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Study of Prevention and Protection against Litchi Pest, *Aceria litchii* on *Litchi chinensis*

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ABSTRACT

Litchi is distinctly a delicate, delicious summer delight, juicy, flavoured and attractive bright red colour fruit having good source of minerals and vitamins. India and china account for about 91 percent of the world's litchi production.The erinose mite, Aceria litchii (Eriophyidae), a major pest of this crop, feeds on the leaves and on all parts of the plants forming erinea. The purpose of this review is to present the most common control methods and to propose integrated management techniques for L. chinensis production systems. A. litchii infestations were detected in Brazilian orchards in 2008. Chemical pesticides are currently the main control measure for this pest; however, the combination of biological, chemical and cultural methods are more promising in the long term. Controlling and preventing the erinose mite are key factors for reducing its spread and establishment. Aceria litchii (Keifer) has been very distructive to litchi crop affecting adversely the production of litchi crop with a view to formulate economic control of the pest.

1. Introduction

Litchi or lychee (*Litchi chinensis Sonn*.) is a subtropical fruit tree belonging to the family Sapindaceae as well as typical sun-loving species. The origin of the litchi is belived to be China and was introduced to India by the end of 17th century. The litchi, *Litchi chinensis* Sonn. (Sapindaceae) is a tropical plant native to Southeast Asia that produces climacteric fruits (Cabral *et al*. 2014) and is cultivated in several countries (Gontier *et al*. 2008; Jiang *et al*. 2013). It is widely sought after on the international market (Yang *et al*. 2016). China and India are the largest producers (Ranjan and Ran 2015). In Brazil, the litchi was introduced in 1810 and by 1970 commercial production began in Sãso Paulo (Yamanishi *et al*. 2010). Currently, it is one of the most popular exotic fruits in the country (Alves *et al*. 2016), with the "Bengal" variety being the most consumed (Suguino 2006). Harvesting is carried out between November and January (Martins *et al.* 2001; Yamanishi *et al*. 2001), when the demand for fruit is high and there is no competition from other countries (Lins *et al*. 2015). The fruit has a red epicarp surrounding the mesocarp consisting of a white layer, with tasty pulp and high nutritional value (Bhoopat *et al*. 2011). The fruits of this plant can be eaten fresh and used to manufacture juices, vinegar, marmalades and fermented alcoholic beverages (Alves *et al*. 2011; Saxena *et al*. 2011). Bioactive compounds such as lignans and flavonoids are present in large quantities in *L. chinensis* leaves and epicarp (Wen *et al*. 2014). In addition, consumption of lychee fruits and seeds can prevent cancer cell growth (Bhat and Al-Daihan 2014; Wen *et al*. 2015).

Among the main *L. chinensis* pests, the mite *Aceria litchii* (Keifer) (Acari: Eriophyidae) stands out (Lall and Rahman 1975; Hameed *et al*. 1992; Huang 2008), having been reported in Australia, Brazil, China, Hawaii, India and Pakistan (Jeppson *et al*. 1975; Sabelis and Bruin 1996; Hong *et al*. 2006, Huang 2008). The lesions caused by *A. litchii* were detected on litchi plants in São Paulo state, Brazil in January 2008, being the first report of this pest in South America (Raga *et al*. 2010). Espírito Santo was the second Brazilian state where infestation was confirmed (Fornazier *et al*. 2014). *Aceria litchii* is located and feeds on the leaves, flowers and underside of young *L. chinensis* fruits (Nishida and Holdaway 1955; Butani 1977; Sharma *et al*. 1986). Abiotic factors such as temperature, relative humidity, wind speed and precipitation affect the population growth of this mite (Singh *et al*. 1987). The symbiotic relationship between *A. litchii* and the algae *Cephaleuros virescens* Kunze (Tentrepohliaceae) favors the formation of erineos (trichomes developed abnormally) (Saha *et al*. 1996). The erineo generates an adequate environment for mites, protecting them from precipitation, temperature, wind (Sharma 1984; Sharma *et al*. 1986; Thakur and Sharma 1990) and the action of chemical products (Jeppson *et al*. 1975; Westphal and Manson 1996). Colonization by these algae causes detrimental effects to the plant through stomatal blockage and hinders photosynthesis (Alam and Wadud 1963). Initially, the erineo is silvery white, changing to light brown, dark reddish brown and black as the infestation advances (Waite 2005). The leaves affected turn thick and wavy, wither and finally fall. Damaged shoots do not produce flowers or fruits (Lall and Rahman 1975).

Practices for litchi mite control should be adopted throughout most of the year (Azevedo *et al*. 2014) mainly in the development of the inflorescence and the expansion of new leaves when the mites migrate to young organs to take refuge, feed themselves and multiply by establishing new erineos (Arthur and Machi 2016). Several chemical products are widely used to control the mite (Azevedo *et al*. 2013), but the adoption of other control methods is desirable.

2. Sampling

This method to estimate the Population level of Aceria litchii (Prostigmata: Eriophyidae) and a study of the population Dynamics of this Species and its Predators on litchi trees. This mite lives in erinose, which impedes direct observation (Azevedo *et al*. 2014). Methods to estimate lychee mite populations and others insects that form erinose have been adapted from one used to evaluate nematode densities in plant roots (Coolen and D 'Herde 1972) consisting of blending litchi infested leaves in a blender for 1 min in 250 ml distilled water and screening the material with a set of sieves with openings of 2, 0.2 and 0.037 mm, respectively, from top to bottom. Larger particles of leaves are retained in the two larger aperture screens, while smaller ones and mites are retained in the screen with a smaller aperture. The mite passage through the upper screens is driven by a jet of tap water for a few seconds. The material retained in the lowest sieve is transferred to a 25 ml cylinder, using sucrose solution (density of 1.15 g/ml, corresponding to 400 g of commercial sucrose dissolved in 750 ml of water). The material should be shaken several times and left to rest for 15 hours allowing the mites to concentrate near the solution surface. The supernatant is poured through a 0.037 mm opening screen and the material retained (mainly mites) is washed with distilled water to remove excess sucrose. The mites should be transferred to a bottle with 15 ml of 70 % ethanol. Mites are counted in Peters sheets, commonly used in nematode counts. The estimate is made by extrapolating the count of three aliquots of 1 ml. This procedure is progressive with higher precision as the *A. litchii* infestation level increases (Azevedo *et al*. 2014). The highest *A. litchii* density on plants in Brazil is recorded at the beginning of the rainy season (October) and in the middle of the dry season (May-June) (Azevedo *et al*. 2014). *Aceria litchii* density can also be determined by stirring 2 cm2 leaf pieces with erineos in a 0.5 % neutral detergent solution for five seconds to dislodge this mite from the erineos. The counting of mites present in the solution is done with a stereoscopic microscope (Picoli 2010).

3. Chemical Control

Aceria litchii is the most important litchi pest in the world. Chemicals are the main control measure for this mite. Pesticides must be applied before and/or during the emergence of the inflorescence and leaf expansion of *L. chinensis* (Picoli 2010). Spraying outside this range has unsatisfactory results (Waite 2005). The main problem with Eriophyidae mite control is its hidden lifecycle. Pesticide application should occur during the stages when the mites temporarily leave the erineos. Control is better provided with acaricides with long residual effect, since the transfer (erine exit) of mites to new leaves extends over several days or weeks (Van Leeuwen *et al*. 2010).

Three preventative dimethoate or sulfur applications in soluble powder at two to three weeks intervals are recommended in Thailand (Waite and Hwang 2002). Dichlorvos, chlorpyrifos, dimethoate and isocarbophos are effective and used in China (Waite 2005). The fenpyroxime, sulfur, abamectin and hexythiazox application cause high *A. litchii* mortality. However, these insecticides were considered harmful to the predator *Phytoseius intermedius* Evans & MacFarlane (Acari: Phytoseiidae) (Azevedo *et al*. 2013). The complete elimination of *A. litchii* was achieved with a double application of espiromesifeno at a concentration of 0.144 g a.i. L-1 in Thailand (Schulte *et al*. 2007).

When effectively used, sulfur presents low toxicity to mammals, but has an impact on natural enemies (Prischmann *et al*. 2005) such as *P. intermedius* (Azevedo *et al*. 2013); *Galendromus occidentalis* (Nesbitt, 1951) (Beers *et al*. 2009); *Euseius victoriensis* (Womersley, 1954) (Bernard *et al*. 2010) and *Typhlodromus pyri* (Scheuten, 1857) (Acari: Phytoseiidae) (Gadino *et al*. 2011). Sulfur is inorganic and ineffective against *Tetranychus urticae* (Koch, 1836) (Acari: Tetranychidae) (Auger *et al*. 2003).

The development of resistance by Eriophyidae mites to pesticides has been reviewed (Messing and Croft 1996). Resistance to organophosphate by *Aculus cornutus* and *A. lycopersici* (Acari: Eriophyidae) was confirmed in the laboratory (Abou-Awad and El-Banhawy 1995), but products with different action mechanisms can reduce the development of resistance in mite pests (Azevedo *et al*. 2013). Compounds to control these mites requires further study. The main reason for lacking information on the toxicity of new compounds is the lower economic importance of these mites compared to others such as Tetranychidae mites (Van Leeuwen *et al*. 2010).

4. Biological Control

Predatory mites: Thenatural Biological Control of Eriophyidae mites is based mainly on predators and to a lesser degree, on pathogens.*Aceria litchii* can be transported by bees from the flowers of infested plants (Waite and Mcalpine 1992; Waite 1999) and can be preyed upon when migrating to new leaves, before forming the erineo (Azevedo *et al*. 2013). Predators attack *A. litchii* when the mite leaves the erineo (Azevedo *et al*. 2014). The main predators of phytophagous mites are Phytoseiidae species (Gerson *et al*. 2003; McMurtry *et al*. 2015). The natural presence and periodic releases of predatory mites has been used to control pests (Moraes and Lima 1983; Momen and Hussein 1999). Phytoseiids are associated with *A. litchii* in India (Thakur and Sharma 1989), Australia, China (Waite and Gerson 1994) and Brazil (Picoli 2010; Azevedo *et al*. 2013). The predator *Amblyseius compositus* (Denmark and Muma, 1973) (Acari: Phytoseiidae) (42.6 %) predominated in Casa Blanca, São Paulo state, Brazilian plantations followed by the other predatory mite *P. intermedius* (31.2 %) (Picoli 2010), but in Limeira, São Paulo, *A. compositus* corresponded to 10 % of phytoseids observed (Azevedo *et al*. 2014). The highest predator population densities generally coincide with the presence of *A. litchii* between October and December (Picoli 2010; Azevedo *et al*. 2014).

Aceria litchii is suitable prey for *P. intermedius* (Azevedo *et al*. 2016). This predator was found on plants with leaves covered with trichomes, such as *Helicteres brevispira* Saint-Hilaire and *Helicteres lhotzkyana* (Schott & Endlincher) (Malvaceae), *Guazuma ulmifolia* Lamarck (Sterculiaceae), *Miconia* sp. (Melastomataceae) and *Cordia sellowiana* Chamisso (Boraginaceae) in São Paulo state, Brazil (Demite *et al*. 2008). However, the erineos on *A. litchii* on litchi leaves reduces the action of the predatory mites. Eight phytoseiid species are associated with *A. litchii* in India (Thakur and Sharma 1990) and *A. compositus*, *Euseius concordis* (Chant, 1959) and *Iphiseiodes zuluagai* (Denmark & Muma, 1972) (Acari: Phytoseiidae) are positively correlated and promising for the biological control of *A. litchii* (Picoli 2010).

Entomopathogenicfungi: Entomopathogenic fungi can regulate arthropod populations by penetrating their cuticle and destroying internal tissues (Kurtti and Keyhani 2008; Rossoni *et al*. 2014; Costa *et al*. 2015). The ease of dispersion of these microorganisms in the field justifies research to investigate their potential for biological control (Meyling *et al*. 2009; Costa *et al*. 2015).

Entomopathogenic fungi (Acari: Eriophyidae) have been reported on mites (Tanzini *et al.* 2000; Demite and Feres 2008); and the erineos conserving the humidity inside the gills providing a favorable microclimate for growth of these microorganisms (Picoli and Vieira 2013). *Hirsutella thompsonii* (Fischer) (Ascomycota: Ophiocordycipitaceae) is the most commonly found fungus on Eriophyidae (McCoy 1996). This fungus is an alternative to control *A. litchii* (Picoli and Vieira 2013). The *H. thompsonii* infestation was higher during rainy periods with a positive correlation with rainfall and relative humidity (Demite and Feres 2008)

Azadirachtin causes low *A. litchii* mortality but has low effect on the predator *P. intermedius* (Azevedo *et al*. 2013). This insecticide is toxic to phytophagous and predatory mites (Castagnoli *et al.* 2000; Brito *et al.* 2006; Duso *et al.* 2008).

In Australia, the management of *A. litchii* consists of three acaricide applications during shoot formation at intervals of 10 to 14 days if erineos on most plants. Satisfactory control has been achieved with successive sprays alternating sulfur and dimethoate, the first performed at the beginning of shoot formation, if the mite is present during *L. chinensis* flowering (Waite 2011). However, there is no pesticide registered for litchi cultivation in Brazil (Brasil 2016).

The chemical control of Eriophyidae mites was reviewed (Childers *et al*. 1996), but the efficiency of other chemical

simultaneously with the population density growth of *A. litchii* on litchi plants in Brazil (Azevedo *et al*. 2014).

Entomopathogenic fungi are recommended for the biological control of other mites (Sreerema Kumar and Singh 2002, 2008; Alves *et al*. 2005; Fernando *et al*. 2007; Paz *et al*. 2007; Edgington *et al.* 2008; Gerson *et al*. 2008). Entomopathogenic fungi presence and impacts on Eriophyidae mites were reviewed (McCoy 1996; Van der Geest *et al*. 2000; Balazy *et al*. 2008) and they can contribute to *A. litchi* management programs.

5. Cultural control

Branch and leaf pruning of erineos and resultant damage is an effective measure to manage mites in litchi plantations. *A. litchii* populations are higher in the lower third of the plants and pruning of symptomatic branches in this region should be complete (Raga *et al*. 2011). However, *A. litchii* management with pruning and acaricide spraying increases production costs for this crop, therefore, litchi plants should be inspected in nurseries to prevent or reduce the spread of this mite (Raga *et al*. 2010).

6. Final considerations

Aceria litchii is the most important litchi pest in the world. Chemicals are the main control measure for this mite. However, adverse effects of pesticides justify the search for ecologically sustainable pest control strategies (Khederi *et al*. 2014). The combination of biological, cultural and chemical methods (Timprasert *et al*. 2014) make the production system more promising over the long term and can reduce pesticide dependence (Hashemi *et al*. 2008). The natural biological control of Eriophyidae mites is based mainly on predators and, to a lesser degree, on pathogens. However, the implementation of this control method presents difficulties. Predatory thrips are commercialized to manage Tetranychidae mites (Gerson *et al.* 2003; de Faria and Wraight 2007). They are are also natural enemies of Eriophyidae mites but none of them is sold specifically to control these mites (Van Leeuwen *et al*. 2010). Few studies have investigated the efficiency of new chemical compounds to control *A. litchii*. Therefore, research into control methods, with special attention on the tritrophic complex (cultural, natural enemies and pests) is fundamental to achieve integrated control and reduce the possibilities of *A. litchi* propagation and establishment.

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