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Utilization of Fig Fruit (*Ficus variegata* Blume) Nanogel as a Detection and Monitoring Tool for Fruit Flies (*Bactrocera dorsalis* Complex) on Bird's Eye Chili (*Capsicum frutescens* L.)

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ABSTRACT

Fruit flies (*Bactrocera* spp.) (Diptera: Tephritidae) are pests that cause significant losses in chili plants, with yield reductions up to 100%. Control using fig fruit nanoextract as an attractant is one environmentally friendly solution that can attract male fruit flies. Chili (*Capsicum frutescens* L) in Risa Village, West Nusa Tenggara (NTB), is a superior commodity that often faces pest attacks. This study aims to examine nanogel extracts (*ficus variegata*) in controlling fruit fly attacks on chili plan. Thisstudy was conducted in Risa Village, Woha District, Bima Regency, West Nusa Tenggara (NTB) and at the Integrated Pest Management Laboratory (IPM Lab), Faculty of Agriculture, Udayana University. This study used a Randomized Block Design (RBD). The Fig Fruit nanogel traps in Risa Village, Woha District, Bima Regency, West Nusa Tenggara (NTB) captured two species of fruit flies, namely *Bactrocera carambolae* and *Bactrocera umbrosa* with a low diversity index. The highest catch of fig fruit nanogel was at 100% concentration (G5) with an average of (13.7 individuals). The relative abundance of *B. carambolae* was (34.05%) and *B. umbrosa* was (15.62%). The relationship between the trapped fruit fly imagoes and the fruit flies around the chili plants showed a linear relationship with an r-value of 0.9689. The relationship between the number of trapped imagoes and the percentage of attack also showed a linear relationship with an r-value of 0.9658.

Keywords: Fig Fruit Nanogel, Detection and Monitoring, Bactrocera dorsalis complex Fruit Fly, Chili

INTRODUCTION

Cayenne pepper (*Capsicum frutescens* L.) is an important horticultural commodity with high economic value. However, national cayenne pepper production is not yet optimal due to various factors, one of which is attacks by plant pests (OPT), especially fruit fly pests (*Bactrocera* spp.). This pest causes significant damage by laying eggs in the fruit, whose larvae then eat the flesh of the fruit, causing the fruit to rot and fall before it is ripe. Yield losses due to fruit fly attacks can reach 30% to 100%. Control efforts commonly used by farmers are not optimal. One environmentally friendly control alternative is the use of attractants to trap male fruit flies. This technique has been proven to reduce pesticide use by up to 75-95%. Apart from synthetic attractants, ingredients from plants (*vegetable*

insecticides) also have the potential to be developed.

Figs (*Ficus variegata*) are known to contain various bioactive compounds such as terpenoids, alkaloids and flavonoids which have the potential to act as natural pesticides. To increase its effectiveness and persistence in the field, fig extract is formulated in Nanogel form. Nanogel is a nano-sized hydrogel particle that allows slow and controlled release of active ingredients (*slow release*). This research aims to determine the effect of concentration and persistence of F. variegata fruit nanogel as a tool for detecting and monitoring fruit flies, as well as analyzing its relationship with the population and level of pest attacks in cayenne pepper plantations.

The cayenne pepper plant is classified as a seasonal crop and is one of the horticultural commodities that many people need almost every day. The cayenne pepper plant is a shrub with a height of 50-150 cm. The cayenne pepper root is a strong taproot and branches to the sides to form fibrous roots. The stems of cayenne pepper plants are dark green. (Djarwaningsih, 2005).

The fig plant (*Ficus variegata* Blume) is a higher plant from the genus Ficus, which is the largest genus in the Moraceae family and is distributed in tropical and subtropical areas (Rasyid, 2017). Figs (F. variegata) are actually not true fruit, but flowers that enlarge at the base and then close to form a ball like a fruit. In the Kehje Sewen Forest, *F. variegata* trees are usually found growing around riverbanks. These trees will bear fruit all year round when grown in a fairly humid area, but during the dry season the leaves will fall.

Fruit flies originate from tropical areas of Asia and Africa as well as subtropical Australia and the South Pacific. Fruit flies have entered Indonesia since 1920. Currently, fruit flies have spread to almost all parts of Indonesia. The imago of male and female fruit flies has differences in the posterior area, namely the ovipositor. Female fruit flies only have an ovipositor to lay eggs while males don't. The size of the ovipositor after experiencing maximum growth is 3 mm (Suputa and Putra, 2021).

Symptoms of infected chili plants are characterized by the stalks of the chili fruit starting to turn yellow and small black spots appearing due to ovipositor punctures. Furthermore, due to pest activities in the fruit, the stains develop wider and the fruit will fall before it is ripe (Saputa et al., 2006).

Nanotechnology is technology that works on a very small scale, namely the nano-scale. This technology involves ways to create or manipulate materials and devices that are small in size, ranging from 1-100 nm. Nanogel is a hydrogel particle formed by a physical or chemical cross-linked polymer network at nanoscale size. Nanogels can be natural, synthetic or combined materials and have a high degree of tunability in terms of size, surface functionalization form and degradation mechanisms (Merta, 2024).

Efforts to apply nanotechnology in agriculture began with the growing awareness that conventional agricultural technology could not increase productivity further or reverse ecosystem damage from the long-term effects of green revolution agriculture (Mukhopadhyay, 2014). Nano-insecticides are plant protection chemicals, where the active ingredients or carrier molecules are developed through Nanotechnology.

MATERIALS AND METHODS

Time And Place of Implementation

This research was conducted in Risa Village, Kec. Woha, Bima Regency, West Nusa Tenggara (NTB). Fig fruit sampling was carried out in Medahan Village, Blahbatuh District, Gianyar Regency. Making fig extract was carried out at the IPM Unud Laboratory. Nanogel manufacturing was carried out at the Maha Saraswati University Integrated Laboratory and field testing was carried out in

Risa Village, District. Woha, Bima Regency, West Nusa Tenggara (NTB).

Materials and tools

The tools for making Nanogel are laboratory glass, homogenizer, ultrasonication, analytical balance, hot plate, beaker glass, magnetic stirrer, DelsaTM Nano particle Size Analyzer (*Beckman Coulter*). The tools used to test Nanogel in the field are a knife, rope, 1.5 liter plastic bottle, camera and writing utensils. The material used is Nanogel (*F. variegata*).

Location determination

Field surveys were carried out in several places to find land planted with cayenne peppers that was attacked by fruit flies.

Sampling of *F. variegata*

Samples were taken in Medahan Village, Blahbatu District, Gianyar Regency. The fruit chosen was fruit that was still intact with a fruit age of 13 weeks and fruit weight (8-9 g). Then it is taken to the laboratory for further processing.

Processing of *F. variegata* samples

Fig samples are selected and sorted based on fruit weight, whether they are not damaged or free from attack by plant pests. The samples were washed thoroughly with running water to remove dirt attached to the fruit. The figs are then sliced or cut to a thickness of 1 mm. Then air-dry indoors without exposure to direct sunlight for 10 days.

Next, the simplicia is blended until smooth. The dried simplicia samples were finely ground, then extracted using the meseration method. The stages of the meserization extraction method are 2 kg of fig powder put into a container, then add Nbutanol 99.5% in a ratio of 1:3 (Febrina *et al*., 2015), soak for 4 days while stirring occasionally every 24 hours, then filter to obtain the filtrate.

The filtrate obtained is then concentrated using a Rotary Evaporator, then a concentrated extract is obtained. Nanogel was made using the pouring method, where the gel base (Carbopol 940, TEA, propylene glycol, methyl paraben) was mixed with *F. variegata* fruit extract nanoemulsion with concentrations of 0%, 2%, 4%, 6%, 8%, 10%.

Research Design and Field Application

This research used a Randomized Block Design (RAK) with 8 treatments and 5 replications, so there were a total of 40 experimental units. The treatment consisted of: *F. variegata* extract nanogel with concentrations of 20% (G1), 40% (G2), 60% (G3), 80% (G4), and 100% (G5), as well as three controls, namely *F. variegata* extract 60% (G6), *F. variegata* nanoemulsion 50% (G7), and Petrogenol 90% (G8). The trap used is a modified Steiner trap made from a 1.5 liter plastic bottle with four entrance holes. Nanogel bait is applied to cotton wool and suspended inside the trap. Traps were installed with a distance of 10 meters between traps at a height of 150 cm above ground level.

Observation and Data Analysis

The parameters observed include:

1. Type and Number of Fruit Flies: Trapped fruit fly adults are identified and counted every day.
2. Diversity Index: Calculated using the Shannon-Wiener formula.
3. Relative Abundance: Calculated for each species found.
4. Nanogel Persistence: Observed based on the number of daily catches until no more imago are trapped.
5. Relationship between Population and Level of Damage: Correlation and linear regression analysis was carried out to determine the relationship between the number of trapped adults and the fruit fly population around the

trap and the percentage of attacks on chili fruit.

The data obtained were analyzed using Analysis of Variance and continued with Duncan's Multiple Range Test at the 5% level using the SPSS version 24 application.

RESULTS AND DISCUSSION

Types and Abundance of Fruit Flies

Based on field observations, two types of fruit flies were found to be trapped. The results of morphological identification revealed a species of fruit fly that attacks cayenne pepper plants in Risa Village, District. Woha of Bima Regency are *B. carambolae* and *B. umbrosa.* Identification of fruit flies can be seen by observing the morphology of the fruit fly's body parts, namely: spot and face shape, mesonotum color, thorax motif, color, pattern and number of hairs on the scutellum, pattern on the wing veins (costa band), shape and pattern of the abdomen. It can be seen in Figure 1 and Figure 2.

The B. *umbrosa* fruit fly is characterized by a small black facial spot and an oval shape (Figure 1B). on the thorax it has a black scutum, with rather wide yellow bands on both lateral sides (Figure 1b), on the wings it has 3 transverse bands (Figure 1C). On the abdomen there is a black line running across terga II, a black line running across terga III, a black line running longitudinally across terga III-V to form the letter T (Figure 1D).

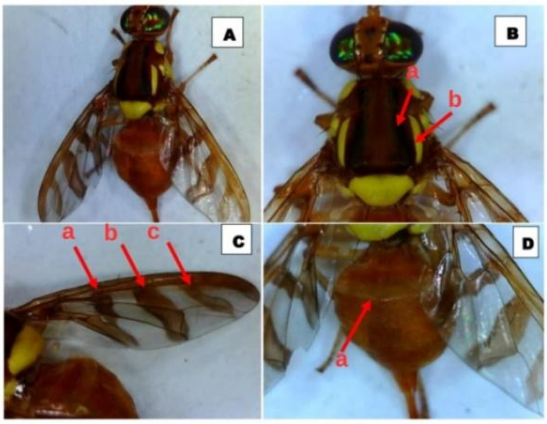


Figure 1. Morphology of *B.ummbrosa* (A) Imago, (B) Thorax, (a) scutum, (b) scutellum, (C) Wings (a,b,c) three transverse bands, (D) Abdomen, (a) black spot on the lateral tergum III

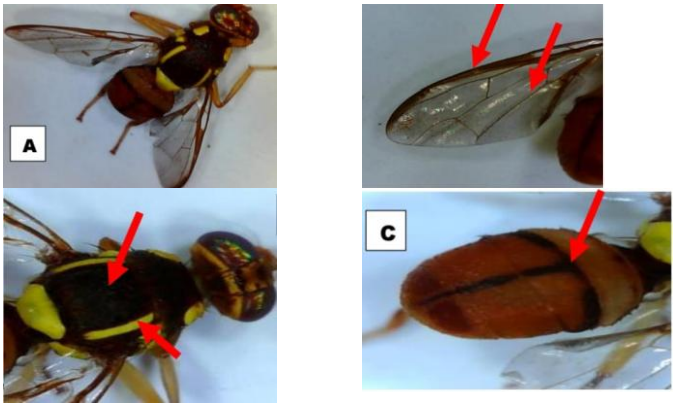


Figure 2. Morphology of Bactrocera *carambolae*: (A) Imago, (B) Wings, (C) Abdomen, and (D) Thorax

The fruit fly B. *carambolae* is characterized by narrow costal band wings descending at R2+3, with a narrow anal stripe (Figure 2B). On the abdomen there is a black line that runs across terga II-III, and longitudinally on terga III-V in the shape of the letter T (Figure 2C). On the thorax, the scutum is reddish-brown black with a band on the side of the tip of the scutellum.

Persistence of *F.variegata* Nanogel as a detection and monitoring tool for fruit flies on cayenne pepper plants

The results of statistical analysis showed that fruit fly imago trapped in trap bottles from observation days I to X showed no significant differences. The highest trapped fruit fly imago was shown in the 100% concentration treatment and the lowest was in the 20% concentration seen in (Table 1).

Table 1. Average Fruit Fly Imago Trapped in Trap Bottles Based on Time of Observation on Cayenne Pepper Plants in Risa Village, District. Bima

Treatment	Fruit fly imago trapped in a trap bottle while observing fruit maturity																			
	15				16				17				18							
Nano 20	6,8	±	0,83	d	7,8	±	4,32	c	7,8	±	2,38	c	9	±	6,89	c				
Nano 40	8	±	3,53	c d	8,8	±	4,43	c	13,4	±	7,89	c	11,2	±	6,34	c				
Nano 60	12,2	±	5,80	c	10,6	±	5,02	c	18,4	±	5,02	b	12,6	±	6,30	c				
Nano 80	14,4	±	4,72	c	16,6	±	12,2 5	c	19,6	±	5,41	b	17,6	±	7,33	b c				
Nano 100	18,8	±	5,31	b	22	±	11,5 5	b	21,2	±	5,93	b	24	±	5,43	b				
Ekstrak Nanoeks	9,6	±	4,87	c	12,2	±	6,22	c	11,2	±	6,61	c b	12,8	±	4,54	c				
Petro.	10,4	±	1,14	c	13,8	±	5,89	c	13,8	±	4,43	c	11,8	±	5,49	c				
	55,6	±	31,11	a	46,2	±	13,3 4	a	47,4	±	19,3 2	a	48,6	±	15,9 7	a				
KK (%)	20,58				11,6				20,11				15,15							

Table 1. advanced

Treatment	Fruit fly imago trapped in a trap bottle while observing fruit maturity																			
	19				20				21				22							
Nano 20	5	±	5,29	b	2,6	±	1,34	c	0,4	±	0,89	d	0	±	0	e				
Nano 40	10,4	±	9,34	b	4	±	3,93	c	0,6	±	1,34	d	0	±	0	e				
Nano 60	12,8	±	7,19	b	5	±	5,049	b c	2,2	±	3,03	d	1,6	±	2,30	d				
Nano 80	15,4	±	6,30	b	10	±	4,84	b	5	±	6,55	c	3,4	±	3,43	c				
Nano 100	18,4	±	14,75	b	11,4	±	7,70	b c	8	±	8,03	b	6,2	±	3,27	b				
Ekstrak Nanoeks	5,4	±	5,36	b	0,2	±	0,44	d	0	±	0	d	0	±	0	e				
Petro.	6,8	±	7,56	b	2,2	±	3,34	c	1	±	2,23	d	0	±	0	e				
	41	±	12,54	a	23,8	±	4,32	a	19,4	±	7,33	a	13,6	±	7,12	a				
KK (%)	18,25				14,07				17,07				13,85							

Table 2. Average Fruit Fly Imago Trapped in Trap Bottles Based on Time of Observation on Cayenne Pepper Plants in Risa Village, District. Bima

Treatment	Fruit fly imago trapped in a trap bottle for observing fruit age				Most adults are trapped in-			
	23		24		10 day			
Nano 20	0 ± 0	e	0 ± 0	e	3,94 ± 0,907193	ef		
Nano 40	1,6 ± 0	e	0 ± 0	e	5,64 ± 2,822765	e		
Nano 60	3,4 ± 2,30	d	1 ± 2,23	d	7,64 ± 2,429609	d		
Nano 80	6,2 ± 3,43	c	2,8 ± 4,14	c	10,56 ± 2,272224	c		
Nano 100	0 ± 3,27	b	5,2 ± 3,56	b	13,7 ± 4,740781	b		
Ekstrak	0 ± 0	e	0 ± 0	e	5,14 ± 0,993982	e		
Nanoeks	13,6 ± 0	e	0 ± 0	e	5,98 ± 1,156287	de		
Petro.	13,85 ± 7,12	a	10,6 ± 5,94	a	31,9 ± 10,15751	a		
KK (%)	15,17		9,2		13,32			

Description: numbers followed by the same letter in the same column shows no significant difference in the BNT test at 5% level data were analyzed after being transformed to (X+0.5)^0.5.

Daily observations showed that *F. variegata* extract Nanogel was able to attract fruit flies effectively until the 10th day (Table 2), with peak catches occurring on the 4th day (37 individuals in the 100% treatment). This ability shows the (*slow release*) nature of the Nanogel formulation, which allows the attractant compound to last longer in the field compared to the Nanoextract formulation (lasts 7 days) and regular extract (lasts 6 days).

Relationship of Traps Catch with Population and Attack Rates

Correlation and regression analysis showed a very strong and positive relationship between the number of trapped fruit fly adults and the adult population observed around the cayenne pepper plants. The regression equation on day 10 is y = 6.4421x + 115.33 with a correlation coefficient (r) = 0.9689 and a coefficient of determination (R^2) = 0.9388. This means that 93.88% of the variation in fruit fly populations in the field can be explained by the number of fruit flies trapped.

Likewise, a very strong relationship was found between the number of trapped adults and the percentage of attacks on chili fruit (r = 0.9658; R^2 = 0.9329). The regression equation y = 0.8027x + 19.505 shows that every increase in catches will be followed by an increase in the percentage of attacks. This strong relationship indicates that this nanogel attractant trap can be used as a reliable monitoring tool to predict pest populations and potential damage in the field.

CONCLUSION

Nanogel from *F. variegata* extract is effective as a tool for detecting and monitoring fruit flies on cayenne pepper plants, with the highest average catch reaching 13.7 (heads) per trap at a Nanogel concentration of 100% (G5), and the types of fruit flies detected were B. carambolae and *B. umbrosa*. The effectiveness of this Nanogel persisted until day 10 and reached its peak on day 4 (24 animals). Furthermore, the number of fruit flies caught had a strong and positive relationship with the fruit fly population in the field (r = 0.9804) and also with the level of fruit fly attacks on cayenne pepper (r = 0.9658.) which indicates that this Nanogel trap is a reliable monitoring tool for predicting the population and potential pest damage in the field.

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