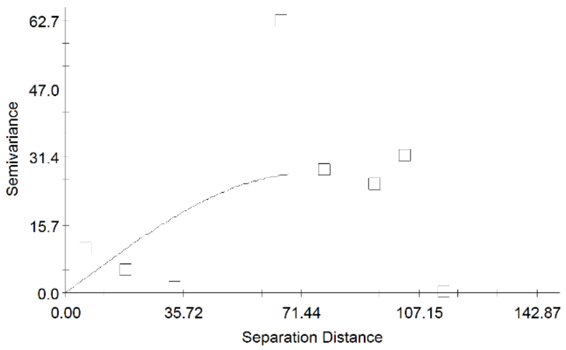


Behbehan

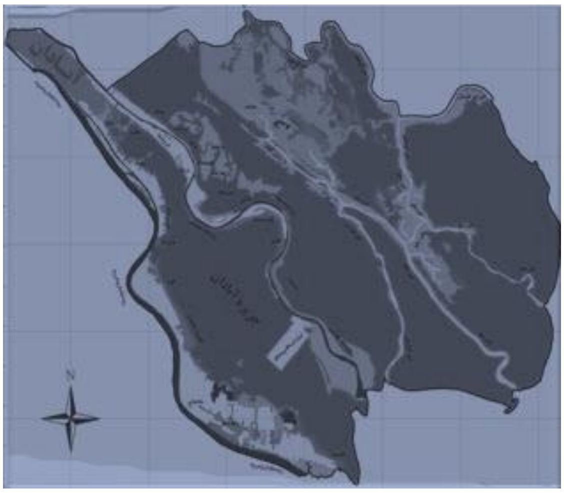
Fig. 1: Variugarms of Date palm spider mite injury distribution in different regions of Khuzestan province

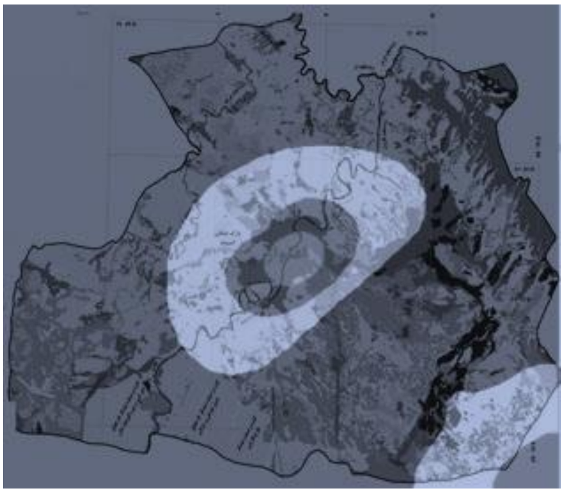
4. Discussion

The results of this research were fundamental step for simulation decision making system in Date palm care network in Khuzestan province. Forecasting and monitoring are used for accurate decision making in integrated pest management. Different models can be used for this purpose (Dent, 1995; Madden & Ellis, 1988). Adaptation to climate phonological models is applicable model that used in this study. The phonological forecasting models are simulated periodic pest biological events associated with seasonal climatic conditions fluctuation and the resulting equation can be used as algorithms for computerized pest Forecasting software (Gendi, 1998; Gaston, 2003; Mawby and Gold 1984). Such as this study has been done with the lesser date moth *Batrachedra amydraula* Meyer and Date palm scale Parlatoria *blanchardi* Targ in Iran (Latifian and Zare, 2003, 2009). Comparison of this study results with other studies showed that in most cases phonological climatic models (Gaston, 2003) and multiple linear regression models have suitable accuracy in the pests management forecasting (Latifian and Zare, 2003, 2009).

Comparison simulated monitoring model in this study with the distribution models of other pests such as Wheat aphid *Sitobion avenae* F. (Winder *et al.,* 1999) and corn root beetle *Diabrotica virgifera* Smith &Lawrence (Wright *et al.,* 2002) showed that geostatistical method had enough accurately for the spider mite dates monitoring in the studied region. In recent years, the geostatistical models have been used successfully for spatial patterns analysis, pest control supervision, traps application design and risk assessment maps in the garden pest management (Sciarretta and Trematerra, 2014). The results of this research can be used similar to planning application of Date palm spider mite integrated management.

The meteorological data of region indices station must be used for Decision making system of protection of plants against the injurious factors. Care in selection appropriate stations for the design of models considerable has influence on the recommendations control quality and pests diagnosis accurate. The efficiency of pest management decisions making system will be increased when the results of geostatistical techniques such as kriging simulations combine with a computer program for the protection of plants (Chokman *et al.*, 2005). In this study, the results of combining the forecasting model based on meteorological models and pest monitoring based on geostatistical models can be utilized practical as a computer program pest for decision-making system in integrated pest management.


Abadan & Khoramshahr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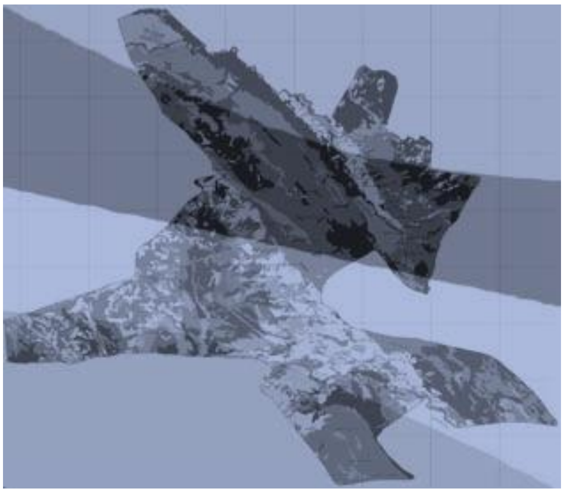
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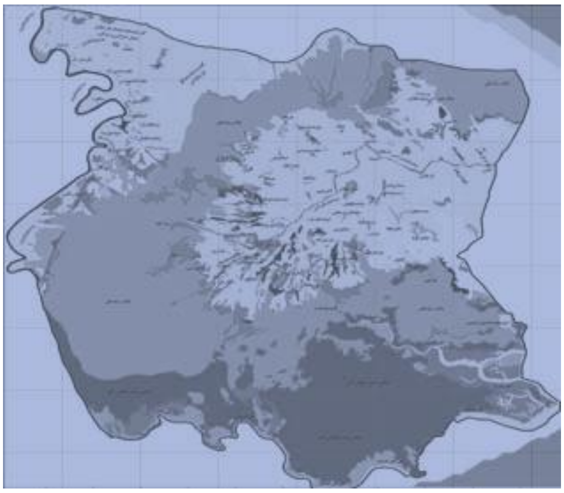
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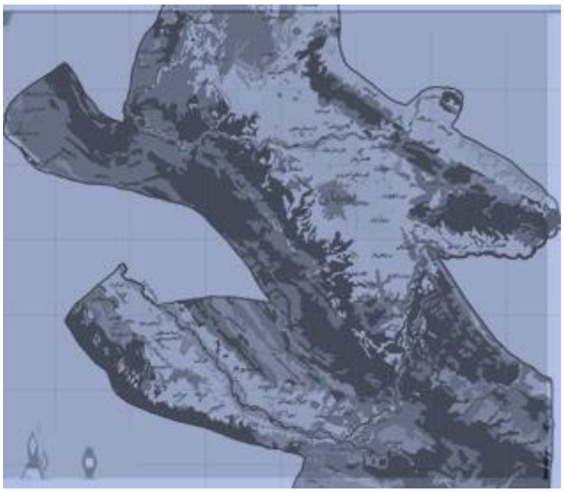
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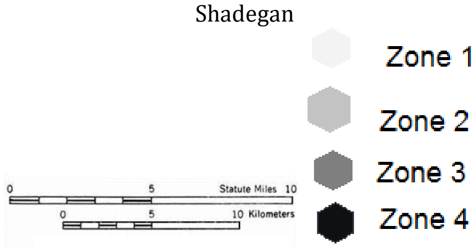

Fig2: Kringing maps of Date palm spider mite injury distribution in different regions of Khuzestan province

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