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Application of MAT Using Methyl Eugenol and Cue-Lure to Control Bactrocera spp. in Vegetable Centers of North Sulawesi

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Abstract: Fruit fly Bactrocera spp is one of the limiting factors in vegetable crop production. The male annihilation tehnique control method can control fruit fly populations by using sex pheromones namely Methyl eugenol and Cue-lure which are able to attract male fruit flies. The purpose of the study was to identify the types of fruit flies that attack vegetable crops, analyze the behavior of the captured population and the differences in the types of fruit flies against the use of methyl eugenol and Cue-lure. The research method is by placing traps containing methyl eugenol and cue-lure at a number of points according to the location so that it can support the representation of fruit fly distribution areas in vegetable crop centers. Observations will be carried out for 6 observations with an interval of 2 weeks. The results showed that the identification of fruit fly species caught using cue-lure a mounted to six species and methyl eugenol there were 11 species The population of fruit flies caught in the four locations of vegetable crop centers using methyl eugenol was higher in the total number of 4719 individuals with a range of 1042-1270 individuals compared to the cue-lure attractant catch of 2973 individuals with a range of 701-743 individuals.

Keywords: Bactrocera spp; Methyl eugenol; Cue-Lure; Male annihilation tehnique (MAT)

Introduction

One group of pests that causes significant damage and losses economically and depresses the production of fruits and vegetables in Indonesia is the fruit fly Bactrocera spp. (Diptera: Tephritidaea) (Kardiman, 2003; Clarke et al., 2005). To date, about 4000 species of fruit flies have been identified, with an estimated 1400 species attacking soft fruits (White & Elson-Harris, 1992). Specifically, the genus Bactrocera has about 500 species organized into 28 subgenus (Barr et al., 2012; Drew, 1989; Drew & Hancock, 1994). Tephritidae (=Trypetidae) fruit flies are one of the families that have the largest number of genus and species of the order Diptera, which is about 4000 species divided into 500 genus (PHA, 2011). According to Metcalf (1990) and Kuba (1991), the genus Bactrocera is reported to have 440 species and the Tephritidae family is the largest group of the order Diptera which is one of the important families because it is economically very detrimental because it acts as a major insect pest.

In nature, Bactrocera spp. have a range of host plants including fruits, vegetables and flowers. The selection of plant fruits by Bactrocera species to serve as hosts appears to be dominated by certain species that have a fairly wide host range but for certain host plant species is also generally dominated by certain fruit fly species as well. The attraction of Bactrocera species to hosts has a special mechanism, especially those related to host plant specialization and plant chemistry (L.M. et al., 2000; Leblanc et al., 2013).

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The use of attractants to control fruit fly populations is basically to attract male insects into the trap and then the male insects will die due to contact insecticides mixed with attractants and hung in the middle of the inside of the trap. According to Subahar et al (1999) and Iwahashi et al (1996) attractants are specific and play a role in sexual selection so that only male fruit flies are attracted. Attractants used in controlling fruit flies are in the form of synthetic chemicals that can emit odors or aromas of food (food lure) of fruit flies such as fruit aroma or fragrance odor of fruit fly lust (sex pheromone). Most attractants are made of unsaturated aliphatic compounds consisting of alcohols, astic acid esters, aldehydes containing carbon chains C10 - C20 (Kakinohana et al., 1997). Furthermore, Metcalf (1990) states that attractants can be used to control fruit fly pests in three ways, namely: (1) Detecting or monitoring fruit fly populations, (2) Attracting fruit flies into traps to be killed, and (3) Disrupting fruit flies in mating, gathering or feeding behavior. According to Fitt (1981) and Kapoor (1993), chemical compounds that are attractants commonly used to attract male insects are methyl eugenol, cue-lure, and Trimedlure.

Iwahashi et al (1996) stated that specifically for attractants methyl eugenol is a very strong attractant when compared to other attractants. Methyl eugenol is the most effective attractant to lure male fruit flies such as B. dorsalis complex (Subahar et al., 1999). The chemical description of methyl eugenol is 3-3 dimethoxi (1) 2 propenyl benzene (Wong et al., 1991). Methyl eugenol is a chemical compound that is strong volatile and releases a fragrant aroma. When smelling methyl eugenol, male fruit flies will try to find the source of the odor and eat it.

The current effective and efficient method of controlling fruit fly populations is the method applied by combining the mating behavior of fruit fly insects through the use of sex pheromones or attractants combined with traps that allow lured fruit flies to die in the trap because it has been smeared with contact insecticides. When traps are laid with a certain method and artificial attractants methyl eugenol and cue-lure are used at a certain time range, the success of the application will be successful as indicated that the population of male fruit flies will decrease with limited natural mating success of fruit flies.

Vegetable crop yield losses continue due to destructive fruit fly attacks so that vegetable production is depressed. The use of sex pheromones or attractants that modify the mating behavior of male fruit fly insects so that the population can decrease will be a wise reference considering that fruit fly control efforts must continue. The successful use of male annihilation technique is an option because its application is not difficult but can give good results.

The objectives of the study were to determine: 1) types of fruit flies according to the type of attractant and 2) the effectiveness of using sex pheromones (methyl eugenol and cue-lure) and modified traps so as to suppress the population of flies that damage vegetable crops.

Method

Place and Time of Research

The research was conducted in the area of vegetable cropping centers in Rurukan and Kakaskasen II villages of Tomohon City and Lineleyan and Sinisir villages of South Minahasa Regency. Identification of captured fruit fly species and calculation of the number of fruit fly species will be carried out at the Laboratory of the Department of Plant Pests and Diseases, Faculty of Agriculture, Unsrat. The research was conducted for 6 months from the first month to the sixth month of 2023.

Materials and Tools

The materials used in the study were samples of fruit fly insects. The sex pheromone/attractant compound is methyl eugenol, cue-lure, alcohol, and contact insecticide; while the equipment needed is a modified trap, gallows, cotton, hose, wire, marker, binocular microscope, camera microscope, hand counter, collection bottle, brush, loup, machete, plastic bag, raffia rope, cuter, GPS, camera, stationery, flash disk, CD, and others.

Research Methods

The research was conducted using a survey method at the location of vegetable crop centers in North Sulawesi Province, namely Tomohon city consisting of Rurukan and Kakaskasen 2 villages and Lineleyan and Sinisir villages, Modoinding sub-district, South Minahasa district. Each location of the vegetable crop area according to the kelurahan/village will be installed traps + attractant 30 traps consisting of 15 traps with methyl eugenol and 15 traps with cue-lure. So that the total traps that will be installed in vegetable crop areas are 4 locations times 30 traps will amount to 120 traps consisting of 60 methyl eugenol traps and 60 traps + cue-lure. Observations will be carried out 6 times with an interval of 2 weeks. When observations are made three times, the attractant will be replaced and continued to the last three observations. The type and number of fruit fly insects according to the type of trap and attractant used will be collected and brought to the laboratory to be identified and counted for further analysis. Data analysis using quantitative methods on the number of

insects caught according to type and type of attractant. The purpose of using sex pheromones/attractants with modified traps is to obtain an effective lure in capturing fruit flies attacking vegetable crops at the observation site and at the same time the fruit fly population in each observation site will tend to decrease.

Result and Discussion

The results of the determination of the morphological characters of fruit fly species using the fruit fly identification key (White & Elson-Harris, 1992; (PHA, 2011) obtained 17 species of fruit flies, namely for the attractant Cue-Lure amounted to 6 species and Methyl Eugenol is 11 species as shown in Table 1.

Table 1. Location, Type of Attractant and Type of Fruit Flies caught during the observation Observations

Location	Attractant Type	No	Types of Fruit Flies
Kakaskasen II	Cue-Lure	1.	*Bactrocera cucurbitae* Coquillett
(Tomohon Utara)		2.	*Bactrocera dorsalis* (Hendel)
		3.	*Bactrocera albistrigata* (de Meijere)
		4.	*Bactrocera exornata* (Hering)
		5.	*Bactrocera tau* (Walker)
	Methyl Eugenol	1.	*Bactrocera carambolae* (Drew & Hancock)
		2.	*Bactrocera dorsalis* complex
		3.	*Bactrocera calumniata* (Coquillett)
		4.	*Bactrocera synnephes* (Hendel)
		5.	*Bactrocera papayae* Drew & Hancock)
		6.	*Bactrocera umbrosa* (Fabricius)
		7.	*Bactrocera facialis* (Coquillett)
		8.	*Bactrocera Frauenfaldi*
		9.	*Bactrocera* sp.2
Rurukan	Cue-Lure	1.	*Bactrocera cucurbitae* Coquillett
(Tomohon Timur)		2.	*Bactrocera dorsalis* (Hendel)
		3.	*Bactrocera albistrigata* (de Meijere)
		4.	*Bactrocera exornata* (Hering)
		5.	*Bactrocera cucumis* (French)
		6.	*Bactrocera tau* (Walker)
	Mathyl Eugenol	1.	*Bactrocera umbrosa* (Fabricius)
		2.	*Bactrocera dorsalis* complex
		3.	*Bactrocera synnephes* (Hendel)
		4.	*Bactrocera papayae* Drew & Hancock)
		5.	*Bactrocera umbrosa* (Fabricius)
		6.	*Bactrocera facialis* (Coquillett)
		7.	*Bactrocera carambolae* (Drew & Hancock)
		8.	*Bactrocera* sp. 2
Lineleyan	Cue-Lure	1.	*Bactrocera cucurbitae* Coquillett
(Mondoinding)		2.	*Bactrocera dorsalis* (Hendel)
		3.	*Bactrocera cucumis* (French)
		4..	*Bactrocera exornata* (Hering)
		5.	*Bactrocera cucurbitae* Coquillett
		6.	*Bactrocera tau* (Walker)
	Methyl Eugenol	1.	*Bactrocera carambolae* (Drew & Hancock)
		2.	*Bactrocera dorsalis* complex
		3.	*Bactrocera calumniata* (Coquillett)
		4.	*Bactrocera synnephes* (Hendel)
		5.	*Bactrocera* sp .3
		6.	*Bactrocera umbrosa* (Fabricius)
		7.	*Bactrocera facialis* (Coquillett)
		8.	*Bactrocera* sp. 2
		9.	*Bactrocera* sp.1

Location	Attractant Type	No	Types of Fruit Flies
Palelon	Cue-Lure	1.	*Bactrocera cucurbitae* Coquillett
(Mondoinding)		2.	*Bactrocera dorsalis* (Hendel)
		3.	*Bactrocera albistrigata* (de Meijere)
		4..	*Bactrocera exornata* (Hering)
		5.	*Bactrocera cucumis* (French)
		6.	*Bactrocera tau* (Walker)
	Methyl Eugenol	1.	*Bactrocera carambolae* (Drew & Hancock)
		2.	*Bactrocera dorsalis* complex
		3.	*Bactrocera calumniata* (Coquillett)
		4.	*Bactrocera synnephes* (Hendel)
		5.	*Bactrocera papayae* Drew & Hancock)
		6.	*Bactrocera umbrosa* (Fabricius)
		7.	*Bactrocera facialis* (Coquillett)
		8.	*Bactrocera Frauenfaldi*
		9.	*Bactrocera* s *Bactrocera* sp.1p.1

Based on Table 1. above shows that the types of fruit flies caught according to the type of cue-lure attractant only amounted to 6 species namely B. cucurbitae; B. dorsalis; B. albistrigata; B. exornata; B. tau and for the Methyl Eugenol attractant there were 11 species namely B. carambolae; B. dorsalis complex; B. calumniata (Coquillett); B. cucumis; B. tau and for the Methyl Eugenol attractant there are 11 species, namely B. carambolae; B. dorsalis complex; B. calumniata (Coquillett); B. synnephes (Hendel); B. papayae; B. umbrosa, B. facialis; B. Frauenfaldi; Bactrocera sp.1; Bactrocera sp.2; Bactrocera sp 3.

17 species of fruit flies found during observations that responded to both attractants used, namely cue-lure and methyl eugenol; according to White & Elson-Harris (1992) are common fruit fly species found in vegetable and fruit crops in Southeast Asia and the diversity of fruit fly species found according to Leblanc et al (2013) is highly dependent on the availability of abundant hosts around vegetable crop centers. The dominant species are B. albistrigata, B. tau, B. cucurbitae, B. carambolae, B. dorsalis complex, B. umbrosa and B. frauenfeldi. There is something interesting when B. dorsalis Compleks was found in the observation with methyl ugenol attractant, according to Drew & Hancock (1994) that this species has about four dozen species that can be found in Asia and is known as the main fruit fly destroying fruits and vegetables.

The results also showed that the types of fruit flies according to the observation location were almost the same with the distribution pattern concentrated in the center of vegetable and fruit crops, namely those in Tomohon City (Rurukan and Kakaskasen II Villages) and South Minahasa Regency (Modoinding: Lineleyan and Palelon Villages). The species of B. cucurbitae, B. carambolae, B. umbrosa, B. Tau, B. albistrigata, and B. dorsalis complex are known to invade vegetable crops, especially chilies, tomatoes, flowering vegetables, Paria, Squash, and others. The existence of these types of fruit flies will always be found when using cue-lure attractants and methyl eugenol because in addition to attacking vegetable plants, these species also attack fruits around vegetable plants such as several types of jack fruit, several types of oranges, breadfruit, advocad, star fruit, flowering plants and others.

Based on observations of the effectiveness of the use of cue-lure attractants and methyl eugenol with modified traps, it can be seen that the types and populations of fruit flies trapped are relatively high because each trap is placed to capture fruit fly populations as shown in Table 2 below.

Table 2. Total population of fruit flies caught using attractants (cue-lure and methyl eugenol) during the observation in vegetable crops center.

Location/Center* Vegetable Crops	attractant	i-th observation						Total	
		I	II	III	IV	V	VI		
								…..(tail)…..	
Kakaskasen II	Cue-lure	281	161	135	96	65	0	738	
	Methyl Eugenol	401	254	233	156	82	12		1138
Rurukan	Cue-lure	277	145	122	85	69	3	701	
	Methyl Eugenol	587	331	198	75	58	21		1270
Lineleyan	Cue-lure	301	206	121	97	66	0	791	
	Methyl Eugenol	433	351	113	78	59	8		1042

Location/Center* Vegetable Crops	attractant	i-th observation						Total	
		I	II	III	IV	V	VI		
								…..(tail)…..	
Palelon	Cue-lure	297	193	102	88	56	7	743	
	Methyl Eugenol	557	399	143	84	61	15		1259
Total		3194	2040	1167	759	516	66	2973	4719

Based on Table 2, it can be seen that the population of fruit flies caught according to the type of attractant is different. The population of fruit flies caught in the four locations of vegetable crop centers using methyl eugenol attractant was higher in the total number of 4719 with a range of 1042-1270 individual compared to the catch of cue-lure attractant which was 2973 with a range of 701-743 individual. The results of this observation show that the number of fruit fly species caught will affect the total number of captured populations as a whole. The identification of fly species showed that cue-lure attractant only captured 5-6 types of fruit flies according to the observation location while methyl eugenol attractant was able to capture 8-9 types of fruit flies. The results showed that the use of methyl eugenol as an attractant in vegetable cultivation areas resulted in higher fruit fly catches compared to cue-lure attractants. The total catch with methyl eugenol reached 4,719 individuals with a range of 1,042–1,270 individuals at each location, while cue-lure only caught a total of 2,973 individuals with a range of 701–743 individuals. This indicates that methyl eugenol is more effective in attracting fruit flies than cue-lure. Biologically, methyl eugenol is known to be more specific in attracting male fruit flies of the genus Bactrocera, particularly Bactrocera dorsalis and its relatives, which are important pests of tropical horticultural crops. According to recent literature (e.g., Vargas et al., 2021; Shelly et al., 2023), methyl eugenol has strong pheromonal attractiveness toward this group, resulting in higher trap catches, both in terms of individual numbers and species diversity. Meanwhile, cue-lure is more effective at attracting species from the Bactrocera cucurbitae group and some other species, but the number of species attracted is relatively lower compared to methyl eugenol. Based on species identification from the catches, cue-lure only captured 5–6 types of fruit flies depending on the location, while methyl eugenol successfully captured 8–9 types. This indicates that methyl eugenol is not only effective in attracting larger numbers of individuals but also has a broader range of attracted species. These findings are consistent with the results of a study by Ekesi et al. (2022), which reported that the use of methyl eugenol can be an effective strategy for monitoring and controlling fruit flies in integrated pest management (IPM) programs. The specific attraction to male flies enables precise population monitoring and can be combined with sterile male techniques (Sterile Insect Technique/SIT).

According to Iwahashi et al (1996), methyl eugenol is a sex pheromone or attractant that is very effective for capturing populations of various types of male fruit flies through the male annihilation method. The lure or attraction caused by a type of sex pheromone will be so strong that it attracts male insects to come to mate and eventually get trapped and die in the trap.

The results of catching fruit fly population according to the type of attractant for all observation locations show that the average catch of cue-lure attractant is lower than the catch of methyl eugenol as shown in the graph in Figure 1.

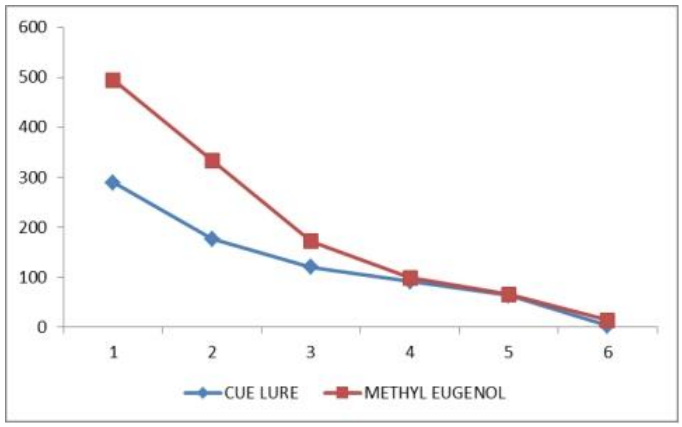

Figure 1. Graph of average fruit fly catches based on the types of cue-lure attractant and methyl eugenol at the four locations for 6 observations

Figure 3 shows that the number of fruit flies caught with methyl eugenol attractant was higher than that of cue-lure attractant. The response of fruit flies to the type of attractant in the initial observation is very high then will decrease in line with the next observation time. This observation shows that the attractant used is very effective in creating attraction to the male population of fruit flies, which finally in the last observation the number of catches has decreased because the population in nature has been caught or died in the trap.

Conclusion

The results of identification of fruit fly species caught using cue-lure attractant amounted to six species

and methyl eugenol there were 11 species. Keseluruhan jenis yang tertangkap adalah genus Bactrocera. The population of fruit flies caught in the four locations of vegetable crop centers using methyl eugenol attractant was higher in the total number of 4719 individuals with a range of 1042-1270 individuals compared to the cue-lure attractant catch of 2973 individuals with a range of 701-743 individuals.

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M.L.: Developing ideas, analyzing, writing, reviewing, responding to reviewers' comments; C.S.R., D.S.K.: analyzing data, overseeing data collection, reviewing scripts, and writing.

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Conflicts of Interest
The authors declare no conflict of interest.

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