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Monitoring of species and population of important insect pest of tomato plants using yellow sticky trap during conventional and integrated pest management system

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1 ABSTRACT
Tomato crop area expansion is an effort to keep up and anticipate market needs for tomatoes, but the pest causes the low production of tomatoes. Information on insect pest species and its population is needed as a first step to address the integrated management of pests. This study aimed at investigating species and population of important insect pest trapped using yellow sticky trap (YST). The YST was installed at integrated pest management (IPM) and conventional areas. At IPM area, black silver plastic mulch was assembled and controlled botanical pesticide was applied, while at conventional area, provision of insecticide was done on a scheduled basis according peasant habits. The botanical pesticide was prepared from the leaves of *Derris eliptica*. The YST was assembled when the tomato plants were three weeks old until harvest time. Monitoring of pest was done by letting the trap for one week and then replaced with a new trap. Important pest insects trapped were collected in a bottle containing 70% alcohol, the number of population was calculated and their types were identified. Results showed that at IPM and conventional areas, four species of important pests were found: *Liriomyza sativae*, *Nesidiocoris tenuis*, *Bactrocera* sp. and *Helicoverpa armigera*. Population of *L. sativae* was the highest at both areas, with 75.73 individuals at conventional area and 53.29 individuals at IPM area. This shows that IPM technique can suppress *L. sativae.* Population of other insect pests was not reducing significantly on tomato plants. The lowest population was *H. armigera*, either at IPM area (0.93 individual) or at conventional area (0.91 individual).

2 INTRODUCTION
Tomato plant (*Lycopersicum esculentum* Mill) is a fruit vegetable crop, which are widely popular with the public as a raw material for seasoning, sauce and juice manufacture. With increasing population, the demand of tomatoes is also increased. The spread of tomato plants in Indonesia is quite extensive, ranging from lowlands to highlands. Likewise, in North Sulawesi the tomato plant is one of agricultural crops, which is widely cultivated by the farming community. According to Central Statistics Agency (2015) the production of tomato in North Sulawesi from 2011 to 2015 showed a tendency to fluctuate from year to year, that is 27,221 (2011), 29,034 (2012), 26,012 (2013), 28,124 (2014), and 26,576 (2015). The

expansion of the plant area is one way to offset and anticipate market demand, but the presence of pests causing low production of tomatoes. According to Sembel *et al.* (2009), the fluctuation of tomato production can be affected among others by season, acreage of cultivation, cultivation system, as well as pests and plant diseases. Toure village, which is located at Minahasa regency, is one of the agricultural centers of vegetables including tomatoes in North Sulawesi. Efforts to improve tomato production in this region are faced with the problem of pests. Sembel *et al.* (2009) found those pests that attack tomato plants known as the leaf miner (*Liriomyza sativae* Blanchard; Diptera: agromyzidae). This pest was first reported in North Sulawesi in 2002. They lay their eggs on the surface of leaves, and after hatching, the larvae will mine the leaves and create winding irregular tunnel like spirals. Eventually the leaves become dry and dead (Sembel, 2014). Insecticide is still a mainstay of farmers in overcoming pest problems. In fact, in addition to expensive, the use of insecticides can also cause other problems such as secondary pest resurgence and explosion. Moreover, intensive use of insecticide has been shown to reduce the population and level of parasitism of natural enemies against *L. sativae* (Fathipour *et al.*, 2006). Baideng (2016) found that population of parasitoid *Hemiptarsensus* was commonly found on tomato plants where this parasitoid has potential as a pest control agent against *L. sativae*. Due to the high intensity of insecticide use on a scheduled basis, it is feared the role of the parasitoid on tomato plants will be suppressed. Takatoshi and Dang (2015) reported a significant number of parasitoid *Neochrysocharis okazakii* affected *Liriomyza chinensis* populations on onion crop. An integrated and comprehensive approach is needed in order to obtain an effective and safe control system for the environment, which does not inhibit the growth of natural enemies organisms. The approach needed to resolve the problem is the integrated pest management system. In the application of IPM systems, observations of insect pests and the population is necessary as a first step in tackling the pest attack.

The use of plastic mulch is one of the techniques to control pathogens that live in the soil and weeds on farmland. This is a technique to protect the soil using solar energy. Using transparent plastic, solar energy is captured to heat the soil. This is done on soil before planting tomato plants and was effective in controlling plant pathogens (Cenis, 1989). Utilization of natural ingredients for plant protection has been intensified over the past three decades. One type of plant that is widely studied and has been shown to have insecticidal activity is *Derris elliptica*. Morgan and Wilson (1999) reported that rotenon which is an active compound found in D. elliptica root is highly toxic to insects, especially from the order of Coleoptera and Lepidoptera. Sihombing *et al.* (2013) reported D. elliptica as an effective anti-mosquito material. Asmono (2004) reported that the extract of EtOAc roots of *D. elliptica* root of 0.11% had LC50 insecticidal effect on *C. binotalis*. The yellow sticky trap (YST) is a trap that is used to control and monitor several kinds of pests in the planting area. Insects are generally interested in the yellow colour and will become trapped. Garekhani *et al.* (2014) reported the effectiveness of YST against *Thrips tabacci* (Lindeman) and some predatory thrips of the family Aeolothripidae on tomato plants. Thrips *Frankliniella occidentalis* are interested in the blue and yellow traps (Larki *et al.*, 2012). This indicates that the YST is efficient in trapping insects so that the existence of the population can be observed in the field. Aside from being a tool used to monitor the presence of the pest population, YST also functions in controlling the population of pests that attack crops. This research activity is intended to get the latest information and the type of insect pest population that is predominantly attacking tomato plants in the village Toure. Such information is the basis for determining policy control strategies to be executed.

3 METHODOLOGY

3.1 Preparation of Integrated Pest Management and Conventional Areas: The experiment took place in the village Toure, North Sulawesi province, Indonesia. The IPM and conventional plots were prepared at tomato plantation for observation. There were 10 beds which were aligned in the two plots, with the size of each bed was 15 meters long, 1.2 meters wide with a distance between the planting path on the side of 1 meter. Observation on two different plots is intended to compare the population of insect pests that attack tomatoes. The plastic mulch was used to cover the soil in IPM plots. Extract of *Derris elliptica* was used for botanical pesticide. At the conventional plots, provision of insecticide was done on a scheduled basis according peasant habits, and without plastic mulch.

3.2 Treatment on tomato plants: Nursery, installation of bamboo stakes, pruning, watering and fertilizing were done in accordance with the custom of farmers. Botanical pesticide *Derris elliptica* was sprayed at the IPM plots in a controlled manner if there was pest. Plant extraction was carried out according to the method proposed by Dadang (1999). The plant leaves were dried and mashed using a disc mill and blender, and filtered with a 0.5 mm mesh sieve. The powder was soaked with methanol at a ratio of 1:10 (w / v) in the Erlenmeyer flask and shaken with a magnetic stirrer for $\pm$ 24 hours. Suspension is filtered and rinsed repeatedly until the filter results were colorless (clear). The filtered liquid is combined in the evaporation flask, the methanol was evaporated using a rotary evaporator at a temperature of (45-50) 0 C, at a spin speed of 50-60 rpm, and at a low pressure of 150-200 mm Hg. After the evaporation was completed, the flask containing the extract was weighed again. The difference between the two weighing results was the weight of the extract. The crude extract of methanol fraction obtained from the evaporation results were partitioned in the hexane-methanol system (95%) at a ratio of 1:10:10 (w / v / v) in the separator flask for 6+ hours, and the hexane phase was washed with 95% methanol. The hexane phase was discarded, while the 95% methanol phase was evaporated with a rotary evaporator. The methanol fraction obtained was then repartitioned in the water-ethyl acetate system in the manner described above, the water phase was discarded and the ethyl acetate phase obtained was stored in the refrigerator (4^{o}C) until use. The concentration used was 0.088 L / 800 L water per hectare with intensity of spraying once a week or as much as 9 times during observation. At the conventional plots, synthetic insecticide Curacron 500 EC was applied twice a week according to the custom of farmers or as many as 18 times spraying. The concentration was 1.6 L of Curacron / 800 L of water per hectare. A total of two YST for each plot was installed (Figure 1) so there were 20 YST traps on the IPM and conventional plots respectively. The instalment was done when tomato plant at the age of three weeks until the harvest time. Trap replacement was done once a week. Important pests were collected in the bottle containing alcohol 70%. The population was calculated and the species of the insects were identified.

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Figure 1: The instalment of yellow sticky trap at IPM plot (left) and conventional plot (right).

3.3 Insect Pest Collection: Insect pests were collected from YST either IPM plot or conventional plot every week with nine replications for each plot. Insect samples collected separated by type of insect and numbered. The collected insects were separated based on species and their number was calculated. Insect pest was separated from predators. Insect identification was done referring to Borror *et al.* (2006), Gauld and Bolton (1988), and Pedigo (2005).

4 RESULTS AND DISCUSSION

Four important insect pests identified in both plots were *Liriomyza sativae* (Diptera: Agromyzidae) (Figure 2a), *Nesidiocoris tenuis* (Hemiptera: Miridae) (Figure 2b), *Bactrocera* sp. (Diptera: Tephritidae) (Figure 2c), and *Helicoverpa armigera* (Figure 2d). The number of important pest populations caught on YST in IPM and conventional plots are shown in Table 1 and 2.

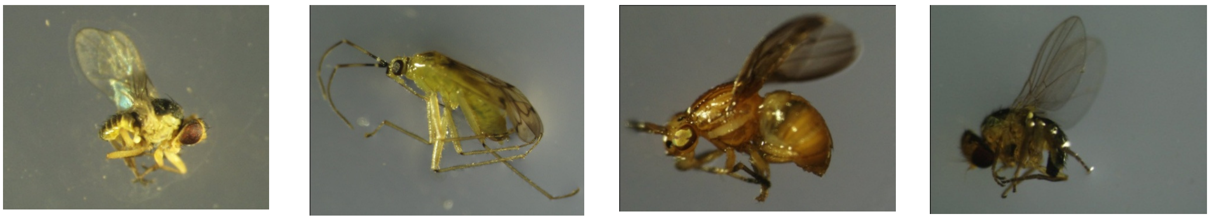
(a) *L. Sativae* (b) *N. tenuis* (c) *Bactrocera* sp. (d) *H. Armigera*

Figure 2: The four important insect pests identified at IPM and conventional plots

Table 1: Pest populations in IPM plots during 9 observations

Species	**Sampling number**									**Number of population (individuals)**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Liriomyza sativae	318	340	460	502	612	646	658	670	590	4796
Nesidiocoris tenuis	118	154	90	140	102	132	158	182	86	1162
Bactrocera papayae	10	12	88	92	32	48	42	52	20	396
Helicoverpa armigera	9	10	11	9	10	7	11	9	8	84

Table 2: Pest populations in conventional plots during 9 observations

Species	Sampling number									Number of population (individuals)
	1	2	3	4	5	6	7	8	9	
Liriomyza sativae	452	552	718	850	674	950	972	892	756	6816
Nesidiocoris tenuis	52	80	126	162	104	180	164	80	130	1078
Bactrocera papayae	20	52	12	114	34	14	32	12	42	332
Helicoverpa armigera	8	16	6	10	14	5	13	4	6	82

The four species with average population in each plot, which found at IPM and conventional plots respectively are as follows: *L. sativae* (Diptera: Agromyzidae) 53.29 and 75.73 individuals, *N. tenuis* 12.91 and 11.98 individuals, *Bactrocera* sp. 4.4 and 3.69 individuals, and *H. armigera* 0.93 and 0.91 individuals. Comparison of the average population of insect pests in the two plots can be seen in Table 3.

Table 3: Average population in each plot of important insect pest trapped using YST at both plots

No.	Insect species	Plots	
		IPM (individual)	Conventional (individual)
1.	*Liriomyza sativae*	53,29	75,73
2.	*Nesidiocoris tenuis*	12,91	11,98
3.	*Bactrocera* sp.	4,40	3,69
4.	*Helicoverpa armigera*	0,93	0,91

The most dominant species found at IPM and conventional plots was *L. sativae*. This means that this insect is the predominant insect pest in tomato plantation. This insect was first reported attacking potato plant in West Java in 1995 and since then spread in Java, Bali and Sumatera, but not in North Sulawesi. According to Sembel (2014), this pest was first reported attacking tomato plant in Minahasa district North Sulawesi in 2002. They usually attack tomato plant leaves by mining the leaves and forming long and twisted spiral. By doing so, they damage leaves' tissue and eventually the leaves become dry. When the attack occurs at the time the plants are still young age (1-2 weeks) then the plants will die. Experiment with IPM was able to control population of *L. sativae*. The number of *L. sativae* at IPM plot was less than those at conventional plot. Plastic mulch used on the plot plays an important role in pest control since the beginning of the planting season. Spraying botanical pesticide *D. elliptica* on IPM plot was carried out in a controlled manner when pest populations appear. Meanwhile, the synthetic insecticide was applied in scheduled basis two times a week at conventional plot. However, this method was not effective in controlling *L. sativae*. The fluctuation of insect pest population is shown in Figure 3 and 4. The abundance of pest population in the field is influenced by two factors: intrinsic and extrinsic factors. Intrinsic factor for example resistance of insect pests, whereas extrinsic factors for example environmental factors, which include the existence and adequacy of food, climate, space, competition, natural enemies and the influence of pesticides (Supharta *et al.*, 2003).

Tantowijoyo *et al.* (2010) found that the altitude and temperature factors influence the spread of *L. sativae* at Dieng Plateau Central Java. These insects are not found at an altitude of 1200 m with an average temperature of 20.7°C, but many found at altitudes below 600m. Environment is vital to the development and growth of the population of insects, especially for the purpose of eating and reproduction. The explosion of *L. sativae* population can also be caused by nonselective spraying of insecticides, which may affect the existence of natural enemies (Johnson *et al.*, 1980). Even excessive use of insecticides can make pest insects become resistant to insecticides. The use of botanical pesticides is beneficial for reducing the impact of pollution on the environment. The combination of botanical pesticide and plastic mulch can suppress the population of *L. sativae* (Baideng *et al.*, 2014).

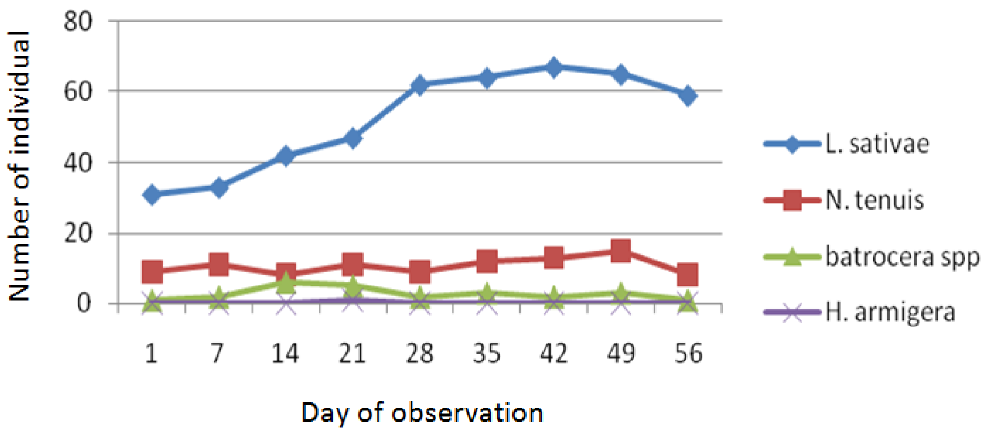

Figure 3: Fluctuation of important insect pest population trapped using YST at IPM plot during 9 weeks observation.

Other pest insects found were not significant in number were *N. tenuis*, *Bactrocera* sp., and *H. armigera*. The population of these insects are found in small amounts of both the IPM plots and conventional plots. This marks the insect population do not jeopardize the tomato plants. *Nesidiocoris tenuis* is an insect pest with dual status, as pests as well as predators (Arno *et al.*, 2010) that attacks stem or stalk of tomato plants. This insect was reported as predator of *Bemisia tabaci* (Calvo *et al.*, 2008) and *Aphis* sp. (Arno *et al.*, 2010). In North Sulawesi, *N. tenuis* can damage tomato plant in certain nature condition (Tulung, 2012). Damage to crops due to *N. tenuis* will increase if the lack of availability of insect prey, thus increasing the feeding activity of the plant (Calvo *et al.*, 2008; Arno *et al.*, 2010). Shridar *et al.* (2012) reported a positive correlation between the minimum temperature and wind speed against *N. tenuis* population on tomato plants.

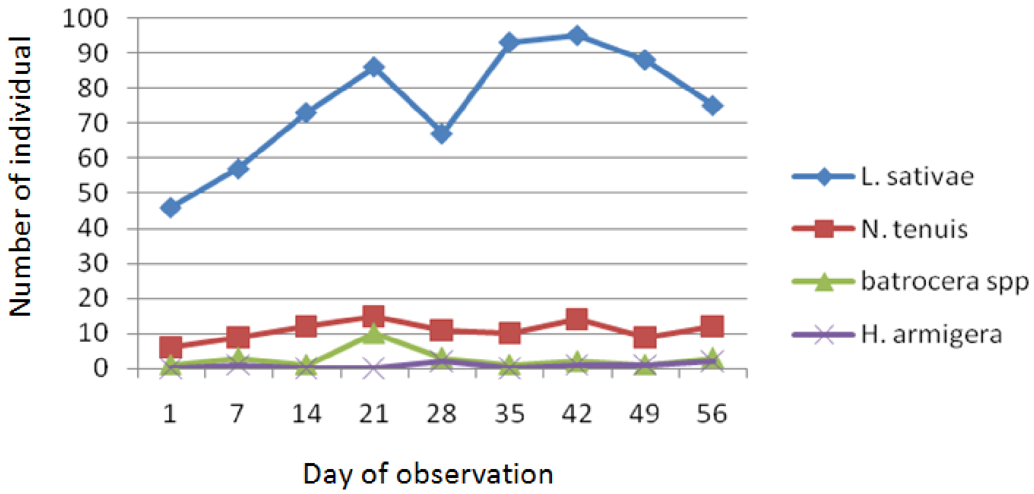

Figure 4: Fluctuation of important insect pest population trapped using YST at conventional plot during 9 weeks observation.

Bactrocera papayae was reported by Manoi (2010) often damaging tomato but the level of attack and the damage is still relatively low. Attacks on young fruit causing fruit to have abnormal shapes, callus and deciduous fruit (Herlinda *et al*., 2007). Intensity of attack of *Bactrocera papayae* increased at cool temperatures, high humidity and low wind blow (Manurung *et al*., 2012). This insect also attacked the banana plant (Siwi *et al*., 2006) and the eggplant (Muryati *et al*., 2008). *Helicoverpa armigera* is polifag pests that can attack several kinds of important crops such as corn, cotton and tomatoes and has a very broad distribution (Sembel, 2014). This insect was reported as a major pest that attacked tomato plants in Bali (Putra, 2013), also became a major pest of maize in Donggala, Central Sulawesi (Khasanah, 2008) and soybean (Siahaan and Maramis, 2014). To conclude, *L. sativae* is the predominant insect pest at both IPM and conventional both. Plastic mulch can suppress the population of *L. sativae*. In addition, the population of pests can be reduced by using botanical pesticide spraying conducted in a controlled manner when pests emerge.

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