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The use of botanical insecticides obtained from local plants to control cabbage leaf webber (*Crocidolomia binotalis*) zeller on cabbage plants

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Abstract. Sustainable agriculture emphasizes the use of botanical insecticides obtained from local plants to control cabbage leaf webber, *Crocidolomia binotalis* Zeller on cabbage plants. The objective of this study was to assess several species of plants for their ability in controlling this destructive pest. The research was conducted at Experimental Garden in Berastagi, from April to September 2017. It was designed using Randomized Block Design (RBD) non-Factorial consisting of 10 treatments with 3 (three) replications. The results revealed that the application of leaf crude extracts of thornapple (*Datura metel*) + tephrosia (*Tephrosia vogelii*) + galangal rhizome (*Alpinia galanga*) (1:1:1) at concentration 20% (E) was more effective in controlling this caterpillar compared to the use of chemical insecticides. The highest average of cabbage production was found in the plants treated with leaf crude extracts of thornapple + tephrosia + galangal rhizome (1:1:1) at concentration 10% (2.85 kg/plot).

1. Introduction

Crocidolomia binotalis Zeller, is one of the main pests in cabbage plants that belonged to family Crambidae, widely known as croci, cabbage head caterpillar or cabbage leaf webber [1]-[3]. They attack plants in groups and they are very destructive. Farmers often control this pest using high-dose synthetic insecticides. Cabbage is one of vegetables that mostly marketed and exported. The intense competition in markets leads producers to provide products required these criteria such as food quality, food safety and environmental quality. Therefore, this leafy vegetable needs to have those three criteria. Sadly, its food safety is still considered low, resulted from the high and continuous use of chemical insecticides [4], [5].

The behavior of using chemical insecticides in high dose could lead pest resurgence, non-target organisms (parasitoids and predators) elimination, secondary pest outbreak and pollution to happen [6], [7]. Regarding to this, there are several efforts to reduce the application of chemicals, for instance the use of botanical insecticides. Botanical insecticides are extracted or derived from plants which display insecticidal properties (biotoxins and secondary metabolites) against pests [8]. Certain plant parts used to make botanical insecticides are seeds, flowers, fruit, stem, skin, leaves and roots to be made into crude extracts. Previous research of Asmaliyah *et al.*, [9] found that the extraction of chemical compound contains in plants is aimed to extract certain components in plants in order to get



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the best botanical insecticides to act as repellent, anti-feedant, digestive system dysfunction, chemosterilant and growth inhibitor [10]. These insecticides can be applied alone, but it would be exhibited better results when it is applied in combination, combining two or more insecticides containing similar active compounds. The application can be done at the same time or with consecutive intake [9].

The use of these medicinal plants and organic waste obtained from the nearest agricultural places as a source to make botanical insecticides is contributed to the reduction of the use of chemicals. In addition, these insecticides are cheaper, safer and environmentally friendly. Several plants that used often in controlling pests were tephrosia (*Tephrosia vogelii*), tobacco (*Nicotiana tabacum* L), tuba root (*Derris elliptica* Benth), galangal (*Alpinia galanga*), thornapple (*Datura metel*) and citronella grass (*Andropogon nardus*) [11]. The objective of this study was to obtain several plant extracts to control cabbage leaf webber.

2. Materials and methods

2.1 Place and duration

This research was carried out at Installation for Research and Assessment of Agricultural Technology (IP2TP) in Berastagi, Sumatra Utara from April to September 2017.

2.2 Materials and tools

Materials used in this research were cabbage seeds, chicken manure, fresh and crude extracts from plants tephrosia (*Tephrosia vogelii*), thornapple (*Datura metel*), tobacco (*Nicotiana tabacum*), galangal rhizome (*Alpinia galanga*), distilled water, detergent and pest feed. Tools used were blender, sieve 100 mesh, termohygrometer, gauze, plastic jars, stationery, etc.

2.3 Data analysis

This research used Randomized Block Design (RBD) non-Factorial, 10 treatments, with 3 (three) replications. The treatments explained as below:

- A = fresh leaf extracts of thornapple + fresh leaf extracts of tephrosia + fresh extract of galangal rhizome (1:1:1) concentration 30%
- B = fresh leaf extracts of thornapple + fresh leaf extracts of tobacco + fresh extract of galangal rhizome (1:1:1) concentration 30%
- C = crude extracts of thornapple + crude extracts of tephrosia + crude extract of galangal rhizome (1:1:1) concentration 20%
- D = crude extracts of thornapple + crude extracts of tobacco + crude extract of galangal rhizome (1:1:1) concentration 20%
- E = fresh leaf extracts of thornapple + fresh leaf extracts of tephrosia + fresh extract of galangal rhizome (1:1:1) concentration 20%
- F = fresh leaf extracts of thornapple + fresh leaf extracts of tobacco + fresh extract of galangal rhizome (1:1:1) concentration 20%
- G = crude extracts of thornapple + crude extracts of tephrosia + crude extract of galangal rhizome (1:1:1) concentration 10%
- H = crude extracts of thornapple + crude extracts of tobacco + crude extract of galangal rhizome (1:1:1) concentration 10%
- I = chemical insecticides
- J = control (application of water only)

Data collected were analyzed using Analysis of Variance (ANOVA) where significant differences were separated using Tukey's Honest Significant Difference Test at probability level 5%.

2.4 Research methods

2.4.1 Preparation of plant extracts. For the fresh extract, the ground-leaves used for botanical insecticides were prepared in the same amount (for instance tephrosia + thornapple + galangal 1:1:1). These ground leaves were then soaked into water (ratio 1:3) for 24 hours. After a day of soaking, the leaves were strained to separate the liquid from the leaves. The liquid then was ready to apply in the research. For crude extract, the leaves were dried in room temperature for 3-4 days and dried leaves then were ground into powder. The powder then was soaked in ethanol 90% (ratio 1:3) for 3 days before being filtrated. The mask then was re-extracted with the same solvent and length of days. The solution was evaporated using rotary evaporator to obtain dry crude extract.

2.4.2 Nursing and transplanting of cabbage seedling. The cabbage seeds were soaked into warm water for 30 minutes, and were dried in room temperature and then were planted into seed tray provided with media (ratio 1:1). The seeds were watered. After 2- weeks of sowing, they were transplanted into the field. The cabbagethen were planted in the plot 1.2 m x 10 m spacing 70 cm between beds, 1 m between treatments and 1.5 m between replications. Dolomites 1-2 kg/m² were applied to the cultivation land. The experiments plots were separated into 3 (three) beds applied with plastic mulch with desired planting space (50 cm x 60 cm).

2.5 Variables observed

2.5.1 Larvae population per plant. Observations on larvae population per plant were carried out at 0-8 weeks after planting

2.5.2 Number of egg per plant. Observations on number of eggs per plant were carried out at two weeks after planting

2.5.3 Attack intensity. The attack intensity was calculated using formula $I = \{(\sum n \times v) \div (Z \times N)\} \times 100\%$, where IS = attack intensity (%), n = number of plant samples at scale v, v = damage scale, N = number of plants observed and Z = highest scale of damage. The scale for damage rates is explained as: 0 (undamaged/healthy), 1 (low damage), 2 (moderate), 4 (high) and 5 (severe) [12].

2.5.4 Wet weight of cabbage yield. Independent 15 sampled plants were harvested at 3 months after planting and were weighed.

3. Results and discussion

3.1 Larvae population per plant

Results in Table 1 described that the pest population appeared on the second week after application and it showed an increase in the number of population week by week. It happened due to high temperature in the field, was about 32 °C, resulted in non-optimal insecticide treatments where this high temperature has caused high evaporation in each treatment. The highest population of *C. binotalis* was found in plants applied with chemicals (5.95 individuals). However, this result was not significant compared to population observed in plants applied with fresh plant extracts of thornapple + tobacco + galangal rhizome at concentration 30% (5.03 individuals) and plants applied with fresh leaf extract of thornapple + fresh leaf extracts of tephrosia + fresh leaf extract of galangal rhizome at concentration 30%. (4.93 individuals). The lowest population was found in plants treated with fresh extract of thornapple + tephrosia + galangal rhizome at concentration 20% (4.00 individuals).

The increase of larvae population in plants treated with both chemical and botanical insecticides might be attributed by the phenomenon of pest resistance resulting from the continuous use of synthetic insecticides. The research of Tarwotjo *et al.*, [13] confirmed that intensive application of synthetic insecticides to control pests in highlands with high doses and short intervals has triggered several serious problems in agriculture, such as pest resistance, pest resurgence and secondary pest

outbreak. Regarding to these conditions, insecticides with recommended doses is essential to be applied in the earliest time, from seedling to harvest.

Table 1. Larvae population on cabbage treated with plant extracts, chemicals, and water.

Treatment	Population of <i>C. binotalis</i> larvae at 0-8 weeks after exposure								
	0	1	2	3	4	5	6	7	8
A (fresh leaf extracts of thornapple + tephrosia + galangal rhizome 30%)	0	0	1.38 d	2.20 d	2.72 e	3.72 d	4.33 d	4.73 d	4.93 d
B (fresh leaf extracts of thornapple + tobacco + galangal rhizome 30%)	0	0	1.29 d	2.0 d	2.66 d	3.62 d	4.43 d	4.80 d	5.03 d
C (crude extracts of thornapple + tephrosia + galangal rhizome 20%)	0	0	1.50 d	2.38 d	2.63 d	3.15 d	3.85 c	4.10 b	4.40 bc
D (crude extracts of thornapple + tobacco + galangal rhizome 20%)	0	0	1.23 c	1.58 c	2.48 b	2.68 c	3.60 b	4.10 b	4.35 b
E (fresh leaf extracts of thornapple + tephrosia + galangal rhizome 20%)	0	0	0.67 a	0.85 a	2.05 a	2.40 a	3.23 a	3.58 a	4.00 a
F (fresh leaf extracts of thornapple + tobacco + galangal rhizome 20%)	0	0	1.05 b	1.32 bc	2.53 bc	2.72 c	3.98 c	4.07 ab	4.52 bc
G (crude extracts of thornapple + tephrosia + galangal rhizome 10%)	0	0	1.11 d	1.24 b	2.50 bc	2.69 cd	3.77 c	4.11 bc	4.50 bc
H (crude extracts of thornapple + tobacco + galangal rhizome 10%)	0	0	0.97 ab	1.53 c	2.53 bcd	2.73 d	3.88 c	4.28 c	4.77 d
I (chemical insecticide)	0	0	0.70 ab	0.12 ab	2.37 ab	2.47 ab	3.95 c	4.35 c	5.95 de
J (water, as control)	0	0	1.95 e	2.45 e	2.77 e	3.97 e	4.62 e	5.88 e	6.55 e
CV	0	0	8.50	15.17	18.08	20.55	22.17	25.50	27.48

Mean values in the same columns followed by the same letters do not differ significantly as determined by Tukey's Honest Significant Difference Test ($\alpha = 0.05$)

Plants thornapple, tephrosia and galangal rhizome contain alkaloid and tannin 0.3-0.4% with main active compounds hyoscyamine and scopolamine [14]. Galangal rhizomes contain about 1% of essential oil. This oil acts as repellent [15]. The research of Binawati and Romsil [16] revealed that extract of thornapple has lowered the population of *Spodoptera exigua*, reached up to 3.77 individuals.

3.2 Number of eggs of *C. binotalis* per plant

The results in Table 2 illustrated that number of eggs of *C. binotalis* per plant appeared on the one week after application and it showed an increase in the number of population week by week. The highest number of eggs was found in plants treated with water (control) is 75.50 eggs, followed by the plants applied with crude extracts of thornapple + crude extracts of tobacco + crude extract of galangal rhizome at concentration 10% is 69.83 eggs. The lowest number was exhibited by the application of fresh extract of thornapple + fresh leaf extracts of tephrosia + fresh extract of galangal rhizome at concentration 20% is 38.10 eggs, followed by the plants applied with crude extracts of thornapple + tephrosia + galangal rhizome 10% is 38.17 eggs. These results indicated that the secondary metabolites from the plant possessed by the plant extracts have caused neurotoxicity, hematotoxicity,

Table 2. Number of eggs of *C. binotalis* on cabbage treated with plant extracts, chemicals, and water.

Treatment	Population of <i>C. binotalis</i> larvae at 0-8 weeks after exposure								
	0	1	2	3	4	5	6	7	8
A (fresh leaf extracts of thornapple + tephrosia + galangal rhizome 30%)	0	2.17 d	7.10 d	17.6 d	25.05 c	37.17 c	45.50 d	56.10 d	65.7 d
B (fresh leaf extracts of thornapple + tobacco + galangal rhizome 30%)	0	2.00 cd	5.50 b	14.17 b	21.67 bc	25.10 ab	38.17 b	38.05 ab	39.0 b
C (crude extracts of thornapple + tephrosia + galangal rhizome 20%)	0	3.09 b	6.83 c	16.17 bc	19.50 bc	25.45 b	39.50 c	40.50 c	49.50 c
D (crude extracts of thornapple + tobacco + galangal rhizome 20%)	0	0.97 b	4.33 a	17.37 c	36.50 d	37.83 c	38.50 b	47.17 c	55.05 c
E (fresh leaf extracts of thornapple + tephrosia + galangal rhizome 20%)	0	0.83 ab	3.50 ab	11.17 ab	19.00 ab	25.00 a	30.17 a	38.10 b	38.10 a
F (fresh leaf extracts of thornapple + tobacco + galangal rhizome 20%)	0	2.10 cd	7.17 d	15.50 b	21.80 b	29.50 b	35.77 ab	49.10 c	55.50 c
G (crude extracts of thornapple + tephrosia + galangal rhizome 10%)	0	1.83 c	4.50 a	17.10 c	20.50 b	30.00 a	36.27 bc	41.50 a	38.17 ab
H (crude extracts of thornapple + tobacco + galangal rhizome 10%)	0	3.05 c	6.10 c	13.50 ab	27.83 b	35.05 c	42.45 d	55.17 d	69.83 d
I (chemical insecticide)	0	0.57 a	3.13 a	10.50 a	18.93 a	29.05 ab	36.50 b	40.10 c	47.67 c
J (water, as control)	0	5.50 e	9.70 e	26.50 e	48.17 e	50.50 d	67.83 e	73.17 e	75.50 e
CV	0	9.17	10.55	13.02	20.74	21.52	24.09	24.72	20.88

Mean values in the same columns followed by the same letters do not differ significantly as determined by Tukey's Honest Significant Difference Test ($\alpha = 0.05$)

hepatotoxicity, dermatotoxicity, oftalmotoxicity, neuphrotoxicity and pneumotoxicity to adults of *C. binotalis* with different mechanisms [17], [18]. These toxicities have affected moth's fecundity.

3.3 Pest attack intensity

The weekly observation showed that the lowest attack intensity was found in plants treated with fresh leaf extracts of thornapple + tephrosia + galangal rhizome at concentration 20% is 16%, followed by the application of crude extracts of thornapple + tephrosia + galangal rhizome at concentration 10% is 17% (Table 3). However, the attack kept increasing every week due to high temperature in the field. The plants treated with water (control) exhibited the highest attack intensity, reached up to 41.11%,

Table 3. Attack intensity of *C. binotalis* on cabbage treated with plant extracts, chemicals and water.

Treatment	Population of <i>C. binotalis</i> larvae at 0-8 weeks after exposure								
	0	1	2	3	4	5	6	7	8
A (fresh leaf extracts of thornapple + tephrosia + galangal rhizome 30%)	0	0.85 d	2.07 d	5.40 d	7.88 d	13.94 d	18.92 d	20.50 d	21.83 d
B (fresh leaf extracts of thornapple + tobacco + galangal rhizome 30%)	0	0.88 d	1.88 c	3.13 c	4.70 c	10.50 c	13.50 b	19.08 c	20.00 c
C (crude extracts of thornapple + tephrosia + galangal rhizome 20%)	0	0.30 b	1.04 b	2.94 b	3.50 b	9.00 b	11.13 b	15.58 b	18.10 b
D (crude extracts of thornapple + tobacco + galangal rhizome 20%)	0	0.75 c	1.22 b	4.83 d	7.47 d	11.83 c	17.25 d	19.42 d	20.75 cd
E (fresh leaf extracts of thornapple + tephrosia + galangal rhizome 20%)	0	0.21 a	0.76 a	2.63 a	3.50 a	8.83 a	10.53 a	15.10 a	16.00 a
F (fresh leaf extracts of thornapple + tobacco + galangal rhizome 20%)	0	0.63b	1.21 b	5.39 d	6.00 d	12.58 cd	15.67 c	19.83 c	21.00 d
G (crude extracts of thornapple+ tephrosia +galangal rhizome 10%)	0	0.21 a	0.76 a	2.63 a	3.50 a	8.83 a	10.53 a	15.10 a	17.00 ab
H (crude extracts of thornapple+ tobacco + galangal rhizome 10%)	0	0.75 c	1.22 b	4.83 d	7.47 d	11.83 c	17.25 d	20.42 d	34.75 e
I (chemical insecticide)	0	0.29 b	0.98 b	2.70 b	3.80 b	9.10 b	12.83 b	15.87 b	18.42 bc
J (water, as control)	0	0.63 b	3.10 d	7.25 d	8.88 d	14.20 d	14.67 d	22.08 d	41.11 f
CV	0	4.78	6.15	11.49	17.05	17.67	21.05	24.50	25.15

Mean values in the same columns followed by the same letters do not differ significantly as determined by Tukey's Honest Significant Difference Test ($\alpha = 0.05$).

followed by the application of crude extracts of thornapple + tobacco + galangal rhizome at concentration 10% is 34.75%.

Insecticidal activities possessed by thornapple, tephrosia and galangal attributed by several secondary metabolites contain in these plants, where thornapple possesses alkaloid, saponin, flavanoid and polyphenol while tephrosia and galangal rhizomes contain rotenones (deguelin, tefrosin and rotenolone) which have caused stimulation to endocrine glands to produce ecdysone hormone contributing to failure in pest metamorphosis. Rotenones act as respiratory poison, inhibiting the transfer of electron NADH-coenzyme ubiquinone reductase (complex I) from the electron transport system in the mitochondria, where this inhibition caused lower ATP production, resulted in cell activity inhibition, which triggered paralysis, where this paralysis happened due to insufficient energy. Insufficient energy experienced by pests could lead them to death [19]-[21]. Previous researches also discover that tephrosia plant contains complex mixture of rotenoids such as rotenone and rotenolone [22], [23] and thornapple plant also contains nicotine and alkaloid [24], [25]. Tank-mixing botanical insecticides can be applied to control several pests at one time as this mixture is more efficient in amount and lower in doses when it is applied compared to the application of insecticide alone.

3.4 Wet weight of cabbage yield

The results indicated that the application of both fresh and crude extracts significantly increased the yield (Table 4).

Table 4. Production of cabbage treated with plant extracts, chemicals and water.

Treatment	Cabbage production	
	Kg/ plant	Kg/plot
A (fresh leaf extracts of thornapple + tephrosia + galangal rhizome 30%)	1.85 c	1.74 c
B (fresh leaf extracts of thornapple + tobacco + galangal rhizome 30%)	2.04 b	1.92 c
C (crude extracts of thornapple + tephrosia + galangal rhizome 20%)	1.92 c	2.05 b
D (crude extracts of thornapple + tobacco + galangal rhizome 20%)	1.83 c	2.55 ab
E (fresh leaf extracts of thornapple + tephrosia + galangal rhizome 20%)	2.56 b	2.85 a
F (fresh leaf extracts of thornapple + tobacco + galangal rhizome 20%)	1.75 c	1.90 b
G (crude extracts of thornapple + tephrosia + galangal rhizome 10%)	2.40 a	2.45 b
H (crude extracts of thornapple + tobacco + galangal rhizome 10%)	1.43 d	1.65 c
I (chemical insecticide)	1.76 c	2.01 b
J (control, water only)	1.50 d	1.60 c
CV (%)	9.17	15.08

Mean values in the same columns followed by the same letters do not differ significantly as determined by Tukey's Honest Significant Difference Test ($\alpha = 0.05$)

The highest weight of cabbage per plant and per plot displayed by plants treated with fresh extracts of thornapple + tephrosia + galangal rhizome at concentration 20%, reached 2.56 kg and 2.85 kg, while the lowest found in plants treated with water (control), 1.50 kg and 1.60 kg. These findings confirmed that the use of botanical insecticides effectively controlled the pests, resulted in an increase of cabbage yield. In comparison with the highest yield treated with botanical insecticides, it increased 1.25 kg/plot and if compared with the plants treated with chemicals, it increased 0.84 kg/plot. These results also are in line with other findings investigated that the use of botanical insecticides has reduced the pest attack, resulted in an increase of quality and quantity of crop plants [25-28].

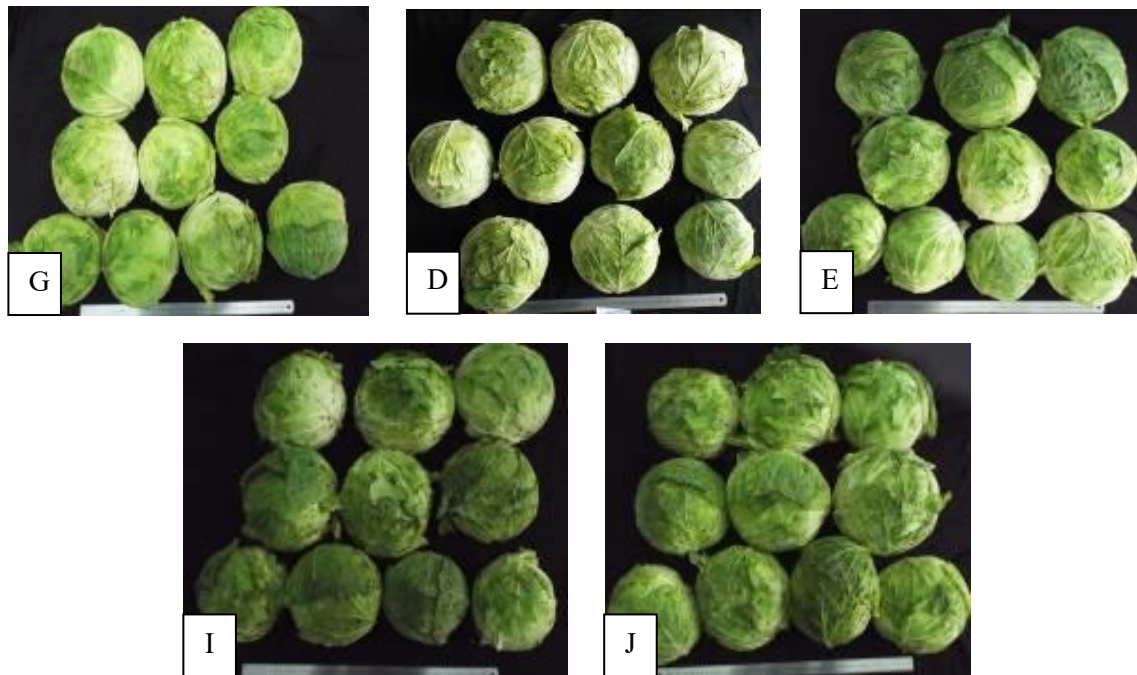


Figure 1. The yield of cabbage as the treatments applied: treatments G, D, E, I and J.

4. Conclusions

The use of botanical insecticides has reduced the pest attack compared to those of on control and chemicals treatments. Eventhough larvae population showed a slight increase week by week, but the population in plants treated with botanical insecticides was lower compared to theplants applied with water (control) and chemicals. The production of cabbage also higher in plants treated with botanical insecticides, where the highest production was demonstrated by the application of fresh extracts of thornapple + tephrosia + galangal rhizome at concentration 20%, reached 2.56 kg and 2.85 kg in each plot.

References

- [1] Amin A, Ibrohim and Tuarita H 2016 *Jurnal Pertanian Tropik* **16** 139-149
- [2] Nailufar N and Prijono D 2017 *Journal of the International Society for Southeast Asian Agricultural Sciences* **23** 102-110
- [3] Mohd B D 2018 *J. Entomol. Res.* **42** 255-258
- [4] Maruli A, Santi D N and Naria E 2013 *Lingkungan dan Keselamatan Kerja* **1** 1-9
- [5] Harahap F S, Atifah Y, Hasibuan I S and Abubakar 2018 *Martabe: Jurnal Pengabdian Masyarakat* **1** 142-148
- [6] Naranjo S E and Akey D H 2005 *Pest Manag. Sci.* **61** 555-566
- [7] Sarwar M 2015 *International Journal of Chemical and Biomolecular Science* **1** 141-147
- [8] Isnaini M, Pane E R and Wiridianti S 2015 *Jurnal Biota* **1** 1-8
- [9] Asmaliyah E E W H, Utami S, Mulyadi K and Yudhistira F W S 2010 *Pengenalan Tumbuhan Penghasil Pestisida Nabati dan Pemanfaatannya Secara Tradisional Dalam Illa Angraeni* (ed.) Kementerian Kehutanan Badan Penelitian dan Pengembangan Kehutanan Pusat Penelitian dan Pengembangan Produktivitas Hutan
- [10] Afifah F 2015 *Lentera Bio: Berkala Ilmiah Biologi* **4** 25-31
- [11] Martono B, Hadipoentyanti E and Udarno L 2004 *Perkembangan Teknologi TRO* **16** 43-57
- [12] Fadillah A, Jumar and Aidawati N 2018 *Proteksi Tanaman Trofika* **1** 25-27
- [13] Tarwotjo U, Situmorang J, Soesilohadi H R C and Martono E 2014 *Jurnal Manusia dan Lingkungan* **21** 202-212

- [14] Baloch A H, Baloch I A, Rehman H, Ahmed I and Ahmed S 2017 *Pure and Applied Biology* **6** 989-1001
- [15] Martinius, Liswarni Y and Iqbal 2010 *Manggara* **11** 18-24
- [16] Binawati D K and Romsil L 2015 *Stigma* **8** 13-16
- [17] Duke S O, Cantrell C L, Meepagala K M, Wedge D E, Tabanca N and Schrader K K 2010 *Toxins* **2** 1943-1962
- [18] Rattan R S and Sharma A 2011 *Indian Journal of Fundamental and Applied Life Sciences* **1** 295-309
- [19] Perry A S, Yamamoto I, Ishaaya I and Perry R 1998 *Insecticides in Agriculture and Environment* (Berlin/Springer)
- [20] Abizar M and Prijono D 2010 *Jurnal Hama dan Penyakit Tumbuhan Tropika* **10** 1-12
- [21] Idris H 2015 *Aspidomorpha miliaris* F. *Jurnal Littri* **21** 41-46
- [22] Aritho N M, Ndungu P K, Inyangala J, Mwangi M, Gicheru M M, Ngeranwa J J N and Anjili C O 2017 *Journal of Pharmacognosy and Phytochemistry* **2** 007-10
- [23] Siame C P, Chitambo H, Muma J B, Choongo K and Moonga E 2019 *Journal of Parasitic Diseases* **43** 624-632
- [24] Nandakumar A, Vaganan M M, Sundararaju P and Udayakumar R 2017 *Meloidogyne incognita* **2** 1-11
- [25] Ally F and Mohanlall V 2020 *Journal of Pharmacognosy and Phytochemistry* **9** 05-13
- [26] Tembo Y, Mkindi A G, Mkenda P A, Mpumi N, Mwanauta R, Stevenson P C, Ndakidemi P A and Belmain S R 2018 *Frontiers in Plant Science* **9** 1-10
- [27] Lengai G M W, Muthomi J W and Mbega E R 2020 *Scientific African* **7** 1-13
- [28] Sudarjat, Kusumiyati, Hasanuddin, Munawar AA 2019 In: IOP Conference Series: Earth and Environmental Science. Institute of Physics Publishing.