Application of the combination of Calontropis gigantea L. and Crescentia cujete L. against Schirpophaga innotata and Leptocorisa acuta Thunb. and predator in paddy plants

P A Palayukan1, S Sjam1, Melina1, Sulaeha1, A Rosmana1, V S Dewi1 and Budirman2

1 Department of Plant Pests and Diseases, Faculty of Agriculture, Hasanuddin University, Makassar, Indonesia
2 Department of Horticulture, Crops, and Oil, Institution of Crops Protection and Horticulture The South Sulawesi Province, Indonesia

E-mail: sylviasjam@yahoo.com

Abstract. C. gigantea L. and C. cujete L. are plants that contain secondary metabolites that can act as insecticides. This study aimed to evaluate the implications of C. gigantea and C. cujete to reduce the population and intensity of attack by stem borer (S. innotata) and stink bug (L. acuta) which are the main pests of paddy plants. This study consisted of 4 treatments consisting of a mixture of C. gigantea and C. cujete extracts, C. gigantea extracts, C. cujete extracts, and control with 5 replications. The extract made by fermentation ant the extract was applied at the age of 1 month after planting with a concentration of 5% for 8 times with a frequency of 1 time a week. Observation parameters were population and attack intensity of S. innotata and L. acuta as well as natural enemy population. The results obtained were that the treatment of all extracts could reduce the population and intensity of attacks compared to the control. Treatment of the mixture of C. gigantea and C. cujete extracts can reduce the population and the intensity of attacks is higher than without the mixture. Predator is not affected by extract applications.

1. Introduction
Paddy (Oryza sativa L.) is a very important food crop commodity in Indonesia. Paddy as a food crop is consumed by approximately 90% of the total population of Indonesia as a daily staple food [1]. Badan Pusat Statistik (BPS) in 2020 noted that rice production in 2019 was 31.31 million tons, down 7.75% from the previous year's production of 33.94 million tons. The decline in rice production occurred due to lower yields.

Efforts to increase rice production are faced with several obstacles and problems, one of which is pest attacks. Until now, pests are still an obstacle for farmers. Almost every season there is an explosion of pests in rice cultivation. Some of the main pests that attack rice plants are the stem borer (S. innotata) and stink bug (L. acuta) [2]. Symptoms of S. innotata attack are in the vegetative phase called deadhearts with symptoms of dead young plant growth points. Symptoms of borer attack in the generative phase are called whiteheads, with dead panicles with hollow spikes that appear white [3]. The larvae attack by drilling the rice stalk and perforating the stem completely [4]. Whereas L. acuta is a pest that damages rice plants when it reaches its mature flowering phase [5]. L. acuta attacks rice plants after flowering by sucking the liquid of rice grains causing the rice grains to become hollow or incomplete filling.

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.
Published under licence by IOP Publishing Ltd
Symptoms of the attack caused by *L. acuta* are black spots due to the puncture, the sucked panicles become hollow and blackish-brown in color [6].

The most common way for farmers to control pests is to use pesticides [7]. The view of the general public in the world, including in Indonesia, says that the more pesticides used, the better because agricultural production is high [8]. Pesticides are made from chemicals and are widely used by farmers because rice that is not protected by pesticides can reduce yields by 40% according to a study by the International Rice Research Institute (IRRI) [9].

The number of problems arising from synthetic pesticides can be reduced by implementing integrated pest management (IPM) [2]. To support the IPM concept to reduce the use of synthetic pesticides is to use bioactive materials such as natural pesticides and the use of natural enemies [10]. The wide variety of biodiversity in Indonesia means that many plants available in Indonesia are rich in active ingredients, including secondary metabolites whose function in plant growth is less clear. However, secondary metabolites can function to interact and protect themselves today’s herbivores. Secondary metabolites can also be used as active ingredients in natural insecticides [11].

One of the plants that can be used as raw material for natural pesticides is *C. gigantea* [12, 13]. *C. gigantea* is reported to have analgesic, antimicrobial, anti-inflammatory, antioxidant, insecticidal, cytototoxic, and hepatoprotective activity [14]. Phytochemical screening of the crude extract of *C. gigantea* leaves showed the presence of phenolic compounds, flavonoids, alkaloids, tannins, saponins, glycosides, and phytosterols [15]. In addition, *C. gigantea* leaves are repellant and reduce feeding activity leading to early death [16]. Another plant that can be used as raw material for natural pesticides is *C. cujete* [17, 18]. The chemical content in the flesh of *C. cujete* fruit includes alkaloids, flavonoids, and tannins [19]. The active compounds in *C. cujete* have anti-exudative and inflammatory properties that cause this plant to have a bitter taste so it is disliked by insect pests [20].

This study aimed to evaluate the implications of *C. gigantea* and *C. cujete* to reduce the population and intensity of stem borer (*S. innotata*) and stink bug (*L. acuta*) which are the main pests of rice plants.

### 2. Materials and methods

#### 2.1. Location

This research was conducted at the Laboratory of Natural Pesticides, Faculty of Agriculture, Hasanuddin University, Makassar and Purnakarya Village, Tanralili District, Maros Regency. The research took place from June 2020 to October 2020.

#### 2.2. Experimental design

This research was conducted at the Laboratory of Natural Pesticides, Faculty of Agriculture, Hasanuddin University, Makassar and Purnakarya Village, Tanralili District, Maros Regency. The research took place from June 2020 to October 2020.

#### 2.3. Extract fermentation of *C. gigantea* and *C. cujete*

The parts of *C. gigantea* taken were the leaves and petioles, while the parts of *C. cujete* taken were the flesh. *C. gigantea* leaves that are used as fermented extracts are green leaves that are not defective and then dried. After that, each materials are chopped using a chopping machine and then put into the container. Each fermentation extract is then added water and molasses with ratio material:water:molasses is 1:1:0.2. The ingredients that have been mixed are then stirred until blended then the container is closed tightly. Let stand for ± 2 weeks. After that, the fermented extract is filtered to separate solid and liquid materials. The fermented extract is then put into a container.

#### 2.4. Land preparation

The land used as the research area was made plots of treatment with a size of 3 x 3 meters, 25 plots with a distance of 2 meters between the plots.
2.5. Extract fermentation applications
The fermentation extract was applied by spraying the rice plants 31 days after planting and subsequent applications were carried out at 1-week intervals. The fermentation extract was sprayed according to the treatment with a concentration of 5%.

2.6. Observation
Initial population observations were carried out at 32 days after planting and observations were made every week. Observations were made on 5 subplots in each replicate plot. Each subplot was observed using 2 methods, namely the visual method by directly looking at the pest population at 2 rice clumps (10 clumps each plot) and the sweep net method by swinging the net 8 times. Population observations were carried out in the morning.

2.7. Observation parameters

2.7.1. The average population of main pests and natural enemies. Observation of average population were carried out by calculating the number of populations of main pests and natural enemies in each clump sample. The formula used to calculate the main pests and natural enemies are:

\[ P = \frac{a}{b} \]  
(1)

2.7.2. Attack intensity of the main pest. Observation of attack intensity was carried out by calculating the intensity of the main pest attack in each clump. The formula used to calculate the intensity of stem borer (\textit{Scirpophaga innotata}) [21] is:

\[ \text{Attack Intensity} (\%) = \frac{\sum \text{tillers symptomatic of deadhearts / whiteheads}}{\sum \text{number of tillers}} \times 100\% \]  
(2)

While the formula used to calculate the intensity of stink bug attacks on each clump [22] is:

\[ I = \frac{n}{N} \times 100\% \]  
(3)

2.8. Data analysis
The data obtained were then analyzed using analysis of variance (ANOVA) using the F test at \( \alpha \) 0.05 and 0.01 levels. Further test using the LSD test.

3. Results

3.1. Average population of \textit{S. innotata} dan \textit{L. acuta}
Population observations of \textit{S. innotata} and \textit{L. acuta} were carried out by observing the population directly in the field and the sweep net. In direct population observations in the field, it was done by looking at the larvae and adults (\textit{S. innotata}) and nymphs and adults (\textit{L. acuta}) phases. The average population of \textit{S. innotata}, it can be seen that the highest population was at 39 DAP or the second application. After that, the population decreased from 46 DAP to 74 DAP and the population was not found at 81 DAP. The population of \textit{S. innotata} in the control treatment was higher than the combination treatment, \textit{C. gigantea} extract, and \textit{C. cujete} extract, except at 32 DAP. Meanwhile, the combination treatment was lower than the treatment without being combined (figure 1).

The average population of \textit{L. acuta}, it can be seen that population has started to appear at 46 DAP but not too many. The new population begins to grow when plants are 60 DAP and increases to 74 DAP and then decreases at 81 DAP. The population of \textit{L. acuta} in the control treatment was higher than the combination treatment, \textit{C. gigantea} extract, and \textit{C. cujete} extract. The combination treatment was lower than the treatment without being combined (figure 2).
3.2. Attack intensity of *S. innotata* and *L. acuta*

Observation of the attack intensity of *S. innotata* was carried out by counting the number of tillers that were attacked and the number of tillers who were not attacked in each clump. Meanwhile, the observation of *L. acuta* attack intensity was carried out after harvesting by counting the number of infected ears and the number of unaffected ears in each clump.

The attack intensity percentage of *S. innotata*, it can be seen that the attack intensity fluctuates from 32 DAP to 74 DAP and the attacks do not appear at 81 DAP. The highest percentage of attack intensity at 39 DAP or in the second application. This is in line because the population of *S. innotata* is the largest at 39 DAP. The attack intensity in the control treatment was higher than the combination treatment, *C. gigantea* extract, and *C. cujete* extract. The combination treatment was lower than the treatment without being combined (figure 3).
The attack intensity percentage of *L. acuta*, it can be seen that the control treatment was higher than the combination treatment, *C. gigantea* extract, and *C. cujete* extract. Then consecutively, *C. gigantea* extract, *C. cujete* extract, and combination extract. In the control treatment (36.53%) and *C. gigantea* extract (29.13%) were included in the moderate attack category, while in the treatment of *C. cujete* extract (21.84) and combination extract (18.34) were included in the category of mild attack (figure 4).

3.3. Average population of natural enemies

Observation of the population of natural enemies (*Coccinella* sp. and spiders) was done by observing the population directly in the field and by the sweep net. To observe the population of *Coccinella* sp. directly in the field, done by looking at the larvae and adult phases.

The average population of *Coccinella* sp., it can be seen that the population fluctuates from 32 DAP to 81 DAP. The population of *Coccinella* sp. at 74 DAP for each treatment (figure 5). fThe average population of spider, it can be seen that the population fluctuates from 32 DAP to 60 DAP, then decreases to 81 DAP. The control treatment was not significantly different from the combination treatment, *C. gigantea* extract, and *C. cujete* extract on each natural enemies (figure 6).

4. Discussion

*S. innotata* appeared during the vegetative period of rice at 32 DAP. The population peaked at 39 DAP then decreased gradually. *L. acuta* started appearing on 46 DAP then its population increased until it peaked on 74 DAP. *L. acuta* population decreased at 81 DAP after reaching the milk maturity phase. *S. innotata* and *L. acuta* populations are closely related to food sources [23]. *S. innotata* infest rice in the vegetative stage causing the death of tillers and at the generative stage causing empty panicles [24]. While *L. acuta* infested rice in the mature phase of milk which caused the grain to become hollow or imperfect [6].

The population of *S. innotata* and *L. acuta* is also caused by environmental factors. Sanitation was not carried out in the vicinity of the research location so that many weeds grew so that insect pests had an alternative host around the rice plant as a place for breeding [6]. In addition, around the research location, there were also rice plants that were planted earlier than the rice plants found in the research location. This causes the migration of insect pests from rice plants that are harvested earlier to rice plants at the research location because insect pests follow the growth phase of rice plants [25, 26].
C. gigantea has various types of secondary metabolites, namely phenols, flavonoids, alkaloids, tannins, saponins, glycosides, phytosterols [15], and cardenolides [27]. Phenol is directly toxic to insects and acts as a food retardant [28, 29, 30]. Glycosides and flavonoids are stomach poisons that work when these compounds enter the insect's body, they will disrupt the insect's digestive organs [31]. Research from [16] states that cardenolides is ovicidal in vitro and cause the nymphs that hatch from eggs to be abnormal.

C. cujete contains secondary metabolites such as alkaloids, flavonoids, and tannins in the pulp [19]. Tannins are compounds that have a bitter taste and can bind to insect protein and digestive enzymes and precipitate them through hydrogen or covalent bonds, thus limiting their availability to insect pests and ultimately reducing insect growth and development [30]. Tannins also affect insects in terms of oviposition. In addition, tannins also have flavonoid compounds that can inhibit leucine amino acid transport and are toxic to insects [5].

The results showed that the average population (figure 1 and 2) and attack intensity of insect pests (figure 3 and 4) in the combination treatment were lower than the unmixed treatment. Individual plant compounds may have no or only weak effects when tested separately, but they may exhibit strong biological activity when part of the combination [32, 33]. Synergy is the combined effect of compounds in a combination that is greater than the sum of the effects for individual compounds acting in isolation [34].

The natural enemy population is Coccinella sp. (figure 5) and spiders (figure 6) do not affect various types of treatment. This causes these natural enemies to control insect pests in rice plants. Predators populations usually increase with the increase in insect pest populations [35]. Coccinella sp. usually found in panicles [36]. Based on their habitat, Coccinella sp. tend to prey on insect pests that exist in their favorite habitat and do not suppress only certain insect pests [37]. Research by [38] stated that Lycosa terrestris and Pardosa birmanica spiders prefer insects in the order Homoptera, while Oxypes javanus spiders prefer lepidopteran insects. Research by [39] stated that a diverse set of predators was more effective in controlling moths, which have multiple growth phases (holometabola), compared to leafhoppers which have nymphs that are almost adult forms (hemimetabola).

Population of natural enemies fluctuated according to the time of observation. This is following the results of research by [40] stated that the spider population fluctuates with the day after planting (DAT) where Lycosa pseudoannulata and Oxypes javanus are highest during the initial growth stage from 40 DAP to 60 DAP, whereas Tetragnatha javana, Argiope catenulate and Neoscona bengalenisis are dominant at 80 DAT until done. This is also following the research results of [41] which stated that the population of Coccinella sp. fluctuated then increased at 70 DAP, while the spider population fluctuated up to 60 DAP then decreased at 80 DAP.

5. Conclusion

The use of natural ingredients as natural pesticides is one way to control pests. Apart from controlling pests, natural pesticides also do not pollute the environment and are not harmful to human health. The control of S. innotata and L. acuta using natural pesticides with extracts of C. gigantea and C. cujete was proven effective. The combination treatment proved to be more effective than the treatment of C. gigantea and C. cujete extracts in controlling the population and attack intensity of S. innotata and L. acuta. The population of natural enemies was not affected by extract treatment.

References

[1] Donggulo C V, Lapanjang I M and Made U 2017 Growth and yield of rice (Oryza sativa L.) under different jajar legowo System and planting space J. Agroland 24 27-35

[2] Effendi B S 2009 Strategi pengendalian hama terpadu tanaman padi dalam perspektif praktek pertanian yang baik (good agricultural practices) Pengembangan Inovasi Pertanian 2 65-78
[3] Ramadhan M B, Sudirata I P, Wijaya I N and Sumiartha I K 2020 Effect of the attack of rice steam borer to rice yields (*Oryza sativa* L.) in Subak Cemagi Let, Cemagi Village, Mengwi District, Badung Regency *J. Agroekoteknologi Tropika* 9 106-114

[4] Sarwar M 2011 Effects of Zinc fertilizer application on the incidence of rice stem borers (*Scirpophaga* species) (Lepidoptera: Pyralidae) in rice (*Oryza sativa* L.) crop. *J. Cereals and Oilseeds* 2 61-65

[5] Sjam S 2006 Pemanfaatan ekstrak buah maja dengan EM4 terhadap penggerek buah kakao *Conophomorpha cramerella* Snellen (Lepidoptera: Gracillariidae) *Buletin Penelitian* 9 18-23

[6] Pratimi A, and Soesilohadi R C H 2011. Population fluctuation of rice bug *Leptocorisa oratorius* F. (Hemiptera : Alydidae) on paddy community, in Kepitu Village, Sleman, Daerah Istimewa Yogyakarta *BIOMA* 13 54-59

[7] Balleras G D 2012 Development of Appropriate Diagnostic Tool and IPM Options for Mindanao condition. *Philippine Rice R and D Highlights* (Nueva Ecija: Philippine Rice Research Institute)

[8] Arif A 2015 Pengaruh bahan kimia terhadap penggunaan pestisida lingkungan *JF UIK UINAM* 3 134-143

[9] Cabasan M T N, Tabora J A G, Cabatag N N, Jumao-as C M and Soberano J O 2019 Economic and ecological perspectives of farmers on rice insects pest management. *Global J. Environmental Science and Management* 5 31-42

[10] Praditya N Y and Syafrial 2017 Analysis of the factors of rice farmers purchase decision on product natural pesticide *J. Ekonomi Pertanian dan Agribisnis* 1 108-118

[11] Kardinan A 2011 Penggunaan pestisida nabati sebagai kearifan lokal dalam pengendalian hama tanaman menuju sistem pertanian organik *Pengembangan Inovasi Pertanian* 4 267-278

[12] Mayasari S L 2016 Pemanfaatan Getah Biduri (*Calotropis gigantea*) dan Buah Lerak (*Sapindus rarak*) sebagai Pestsida Nabati Pembasmi Keong Mas (*Pomacea canaliculata*) (Surakarta: Universitas Muhammadiyah Surakarta)

[13] Devi N I, Nelson S J and Kannan M 2018 Effect of *Calotropis gigantea* (L.) W.T. Aiton on pink mealybug, *Maconellicoccus hirsutus* (Green) (Hemiptera: Pseudococcidae). *J. Entomol. Res.* 42 503-506

[14] Sarkar S, Chakraverty R, and Ghosh A 2014. *Calotropis gigantea* Linn: A complete busket of indian traditional medicine. *Int. J. Pharm. Res. Sci.* 2 7-17

[15] Kumar P S, Suresh E, and Kalavathy S 2013 Review on a potential herb *Calotropis gigantea* I (L.) R. Br. *Sch. Acad. J. Pharm.* 2 135-143

[16] Sjam S and Sari D E 2017 Efek repellent ekstrak *Calotropis gigantea* R. Br. Terhadap *Paraeucosmetus pallicornis* Dallas *J. Agrominions* 2 103-109

[17] Purwani K I, Ermavitilini D, Nurhidayati T, Nurhatika S and Bagus T 2015 Exploration of potential plants as a bio-insecticide at its Surabaya campus *KnowledgeE Publishing Services* 2 662

[18] Safirah R, Widodo N and Budiyanto M A K 2016 Effectiveness botanical insecticides *Crescentia cujete* fruit and flowers *Syzygium aromaticum* mortality against *Spodoptera litura* in vitro as a learning resource biology *J. Pendidikan Biologi Indonesia* 2 263-276

[19] Ogbuagu M N 2008 The nutritive and anti nutritive compositions of calabash (*Crescentia cujete*) fruit pulp *J. Anim. Vet. Adv.* 7 1069-1072
[20] Rismayani 2013 Manfaat buah maja sebagai pestisida nabati untuk hama penggerek buah kakao (Conopomorpha cramerella) Warta Penelitian dan Pengembangan Tanaman Industri 19 24-26
[21] Aryantini L T, Suparthar I W and Wijaya I Y 2015 Kelimpahan populasi dan serangan penggerek batang padi pada tanaman padi di Kabupaten Tabanan J. Agroekoteknologi Tropika 4 203-212
[22] Direktorat Perlindungan Tanaman Pangan 2018 Petunjuk teknis pengamatan dan pelaporan organisme pengganggu tanbhuan dan dampak perubahan iklim (OPT-DPI) (Jakarta: Kementerian Pertanian, Direktorat Jenderal Tanaman Pangan)
[23] Makmur A A H, Sjam S and Rosmana A 2016. Control of white stem borer Schirrophaga innotata Walker and earhead bug Leptocorisa oratorius Fabricius by using formulated Calotropis gigantea linn extract in rice field. Res. J. Pharm. Biol. Chem. Sci. 7 3012-3018
[24] Suharto H and Usyati N 2005 The stem borer infestation on rice cultivars at three planting times. Indonesian J. Agricul Sci 6 39–45
[25] Rauf A 2010 Ekspedisi hitam di Sulawesi Utara. Buletin Peramalan OPT. Jatisari- Jawa Barat.
[26] Kaparang C L, Pealeau J and Salaki C L 2011 Population and attacking intensity of Paraeucostraeus pallicornis in South Minahasa Regency Eugenia 17 171-178
[27] Kumar G, Karthik L and Rao K V B 2011 A Review on Pharmacological and Phytochemical Profile of Calotropis gigantea Linn Pharmacology online 1 1-8
[28] Atteyat M, Abu-Romann S, Abu-Darwish M, and Ghabeish I 2012 Impact of flavonoids against woolly apple aphid, Eriosoma lanigerum (Hausmann) and its sole parasitoid, Aphelinus mali (Hald.) J.Agricult. Sci. 4 227–236
[29] Dixit G, Praveen A, Tripathi T, Yadav V K, and Verma P C 2017 Herbivore responsive cotton phenolics and their impact on insect performance and biochemistry J. Asia-Pacific Entomol. 20 341–351
[30] War A R, Taggar GK, Hussain B, Taggar M S, Nair R M and Sharma H C 2018 Plant defence against herbivory and insect adaptation AoB PLANTS 10 1-19
[31] Sinaga R 2009 Uji efektivitas pestisida nabati terhadap hama Spodoptera littura pada tanaman tembakau (Medan: Universitas Sumatera Utara)
[32] Richards L A, Glassmire A E, Ochsenrider K M, Smilanich A M, Dodson C D and Jeffrey C S 2016 Phytochemical diversity and synergistic effects on herbivores Phytochem. Rev. 15 1153–1166
[33] Slinn, H L, Richards L A, Dyer L A, Hurtado P J and Smilanich M A 2018 Across multiple species, phytochemical diversity and herbivore diet breadth have cascading effects on herbivore immunity and parasitism in a tropical model system. Front. Plant Sci. 9 656
[34] Dyer L A, Dodson C D, Stireman J O, Smilanich A M, Fincher R M and Letourneau D K 2003 Synergistic effects of three Piper amides on generalist and specialist herbivores. J. Chem. Ecol. 29 2499–2514
[35] Gangurde S 2007 Above ground arthropod pest and predator diversity in irrigated rice (Oryza sativa L.) production systems of the Philippines J. Trop. Agricult. 45 1-8
[36] Shailaja B, Mishra I and Mishra B K 2014 Biodiversity of coccinellid predators in different crop ecosystems of Odisha Environ. Ecol. 32 1730-1733
[37] Anitha G 2016 Abundance and Diversity of Spider and Coccinellid Predators and Their Impact Analysis on Major Pest in Varied Rice Systems (Hyderabad: Profesor Jayashankar Telangana State Agricultural University)
[38] Tahir M and Butt A 2009 Some new species of family Lycosidae from agricultural fields on Punjab, Pakistan Pakistan J. Zool. 38 185-189

[39] Wilby A, Villareal S C, Lan L P, Heong K L and Thomas M B 2005 Functional benefits of predator species of diversity depend on prey identity Ecol. Entomol. 30 497-501

[40] Borkakati R N, Saikia D K and Buragohain P 2018 Natural enemy fauna of paddy and horticultural ecosystems in Upper Assam Indian J. Entomol. 80 658-661

[41] Thamrin N T and Mursalat A 2020 Population of natural enemies in three varieties of rice plants in Turikale Subdistrict, Maros District Agrotech J. 5 47-51