Evaluation of effectiveness of some Bioinsecticidal against the white scale insect, *Aulacaspis tubercularis* (Homoptera: Diaspididae) on mango trees in Egypt

Abd El-Salam, A.M.E[1], Haggag Wafaa M[2]

Abstract— **The white scale insect, Aulacaspis tubercularis on, is one of the most destructive pests of mango trees throughout in Egypt. Toxicities of three commercially available bioinsecticides for scale insects were compared with M-Pede and Selecron + Capi in the laboratory and the field which are currently used to treat the scale insects in Egypt. Two spraying applications were carried out during the outbreak of the insect pest. Selecron + Capi and M-Pede significantly suppressed the nymphs and adult nymphs when exposed to the recommended-field rats of 1.0+10.0 and 5.0 ml/l, respectively. Nimbecidine was the highest effective followed by bio-catch and bio-power. In a field test,5.0 ml/l of Nimbecidine as neem plant extract caused 92.7% reduction increasing to 100% reduction after the first and second application, respectively. The entomopathogenic fungi formulations as bio-catch (Lecanicillium lecanii) was highly effective than Bio-power (Beauveria bassiana) achieving 86.7 and 67.0% reduction, respectively, after two applications. The results showed the importance of the bioinsecticides as eco-friendly in controlling the insect pest because of protection the environmental from the pollution.**

Index Terms— **the white scale insect, Aulacaspis tubercularis, mango trees, Bioinsecticidal, neem , entomopathogenic fungi .**

I. INTRODUCTION

Mango (*Mangifera indica*), a member of family Anacardiaceae, is known as King of fruits. Its popularity is mainly due to its excellent flavour, delicious taste and high nutritive value. Its original home is believed to be south Asia where it has been cultivated for the last four thousand years (Salunkhe and Desai, 1984). It is now an important fruit of the tropic and sub-tropical parts of the world. It is a rich source of vitamin A and vitamin C. Ripe pulp of mangoes provides 74 Kcal of energy per 100 grams of edible portion. Mango (*Mangifera indica*), like most fruit tree crops, is usually attacked by two or three key pests, several secondary pests and a large number of occasional pests in localized areas where it is grown. Worldwide lists of pests of mango have been published by Veerish (1989). Some publications contain check-lists of mango pests and most contain details of life histories and control of mango pests (Golez, 1991,Murray, 1991).

The mango scale, *Aulacaspis tubercularis* Newstead (Hemiptera: Diaspididae) is found throughout the world where mango is cultivated, including the northern part of South America, the Caribbean, the east and west coasts of Africa, and India, and Italy . *Aulacaspis tubercularis* attacks mango leaves, branches and fruit, where it causes superficial pink or yellow blemishes to develop, making the fruit unmarketable (Joubert *et al.*, 2000), although precise economical figures are lacking. In the absence of evidence, Economic Impact is rated Medium (2). Scales are found on the upper or lower surfaces of leaves and also on fruits. Halteren (1970) studied the development of *A. tubercularis*, and concluded that development is completed in 35–40 days for females and 23–28 days for males.

In Egypt, It has become the most important pest in Egypt (Morsi et al.,2001). However, there is little information on the specific economic losses caused by this scale. This insect is mainly a problem as a contaminant on fruit, which can cause rejection in most fresh fruit markets (Blackburn and Miller, 1984). It also causes dieback of twigs, premature drop of fruit and leaves, and deformation of fruit (Blackburn and Miller, 1984). Large populations cause chlorosis and premature drop of leaves, dieback of twigs and branches, stunting and distortion of the fruit, and premature fruit drop (Blackburn and Miller, 1984). Mohyuddin and Mahmood (1993) reported that scale insects became serious pests following nonjudicious use of insecticides against fruit flies.

In recent years, the extensive and continuous use of chemical insecticides in crop protection has triggered the onset of resistance phenomena in several plant pests considerable environmental pollution and a severe impact on human and animal health.

This scenario has prompted an increased demand for more environmental-friendly products in order to minimize the collateral effect of their extensive application in plant defence.

The use of biopesticides in crop protection appears to be a good alternative to conventional synthetic fungicides and insecticides. Neem formulations have been thought to be a promising source of natural pesticide as an insect control agent. The major component of neem seed kernel extract is azadirachtin, a tetranortriterpenoid. It combines various ways of action against insects such as antifeedant, growth disrupting, moulting defects, repellency, fecundity and fitness-reducing properties on many insect species (Rembold,1989; Schmutterer, 1990; Mordue and Blackwell, 1993; Mordue and Nisbet, 2000; Morgan, 2009; Abd El-Salam et al., 2013). Neem oil and its components, taken together, have direct effects on midgut and a variety of tissues

Manuscript received Non 15, 2014

Abd El-Salam, A.M.E, Pests & Plant Protection Department, National Research Centre, El-Tahrer St., Dokki ,Cairo, Egypt.

Haggag Wafaa M, Plant Pathology Department, National Research Centre, El-Tahrer St., Dokki ,Cairo, Egypt.

and organs (Nasiruddin and Mordue, 1993; Sayah et al., 1996; Nogueira et al., 1997; Lucantoni et al., 2006; Ghazawi et al., 2007; Ndione et al., 2007; Correia et al., 2009;Scudeler and Santos,2013). The use of entomopathogenic fungi is one of the most promising alternative control methods (Moore et al.,2000; Abd El-Salam et al.,2013). Among the fungal species tested, *Beauveria bassiana* (Balsamo) Vuillemin (Ascomycota: Hypocreales)and *Lecanicillium lecanii* have shown good results so far, for many insect species (Moore et al., 2000; Lord, 2001, 2005; Akbar et al.,2004; Vassilakos et al., 2006; Hansen and Steenberg, 2007).For several years, mineral oils have been used as insecticides only on woody plants during winter due to their phytotoxicity on green parts. Nevertheless, the more recent availability of "narrow-range mineral oils" has allowed their utilization in spring and summer treatments too. In addition, vegetable oils have been evaluated mainly for their fungicidal effects (Osnaya and Schloser 1998; Martín et al. 2005). In comparison to conventional pesticides, oils have many advantages: (1) good control of some pests and plant pathogens at low doses (1–2%); (2) no resistance induction in target pathogens; (3) low cost; (4) excellent spreading and good wetting ability of leaf surface and low environmental impact. Nevertheless, at high concentrations, mineral oil can determine phytotoxicity on some crops, especially if treatments are carried out when plants are stressed.

The aim of the paper is to study the efficacy of some bioformulations in comparison with mineral oil and chemical insecticides against the white scale insect.

II. Materials & methods

2.1. Commercial compounds

The present study was carried out in mango orchards at Bernacht, Giza Governorate. This study was carried out with 4 year old mango trees (Ewias, variety)cultivated in an area of 12 feddan. Six commercial formulations were used in this evaluation as follows: Nimbecidine containing 0.03 % Azadirachtin as active ingredient (Botanical insecticides). Bio-catch containing 1x 10^{9} Lecanicillium lecanii spores / ml (Entomopathogenic fungi).Bio-power containing 1x 10^{9} Beauveria bassiana spores / ml(Entomopathogenic fungi).M-Pede is a commercial insecticidal soap based on potassium salts of naturally derived fatty acids. Selecron is a commercial phosphorus insecticide containing 50% Profenofós as active ingredient. Capi is a commercial insecticidal soap contained mineral compounds " 2.0% nitrogen,0.25% phosphor, 0.25% potassium ,2.5% sulpher ,26.0 ppm copper and 94.0% paraphen oil as carrier material . The commercial formulations were purchased from Egypt market.

2.2. Bioassay test.

The rate of application was 5.0,2.5,1.25 ml/liter water for Nimbecidine , Bio-catch , Bio- power ,M-Pede .Mixing from Selecron and Capi as following 1.0+10.0 ml, 0.5 +10ml ,0.25 +10ml / liter . Samples leaves had highly infested with A. tubercularis stages were selected from mango trees (5 leaves from each tree infested with 100-150 A. tubercularis individual). The infested leaves put on Petri-dishes (15cm diameter) and spraying with the above mentioned concentrations for each formulation alone and left for 72 hours then after that inspected under binocular microscope to count the mortality individuals for each formulation. The lethal concentration for 50 and 90 % individuals were calculated by Finny 1971 equation.

3.3. Field experimental.

Thirty mango trees were selected to evaluate the efficacy of commercial formulations against A. tubercularis stages at Giza governorate. Twenty five trees for treatment and the other five trees for control. Two spray was carried out, firstly, March 1st and secondly April 1st 2014. The rate of application was 5ml/l for Nimbecidine, Bio-catch, Bio-power, M-Pede, 1ml /l for Selecron and 1ml Selecron + 10 ml Capi as mixed were carried out. Sparer by motor (600 liter capacity) was used in all applications.

The treated trees divided five replicated (one tree / replicate) while the other five trees divided five replicated (one tree / replicate). The random samples were taken as five leaves from each tree for treated and untreated. The samples were taken before spraying the previous compounds and after spraying .The number of living nymphs and adults were recorded with each sample under binocular microscope each month. The percentage reduction in living individuals was calculated by Henderson and Tillton equation (1955).

2.4. Statistical analysis

The data were statistically analyzed using one- way analysis of variance (ANOVA) and comparisons were made based on Duncan' s new multiple range test (computer program Microstat version 2.5, 1991).

III. Results & Discussion

3.1. Bioassay test.

The LC_{50} and LC_{90} values of the commercial formulations were obtained for A. tubercularis individuals, 72 h after treatment (Table 1). Based on the lethal concentration ($LC_{50\&90}$) values 72 h after treatment, A. tubercularis individuals were most susceptible to Selecron +Capi, followed by, Nimbecidine, M-Pede, Bio-catch and Bio-power values of 0.06 & 0.44, 0.81 & 4.25, 1.42 & 7.7,2.42 & 8.7 and 2.9 & 10.82 ml/l ,respectively. Mineral and parrafinic oils are consider one of the safest methods in controlling pests especially the scale insects and mealy bugs infesting different plants. One of the safest methods in controlling pests especially the scale insects and mealy bugs infesting different plants. Applied of capi in mixture with low concentration of Selecron (0.44 ml/l) and M-Pede alone (8.7 ml/ l) achieved 90.0% mortality. Garcera et al.,(2011) stated that a way to restrict contamination by pesticides is through the reduction of the amount of active ingredient (a.i.) delivered per unit area of cultivation. This could be achieved by decreasing the concentration of a.i. in the solution whilst maintaining the water volume. Also, in the laboratory to assess the insecticidal effect on Myzus persicae Sulzer of different oils applied alone or combined with imidacloprid or pirimicarb. The oils tested were a horticultural mineral oil, a refined rapeseed oil, a refined soya oil and a raw fish oil. When the oils were sprayed alone on pepper plants infested with M. persicae, mineral oil caused the highest mortality of aphids (over 80%). Applied before aphid infestation of pepper leaves and in mixture with low doses of imidacloprid (at one-fifth of the dose recommended by the manufacturer) and pirimicarb (at one-tenth of the dose recommended by the manufacturer), the oils did not significantly increase the toxicity of the insecticides alone. However, sprayed on aphid-infested pepper plants, the mortality rates achieved by imidacloprid/mineral oil and imidacloprid/rapeseed oil mixtures were significantly higher than those achieved by imidacloprid alone at 16 and 24 h (Lopez et al., 2006). Entomopathogens are ready-made components of IPM because of their complementary or synergistic insecticidal activity with other control elements including predatory and parasitic insects (Goettel et al., 2010; Abd El-Salam et al., 2013). Biological options in an integrated pest management (IPM) approach offer a solution to sustainable control of insect pests. In Egypt, farmers use botanical pesticides, mostly aqueous seed extracts of the neem tree, Azadirachta indica A. Juss, against a wide range of other arthropod pests (Abd El-Salam et al., 2013). From the results in table (1), the bioformulations such as Nimbecidine was the highest efficiency as compared with the entomopathogenic fungi whereas achieving 90.0% mortality at 4.25 ml/l. On the other hand, bio-catch (Lecanicillium lecanii) was highly effective than bio-power (Beauveria bassiana).

3.2. Efficacy of some Bioinsecticides in field application

The results obtained in table (2) indicated that the number of scale insects (nymph and adults) on trees sprayed with Nimbecidine showed maximum reduction of 63.7% and 92.7% after 3 and 7 days of treatment, respectively with the first spray. While, the second spray, Nimbecidine achieved 84.8% and 100 % after 3 and 7 days of treatment, respectively. M-ped caused 74.3% and 93.6% reduction in number of living individuals (nymph and adults) after 3 and 7 days (1st application) , respectively,. After 2nd application, M-ped achieved 67.7% and 96.0% reduction in number of living individuals after 3 and 7 days, respectively. Bio-catch caused 53.8% and 86.5% reduction in number of living individuals (nymph and adults) after 3 and 7 days , respectively, of 1st application . After 2nd application, Bio-catch achieved 76.3% and 86.70% reduction in number of living individuals after 3 and 7 days, respectively.

On the other hand, Bio-power achieved 14.3% and 63.9% reduction in number of living individuals after 3 and 7 days, respectively, of 1st application. With 2nd application, Bio-power caused 56.2% and 67.0% reduction in number of living individuals after 3 and 7 days, respectively. On calculating the overall percentage of reduction , Nimbecidine was superior to M-ped ,Bio-catch and Bio-power as it gave 85.2% overall reduction after 2 weeks compared to 82.9 % , 75.8% and 50.35% in case of M-ped ,Bio-catch and Bio-power, respectively. This obviously shows that Azadirachtin containing formulations are effective under field conditions as reported earlier by Schmutterer (1988) demonstrating that the residual effect usually lasted for 4 to 6 days depending on the environmental conditions and the treated plant species.

In comparison, the highest reduction achieved with the mixture from Selecron + Capi (1.0+10.0ml/l) reached 92.95% reduction. Thus, it will help to minimize the negative environmental impact and other deleterious effects caused by insecticides while providing a more sustainable approach to pest control, as well as to maintain crop quality, productivity and profitability (Pimentel et al. 2005). Domenico et al., (2008) found that mineral oil in water emulsion (2%), containing Brassicaceae seed meals (2 g / l), induced total mortality (100%) among adult female California red scales on detached orange fruits, whereas only 47.5% of insect mortality was observed with the same mineral oil when used alone. Also, the authors found that The formulation, essentially based on oil, meals and some minor additives, shows the following advantages: (1) high insecticidal activity against an insect pest difficult to control such as Aonidiella aurantii (Maskell); (2) simultaneous control of several pathogens seems to be possible; (3) non-appearance of resistance phenomena in plant pathogens; and finally, (5) absence of phytotoxicity. Stephanie et al., (2008) found that pyriproxyfen showed greater efficacy in control of California red scale compared with buprofezin.

Abo-Shanab,(2011)evaluate the efficacy of three summer/light mineral oils [Super Masrona oil® 95%, CAPL2 oil® 96.62% and Diver oil® 97%], against A. tubercularis infested Mango trees. The data indicated that, the summer oil, “Diver” was the most effective one during the two experiments (2009 and 2010) against A. tubercularis on mango trees followed by “CAPL2” and “super masrona” recorded the least effect among the tested insecticides through the experiments. There was no significant difference between reduction effect of Diver oil and CAPL2 oil, but there was significant difference between reduction effect of super masrona and the other two tested mineral oils. The tested mineral oils caused mean reduction effects (90.15%), (93.55%) and (95.43%) with check reduction effect (7.75%) during the first experiment (2009) for super masrona, CAPL2 and Diver oils, respectively. These results are agreement with the recently an interesting extension of the use of mineral oils against homopterous insects is encouraged. Mineral oils are valuable insecticide materials because they have little residual toxicity for beneficial insects as mentioned by (Moursi et al., 1991; Abo-Shanab, 2005; Helmy et al., 2006 and El-Halawany et al., 1987). Potenza et al. (1993) described field studies of a range of insecticide and mineral oil combinations against A. tubercularis in mango orchards in Brazil. Certain insecticides are not recommended for use against mango scale, as marked increases in the pest population can result due to elimination of natural enemies (Viljoen and De Villiers, 1987). Abd-Rabou et al.,(2012). indicated that the treatment with different compounds (Biofly ‘‘Beauveria bassiana’’, Neemazal ‘‘Azadirachta indica’’, and Super Misrona oil) gave a moderate reduction of percent in the population of adult females and nymphs of P. nigra and P. floccifera, respectively, as compared to Malathion and its mixture (‘‘Super Misrona oil+Malathion’’) which gave a higher reduction rate after the 1st, 2nd and 3rd weeks after spraying. Also, these compounds gave a moderate mortality to the parasitoids as compared to Malathion and its mixture (‘‘Super Misrona oil+Malathion’’) which gave higher toxicity after the 1st, 2nd and 3rd weeks after spraying. Hassan et al.,(2013) found that alboleum oil has reduction efficiency when sprayed by two flow rates (86.16% and 87.46% reduction) while, diver oil appeared best action when sprayed by high flow rate (89.42%) reduction.

The present study demonstrates that Nimbecidine and bio-catch have potential as an alternative insecticide for the control of all developmental stages of A. tubercularis

Table (1): Lethal concentration of some Commercial formulations against *A. tubercularis* (nymphs & adults).

Formulations	Lc_{50}	Lc_{90}	Slope	X^2
Nimbecidine	0.81	4.25	1.78	2.35
Bio-Power	2.9	10.82	3.04	9.65
Bio-Catch	2.42	8.7	1.97	6.72
M-Pede	1.42	7.7	1.63	1.11
Selecron + Capi	0.06	0.44	1.52	3.4

Concentration calculate as ml/l

Table (2): Effect of some bioinsecticides against the white scale insect, *Aulacaspis tubercularis* on mango trees.

Bioinsecticides	Rate of application ml/l	Before spray	After 1 st spray				Before spray	After 2 nd spray				Mean % Reduction In living individuals
		Mean No. of living individuals / 5 leaves	3 days		7days		Mean No. of living individuals / 5 leaves ±SD	3days		7 days		
			Mean No. of living individuals / 5 leaves ±SD	% Reduction In living individuals	Mean No. of living individuals / 5 leaves ±SD	% Reduction In living individuals		Mean No. of living individuals / 5 leaves ±SD	% Reduction In living individuals	Mean No. of living individuals / 5 leaves ±SD	% Reduction In living individuals	
Nimbecidine	5.0	45.25	44.75±20.1c	63.7	12.5±2.5c	92.7	12.5±2.5c	2.0±0.8c	84.8	0.0±0.0c	100	85.2
Bio- power	5.0	45.25	104.0±7.9ab	14.3	61.25±17.4b	63.9	61.25±17.4b	28.25±11.7b	56.2	23.0±13.6b	67.0	50.35
Bio- catch	5.0	45.25	78.0±30.4b	53.8	23.0±8.7c	86.5	23.0±8.7c	5.75±2.2c	76.3	3.5±3.7c	86.7	75.8
M-Pede	5.0	45.25	31.25±21.2c	74.3	11.0±6.5c	93.6	11.0±6.5c	3.75±0.9c	67.7	0.5±0.75c	96.0	82.9
Selecron + Capi	1.0+10.0	45.25	16.75±4.1c	86.2	3.5±3.1c	98.0	3.5±3.1c	1.5±0.6c	84.8	0.0±0.0c	100	92.25
Control	0.0	45.25	121.0±22.6a	------	169.0±51.9a	-------	169.0±51.9a	177.75±14.8a	--------	192.0±12.4a	-------	--------
F	------	------	17.7*	------	30.7*	------	30.7*	------	------	399.5*	------	------
LSD_{05}	------	------	29.5	------	33.96	------	33.96	------	------	11.4	------	------

Means (± (SD) standard division) followed by the same letters in columns indicate no significant difference ($P \le 0.05$).

REFERENCES

[1] Abd El-Salam, A.M.E., H.A. Salem and S.A. Salem (2013). Biocontrol agents against the leafminer, *Liriomyza trifolii* in faba bean fields. Archives of Phytopathology and Plant Protection,46(9-12),1054-1060.

[2] Abd El-Salam, A.M.E, S.A. Salem and M.Y. El-Kholy (2012). Efficiency of Nimbecidine and certain entomopathogenic fungi formulations against bean aphids, *Aphis craccivora* in broad bean field. Archives of Phytopathology and Plant Protection,45(19),2272-2277.

[3] Abo-Shanab, A.S.H.(2011). Suppression of white mango scale, *Aulacaspis tubercularis* (Hemiptera: Diaspididae) on mango trees in El-Beheira Governorate, Egypt. Egypt. Acad. J. Biolog. Sci., 5(3): 43-50

[4] Abo-Shanab, A.S. (2005).Efficacy of some IGR/insecticides, Kz mineral oil and binary mixtures on mortality and enzyme activity of Egyptian mealy bug *Icerya aegyptiaca* (Douglas) attacked Guava trees in Alexandria Governorate. J.Pest C ont. and Environ. Sci., 13(1): 73-85.

[5] Abd-Rabou, S. and Mona Moustafa (2006). Ecological studies on the first recorded scale Insect, *pinnaspis aspidistrae* (signoret) (homoptera: diaspididae) and its parasitoids on Mango trees in Egypt.Egypt. J. Agric. Res., 84(2),337-401.

[6] Abd-Rabou, S ., Hoda Badary, Noha Ahmed (2012). Control measures of two soft scale insects (Hemiptera: Coccidae) infesting guava and mango trees in Egypt. The Journal of Basic & Applied Zoology , 65, 55–61

[7] Akbar, W., Lord, J.C., Nechols, J.R., Howard, R.W.(2004). Diatomaceous earth increases the efficacy of *Beauveria bassiana* against *Tribolium castaneum* larvae and increases conidia attachment. J. Econ. Entomol. 97,273–280.

[8] Angeles, N. and Requena, J. (1966). Moth injury of mangoes in Venezuela. *Plant Prot. Bull. F.A.O.* 14:86-87.

[9] Blackburn, V.L. and Miller, D.R. 1984. Pests not known to occur in the United States or of limited distribution. No. 44: Black parlatoria scale. United States Department of Agriculture, Plant Protection & Quarantine, Animal and Plant Health Inspection Service 81–45: 1–13

[10] Garcera ,C., Enrique, M., Patricia, C.(2011). Effect of spray volume of two organophosphate pesticides on coverage and on mortality of California red scale Aonidiella aurantii (Maskell). Crop Protection 30 , 693-697.

[11] Correia, A.A., Wanderley-Teixeira, V., Teixeira, A.A.C., Oliveira, J.V., Torres, J.B. (2009). Morfologia do canal alimentar de lagartas de *Spodoptera frugiperda* (J E Smith) (Lepidoptera: Noctuidae) alimentadascomfolhas tratadascomnim. Neotropical Entomology 38, 83–91.

[12] Denmark, H. (1983). *Eriophyes mangiferae* (Sayed), a pest of mango (Acarina: Eriophyidae). *Fla. Dep. Agric. Consum. Serv. Div. Plant Ind. Entomol. Circ.* 254.

[13] Domenico Rongai ; Claudio Cerato ; Luca Lazzeri; Sandro Palmieri ; Giampiero Patalano,(2008). Vegetable oil formulation as biopesticide to control California red scale (*Aonidiella aurantii* Maskell). J .Pest Sci.,10, 1007-1014.

[14] El-Halawany, M.E.; Metwally, A.M. and Nassar, M.E. (1987). Activity of Albolium on the citrus brown mite biology and the sensitivity of different mite species to certain chemicals. Agric. Res. Rev., 65(1): 37-42.

[15] Ghazawi, N.A., El-Shranoubi, E.D., El-Shazly, M.M., Abdel Rahman, K.M.(2007). Effects of azadirachtin on mortality rate and reproductive system of the grasshopper *Heteracris littoralis* Ramb. (Orthoptera: Acrididae). Journal of Orthopaedic Research 16, 57–65.

[16] Golez, H.G. (1991). Bionomics and control of the mango seed borer, *Noorda albizonalis* Hampson (Pyralidae: Lepidoptera). *Acta Hortic.* 291:418-424.

[17] Goettel, M.S., Eilenberg, J., Glare, T.R.(2010). Entomopathogenic fungi and their role in regulation of insect populations. In: Gilbert, L.I., Gill, S. (Eds.), Insect Control:Biological and Synthetic Agents. Academic Press, London, UK, pp. 387–432.

[18] Greathead, D. J.(1990). Crawler behaviour and dispersal, pp. 305-308. *In* D. Rosen [ed.], Armored scale insects. Their biology, natural enemies and control. World Crop Pests Volume 4A. Elsevier Scientific Publishers, Amsterdam.

[19] Greathead, D. J. (1997). Ecology: Crawler behaviour and dispersal, pp. 339-342. *In* Y. Ben-Dov and C. J. Hodgson [eds.], Soft scale insects: their biology, natural enemies and control. Elsevier Scientific Publishers, Amsterdam.

[20] Halteren, P. van (1970). Notes on the biology of the scale insect *Aulacaspis mangiferae* Newst. (Diaspididae, Hemiptera) on mango. *Ghana J. Agric. Sci.* 3:83-85.

[21] Hamon, A. B. (2002). White Mango scale, *Aulacaspis tubercularis* Newstead (Coccoidea:Diaspididae). (Florida) Department of Agriculture and Consumer Services. <http://doacs.state.fl.us/~pi/enpp/ento/aulacaspis-tubercularis.html>.

[22] Hansen, L.S., Steenberg, T.(2007). Combining larval parasitoids and an entomopathogenic fungus for biological control of *Sitophilus granaries* (Coleoptera: Curculionidae) in stored grain. Biol. Control 40, 237–242.

[23] Hassan, N. A.; Radwan, S. G.; Ammar, A. E. E.; El-Sahn, O. M. N.(2013). Effect of alternative insecticides sprayed with two flow rates against some scale insects on mango trees by using conventional motor sprayer at Qalubyia governorate, Egypt.Proceedings of the International Conference of Environmental Sciences (ICES), Ain Shamas University, Cairo, Egypt, 21-22 May 2013 , pp. 62-79

[24] Helmy, E. I.; Kwaiz, F. A. and Radwan, S. G. (2006). Mineral oils as safe alternative pesticides against *Russellaspis* (=*Asterolecanium*) *pustulans* (Cockerell) (Hemiptera: Coccoidea: Asterolecaniidae) on apple at El-Nobariya district, Egypt. Egypt. J. Appl. Sci., 21 (10B): 786 – 793.

[25] Henderson, C.F.and Tilton, E.W. (1955). Test with acaricides against the brown wheat mite. J. Econ. Entomol. 48, 157 -161.

[26] Joubert, P. H., Daneel, M. S., and Grover, T. (2000). Progress towards integrated pest management (IPM) on mangoes in South Africa. Acta Horticulturae 509: 811-817.

[27] López ,M., Varela I., Marnotes, S., Cabaleiro, C.(2006). Use of oils combined with low doses of insecticide for the control of Myzus persicae and PVY epidemics. Pest Manag Sci. 62(4):372-380.

[28] Lord, J.C.(2001). Desiccant dusts synergize the effect of *Beauveria bassiana* (Hyphomycetes, Moniliales) on stored-grain beetles. J. Econ. Entomol.94, 367–372.

[29] Lord, J.C.(2005). Low humidity, moderate temperature and desiccant duct favor the efficacy of *Beauveria bassiana* (Hyphomycetes: Moniliales) for the lesser grain borer *Rhyzopertha dominica* (Coleoptera: Bostrychidae). Biol. Control 34, 180–186.

[30] Lucantoni, L., Giusti, F., Cristofaro, M., Pasqualini, L., Esposito, F., Lupetti, P., Habluetzel,A.(2006). Effects of neem extract on blood feeding, oviposition and oocyte ultrastructure in *Anopholes stephensi* Liston (Diptera: Culicidae). Tissue and Cell 38, 361–371.

[31] Martín B, Hernandez S, Silvarrey C, Jacas JA, Cabaleiro C (2005). Vegetable, Wsh and mineral oils control grapevine powdery mildew.Phytopathol Mediterr 44:169–179
[32] Mohyuddin, A.I. (1981) .A review of biological control in Pakistan. *Proc. 2nd Pakistan Congr. Zoology* (Tandojam, Pakistan), pp. 31-79.
[33] Mohyuddin, A.I. and Mahmood, R. (1993). Integrated control of mango pests in Pakistan. *Acta Hortic.* 341:467-483.
[34] Moore, D., Lord, J.C., Smith, S.M.(2000). Pathogens. In: Subramanyam,Bh., Hagstrum, D.W. (Eds.), Alternatives to Pesticides in Stored-Product IPM. Kluwer Academic Publishers, Dordreecht, pp. 193–227.
[35] Mordue, A.J., Blackwell, A.(1993). Azadirachtin: an update. Journal of Insect Physiology 39 (11), 903–924.
[36] Mordue , A.J., Nisbet, A.J.(2000). Azadirachtin from the neem tree *Azadirachta indica*: its action against insects. Annales de la Societe Entomologique de Brasil 29 (4), 615–632.
[37] Morgan, E.D.(2009). Azadirachtin, a scientific gold mine. Bioorganic and Medicinal Chemistry 17, 4096–4105.
[38] Moursi, K.S.; Gomaa, E.M. and Youssef , K.H. (1991). On the chemical control of the olive tree scale, *Leucaspis riccae* Targ. In dray farm system. J. Agric. Sci., Mansoura Univ., 16(4): 924-926.
[39] Morsi, G.A.; Girgis, M.F. and Abdel-Aziz, M. A. (2002): The Population Density of the Mango Scale, *Aulacaspis Tubercularis* (Newstead) (Homoptera: Diaspididae) and its Parasitoids in Middle Egypt. 2nd International Conference, Plant Protection Research Institute, Cairo, Egypt, 21-24 December, 2002.
[40] Murray, R.C. (1991). Arthropod pests of mango in the Caribbean Islands. Rev. Crop Prot. Univ.West Indies, Kingston.
[41] Nasiruddin, M., Mordue (Luntz), A.J.(1993). The effect of azadirachtin on the midgut histology of the locusts *Schistocerca gregaria* and *Locusta migratoria*. Tissue and Cell 25 (6), 875–884.
[42] Ndione, R.D., Faye, O., Ndiaye, M., Dieye, A., Afoutou, J.M. (2007). Toxic effects of neem products (*Azadirachta indica* A. Juss) on *Aedes aegypti* Linnaeus 1762 larvae. African Journal of Biotechnology 6 (24), 2846–2854.
[43] Nogueira, N.F.S., Gonzales, M., Garcia, E.M., Souza, W.(1997).Effect of Azadirachtin A on the fine structure of the midgut of *Rhodnius prolixus*. Journal of Invertebrate Pathology 69, 58–63.
[44] Osnaya M, Schloser E (1998) Effect of vegetable oils on black spot of roses. Mededelinge Facultiet Landbouww Universiteit Gent 63(3b):995–998 Pena, J.E. (1993). Pests of mango in Florida. Acta Hortic. 341:395-406.
[45] Pimentel D, Zuniga R, Morrison D (2005) Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecol Econ 52:273–288.
[46] Potenza M.R; Sato, M.E.; Raga, A.; De Souza Filho, M.F. (1993). Chemical control of *Aulacaspis tubercularis* Newstead (Hemiptera, Diaspididae) in mango
[47] orchards (*Mangifera indica* L.). Revista de Agricultura-Piracicaba, 68(3): 315-322.
[48] Tandon, P.L. and Verghese, A. (1985) World list of insect, mite and other pests of mango. Tech. Doc. Indian Inst. Hortic. Res. 5.
[49] Rello, S., Stockert, J.C., Moreno, V., Gamez, A., Pacheco, M., Juarranz, A., Calnete, M., Villanueva, A.(2005). Morphological criteria to distinguish cell death induced by apoptotic and necrotic treatments. Apoptosis 10 (1), 201–208.
[50] Rembold, H.(1989). Azadirachtins: their structure and mode of action. In: Arnason, J.T., Philogene, B.J.R., Morand, P. (Eds.), Insecticides of Plant Origin. American Chemical Society, Washington, DC, pp. 150–163.
[51] Salunkhe, D. K. and Desai, B. B. (1984). Postharvest Biotechnology of Vegetables. Vol. 2. pp.70-75 CRC Press, Inc. Boca Raton, Florida, USA. 193p.
[52] Sayah, F., Fayet, C., Idiomar, M., Karlinsky, A.(1996). Effect of azadirachtin on vitellogenesis of *Labidura riparia* (Insect Dermaptera). Tissue and Cell 28 (6),741–749.
[53] Schmutterer, H.(1988). Potential of azadirachtin containing pesticides for integrated pest control in developing and industrialized countries. J. Insect Physiol. 34,713 – 719.
[54] Schmutterer, H.(1990). Properties and potential of natural pesticides from the neem tree, Azadirachta indica. Annual Review of Entomology 35, 271–297.
[55] Scudeler, E. L; Santos, D. C.(2013). Effects of neem oil (Azadirachta indica A. Juss) on midgut cells of predatory larvae *Ceraeochrysa claveri* (Navas, 1911) (Neuroptera: Chrysopidae). Micron 44 : 125–132.
[56] Stephanie M. Rill ; Elizabeth E. Grafton-Cardwell ;Joseph G. Morse (2008). Effects of two insect growth regulators and a neonicotinoid on various life stages of *Aphytis melinus* (Hymenoptera: Aphelinidae) . BioControl , 53:579–587
[57] Vassilakos, T.N., Athanassiou, C.G., Kavallieratos, N.G., Vayias, B.J.(2006). Influence of temperature on the insecticidal effect of *Beauveria bassiana* in combination with diatomaceous earth against *Rhyzopertha dominica* and *Sitophilus oryzae* on stored wheat. Biol. Control 38, 270–281.
[58] Veerish, G.K. (1989). Pest problems in mango – world situation. Acta Hortic. 231:551-565.
[59] Viljoen, H.M and De Villiers, E.A. (1987). Effectiveness of fenvalerate and monocrotophos against the mango scale, *Aulacaspis tubercularis* Newstead. Information Bulletin, Citrus and Subtropical Fruit Research Institute, South Africa, No.173:19-23
[60] Wysoki, M., Ben-Dov, Y., Swirski, E. and Izhar, Y. (1993). The arthropod pests of mango in Israel. Acta Hortic. 341:452-466.