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Effectiveness of Nano Turmeric Essential Oil against the African Red Mite [*Eutetranychus africanus* (Tucker)]

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The study aimed to proof the efficiency in terms of toxicity and repellent properties of nano essential oil of turmeric (*Curcuma longa* Linn.) against the African red mite (*Eutetranychus africanus* (Tucker)) by using leaf dipping method. The mulberry leaf was cut into circle, 2.7 cm in diameter and dipped in various concentrations of nano essential oil at 0.0 (water), 0.2, 0.4, 0.6, 0.8 and 1.0% for 1 min. Then mite mortality was observed at 24 h and compared to the treatments of various concentrations of surfactant, Tween80 and ethylene glycol 400 (PEG400). As for repellent test, the choice test was performed by dipping an half cut leaf into the nano essential oil at 0.02, 0.06 and 0.1% concentrations, whereas the other half leaf was dipped in surfactant. The repellent rate was checked at 24 h. The result showed that nano turmeric essential oil at concentration 1% had a high toxic property, showed 95.5% mortality and showed LC_{50} and LC_{90} at 0.39 and 0.74%, respectively, whereas different concentrations of surfactant also showed high toxic effect to the mite with LC_{50} and LC_{90} at 0.49 and 0.98%, respectively. Anyhow, there was no significant difference among them. In addition, nano turmeric essential oil at 0.1% showed extremely the repellent property to the African red mite, presented 90%RI at 24 h.

Keywords: nano turmeric essential oil, African red mite, *Eutetranychus africanus*, toxicity, repellent

Introduction

The African red mite (*Eutetranychus africanus* (Tucker)) is an economic important pest of many economic crops, such as tangerines, grapefruit, lime, bergamot, papaya and durian. The larvae, nymphs and adults of the African red mite suck the fluid on the front or top of the leaves, particularly in durian plant, it causes many white spots on the leaves. If a severe outbreak can cause leaf and fruit loss eventually. The use of chemicals is the way that farmers often widely apply to control the insect or mite pests. But the use of chemicals directly affect to the farmers, consumers and the environment. It also results in

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increased resistance of mite to acaricide and increased environmental risks. The search for replacing the use of synthetic chemicals by other control methods is increasing nowadays, especially natural products because of their low toxicity, and consumer approval. Moreover, they are considered to be environment friendly due to their biodegradable characteristics (Katz *et al.,* 2008; Lertsutthiwong and Rojsitthisak, 2011; Chung *et al.,* 2013). Botanical pesticide is one of the main components of safety control strategies as well as nanotechnology is helpfully used to improve its efficiency. There are several methods to produce polymeric micro or nanocapsules, such as: spray-drying, complex coacervation (or phase separation), atomization and liposomes. One of them, the emulsion cross-linking method, is based on an oil-in-water emulsion of the polymer aqueous solution in the oily core material. Micelles undergo a hardening process with the addition of a crosslink agent. Nevertheless, the system variables are difficult to control since the size of the microcapsules depends on the extent of cross-linking agent and by stirring speed (Streck *et al.,* 2014; Agnihotri *et al*., 2004).

Therefore, the use of plant essential oils, especially, in the form of nanoparticle to control insect and mite pests to replace the use of synthetic chemicals, or reducing the import of chemicals from foreign countries is promising work. Essential oils from plants also decay faster, non toxic residue in the environment and very low toxic to worm blood animals as well. Insung *et al.* (2008) reported that extract from *Piper retrofractum* at the concentration of 1% could completely control the African red mite. When, Pumnuan et al. (2009) found that lemon grass and citronella grass essential oils at the concentration of 75 $\mu g/cm^3$ were the most effective in inhibiting hatching of the mushroom mite, *Luciaphorus perniciosus* Rack, and resulted in 97.3 and 95.8% mortality. Pumnuan *et al*. (2010) also reported that the essential oil of *Litsea cubeba* showed to be the most toxic to *Luciaphorus perniciosus* by both contact and fumigation methods with LD_{50} values equaling to 0.932 and 0.166 $\mu g/cm^3$, respectively, followed by essential oil of *Litsea salicifolia* and *Melaleuca cajuputi*. Previous study by Danarun *et al.* (2015) reported that essential oil from turmeric (*Curcuma longa* Linn.) and lemon grass (*Cymbopogon citratus* Stapf) were highly effective to adult of the African red mite with EC_{50} at 1.66 and 2.43%, respectively.

The purpose of this study was to investigate the efficiency in terms of toxicity and repellent properties of nano essential oil from turmeric (*Curcuma longa* Linn.) against the African red mite (*Eutetranychus africanus* (Tucker)) by using leaf dipping method.

Materials and methods

The African red mite cultures

The African red mite (Eutetranychus africanus (Tucker)) was cultured in the laboratory by putting mulberry leaves on a cotton swab soaked in a tray to serve as a food source. Plenty of female and male adults of the African red mite were released on the leaves. The dried leaf was changed every 4-5 days and kept at 25±2 ℃, 85±2% relative humidity.

Essential oil preparation

Based on a study of Danarun *et al.* (2015) and other scientific papers revealed that turmeric (*Curcuma longa* Linn.) essential oil was evaluated as high toxicity to the African red mite. This essential oil was arranged by procurement from Thai-China Flavours and Fragrances Industry Co., Ltd., Thailand, HACCP (Hazard Analysis and Critical Control Point).

Preparation for nano essential oil

The essential oil of turmeric was diluted in water by using emulsifiers or surfactants. Then the essential oil particles were resized to be nanoparticle by the dilution of surfactant and co-surfactant at different concentration. In this experiment, Tween80 (HLB = 15) was used as primary surfactant and ethylene glycol 400 (PEG400) (HLB = 13) as co surfactant. Then, the surfactant and co-surfactant, were mixed each other with a mix ratio called Smix as follows 1: 1, 1: 1.5, 1: 2, 1: 2.5, 1: 3, 1: 3.5, 1: 4 and 1: 4.5 (1:1 means 100 µl:100 µl). After that distilled water was filled up to obtain 10 ml. Then turmeric essential oil was mixed with Smix at the ratio 1: 1, 1: 1.5, 1: 2, 1: 2.5, 1: 3, 1: 3.5, 1: 4 and 1: 4.5 at room temperature for further experiment. Reduction of particle size of plant essential oil was done by High Pressure Homogenizer. Beside, the stability refers as zeta Potential Charge of nano plant essential oils was measured by Nano plus Zeta / Nano Particle Analyzer.

Bioassay

Toxicity properties by leaf dipping method.

In this study, toxicity property of nano essential oil of turmeric against the African red mite was investigated by using leaf dipping method. The mulberry leaf was cut into circle, 2.7 cm in diameter and dipped for 1 min with various concentration of nano essential oil at 0.0 (water), 0.2, 0.4, 0.6, 0.8 and

1.0%. Discharged to air-dry at room temperature 15-20 min, then amout 10-15 adults of the African red mite were introduced. The mite mortality was observed at 24 h and compared to the surfactant at different concentration. The data was analyzed after Abbott's formula.(Abbott, 1987)

Repellent properties by leaf dipping method.

In this study, repellent property of nano essential oil of turmeric against the African red mite was performed by using leaf dipping method. The mulberry leaf was cut into circle, 2.7 cm in diameter. Then the cut leaf was separated into 2 equal parts and dipped one side with essential oil at 0.02, 0.06, and 0.1%, the other one was dipped with surfactant (control). Both were discharged to air-dry at room temperature 15-20 min. About 10-15 adults of African red mite, were released. Then the repellent activity was observed at 24 h to gain repellent index: %RI; according to Pascual-Villalobos & Robledo. (1998) as the equation below.

$$\%RI = [(C-T)/(C+T)] \times 100$$

by C = control

T = treatment

Statistical analysis

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The experiment was designed in three completely randomized design with five replicates. The data obtained was statistically analyzed by analysis of variance (ANOVA) and Duncan's multiple range tests (DMRT). The values of LC_{50} (50% lethal concentration) and LC_{90} (90% lethal concentration) were calculated by the probit method.

Results and Discussion

Toxicity property of nano essential oil of turmeric against the African red mite by using leaf dipping method revealed that nano turmeric essential oil at concentration 1% had a high toxic property, showed 95.5% mortality and showed LC50 and LC90 at 0.39 and 0.74%, respectively. Whereas, the surfactant gave the LC50 and LC90 values of 0.49 and 0.98%, respectively. (Table 1) and (Figure 1). Normally, there were no significant diffrance compared to surfactant, but significantly different appeared at 0.6% concentration ($P<0.05$).

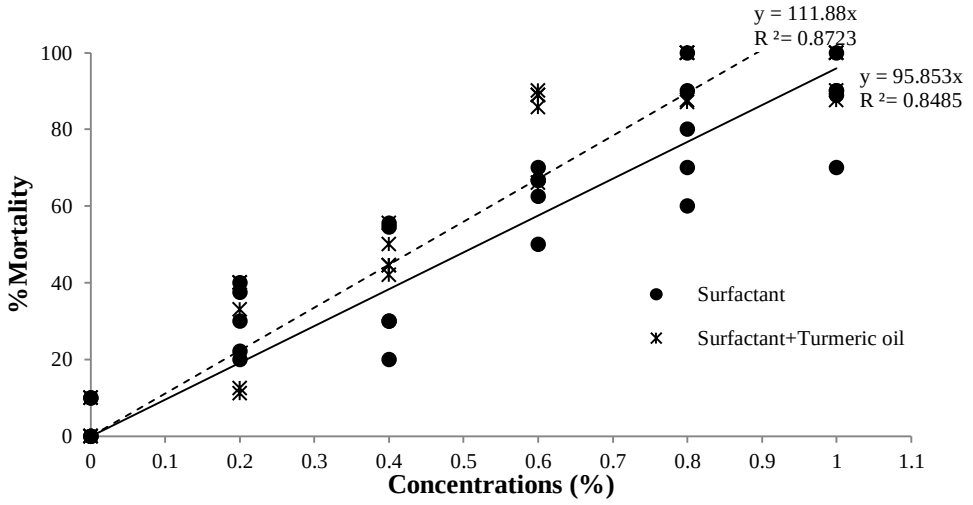

Figure 1. Percentage of mortality of the African red mite (*Eutetranychus africanus* (Tucker)) after treated with nano turmeric essential oil and surfactant (Tween80+PEG400) at various concentrations at 24 h by leaf dipping method.

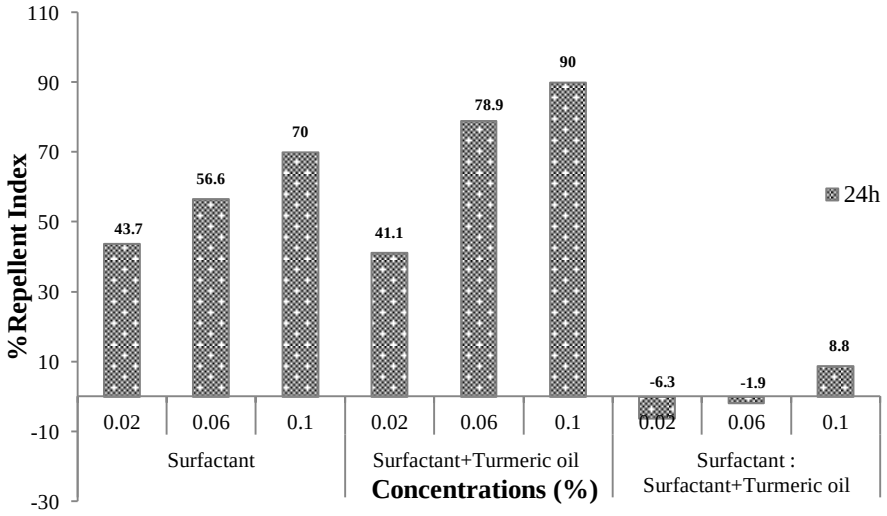

Figure 2. Percentage of repellent index of against nano turmeric essential oil and surfactant (Tween80+PEG400) at various concentrations the African red mite (*Eutetranychus africanus* (Tucker)) at 24 h by leaf dipping method.

Table 1. Percentage of mortality of the African red mite (*Eutetranychus africanus* (Tucker)) caused by nano turmeric essential oil and surfactant (Tween80+PEG400) at various concentrations at 24 h by leaf dipping method.

Nano-Essential oils	% Mortality [1/]						LC_{50}	LC_{90}	Slope ±SE
	Concentration (%)								
	0.0	**0.2**	**0.4**	**0.6**	**0.8**	**1**			
Surfactant	5.00 ±5.48^{Da}	29.9 ±8.9^{Ca}	38.0 ±16.1^{Ca}	63.2 ±7.8^{Bb}	80.0 ±15.8^{Aa}	87.8 ±10.9^{Aa}	0.49	0.98	2.584 ±0.192
Surfactant+Turmeric oil	5.00 ±5.48^{Da}	27.3 ±14.5^{Ca}	47.3 ±5.5^{Ba}	83.9 ±10.1^{Aa}	94.9 ±7.0^{Aa}	95.5 ±6.2^{Aa}	0.39	0.74	3.632 ±0.244
%CV	91.28	41.92	28.15	12.31	13.97	9.69			

[1] Means ± SD in column followed by the same common letter and means in row followed by capital letter are not significantly different (P<0.05) according to DMRT

The repellent property of nano essential oil of turmeric against the African red mite revealed that the nano essential oil of turmeric at 0.06-0.1% concentration showed mostly effective %RI (repellent index) of 78.9 to 90%, followed of surfactant which presented %RI of 56.6 to 70%, respectively. (Figure 2) Turmeric essential oil with surfactant at various concentrations caused very low repellent activity to the African red mite.

Toxicity and repellent properties of nano essential oil of turmeric, against the African red mite was recorded. Danarun *et al*. (2015) reported that essential oil from turmeric and lemon grass were highly effective to adult of the African red mite with LC_{50} at 1.66 and 2.43%, respectively. There was much difference when LC_{50} at 0.39% was obtained in this study. Beside, higher concentration of nano essential oil caused higher mortality of mite. Previous research on the indigenous medicinal plants to check the invasion of red flour beetle against wheat grains. Results painted that percent mortality was directly proportional to increasing concentration of extracts. Both *Allium sativum* and *C. longa* significantly reduced the larval, pupal and adult emergence. The botanicals could be used as effective tool against *Tribolium castaneum* (Herbst) along-with other IPM tactics. (Ali *et al.,* 2014) Singkhornart *et al.* (2007) revealed the toxicity towards the maize weevil, that turmeric at concentration greater than 15 µl.cm-2, were highly toxic produced 100% mortality within 1 day after treated fumigation. Acaricidal effects of some plants against two spotted spider mites, *Tetranychus urticae* Koch were also performed (Aslan *et al.,* 2004; Choi *et al.,* 2004; Miresmaili *et al*., 2006). Aslan *et al.* (2004) investigated the toxicity of essential oil vapours from *Thymus vulgaris* L., *Ocimum basilicum* L., and *Satureja hortensis* to *T. urticae* and those gave satisfactory result. Choi et al. (2004) tested 53 essential plant oils for their toxicity against the eggs and adults of *T. urticae* as well as the adults of Phytoseiulus persimilis Athias-Henriot obtained result presented that citronella java, lemon eucalyptus, peppermint oils gave > 90% mortality against adult *T. urticae*. Miresmaili *et al.* (2006) compared the toxicity of *Rosemarinus officinalis* L. essential oil and a blend of its major constituents against T. urticae on two different host plants. It was found that some constituents accounted for most of the toxicity but some were relatively inactive. Insung *et al.* (2008) reported that extract from piper retrofractum at the concentration of 1% could completely control the African red mite. As for the other reports dealing with using essential oil to control mite, Pumnuan *et al*. (2009) found that lemon grass and citronella grass essential oils at the concentration of 75 µg/cm3 were the most effective in inhibiting hatching of Luciaphorus perniciosus Rack, and resulted in 97.3 and 95.8% mortality. Pumnuan *et al*. (2010) also reported that essential oil of *Litsea cubeba* found to

be the most toxic to *Luciaphorus perniciosus* by both contact and fumigation methods with LD_{50} values equaling to 0.932 and 0.166 μg/cm^3, respectively.

Conclusion

The study of effectiveness in terms of toxicity and repellent properties of nano essential oil of turmeric (*Curcuma longa* Linn.) against the African red mite (*Eutetranychus africanus* (Tucker)) showed that nano turmeric essential oil at concentration 1% had a high toxic property, showed 95.5% mortality and it showed LC_{50} and LC_{90} values at 0.39 and 0.74%, respectively, whereas different concentrations of surfactant also showed high toxic effect to the mite with LC_{50} and LC_{90} values at 0.49 and 0.98%, respectively. Anyhow, there was no significant difference among them. In addition, nano turmeric essential oil at 0.1% showed extremely the repellent property to the African red mite, presented 90%RI at 24 h.

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