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Diversity of Soil Surface Arthropods on Shallots Plants (*Allium ascalonicum* L.) Applied by Several Botanical Pesticides In Peatlands

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Abstract

To overcome the pest insects problems in shallots, farmers still use chemical pesticides with a lot of negative impacts, so they are offered the use of botanical pesticides such as Kepayang (*Pangium edule*) seeds, Kirinyu (*Chromolaena odorata*) leaves and Galam (*Melaleuca leucadendron*) leaves as an alternative environmentally-friendly control. This study aims to determine whether botanical pesticides applied to shallot plants affect the diversity of arthropods on the soil's surface and identify what types of arthropods are found in shallot cultivation in shallot cultivation peatlands. This research was conducted from April-August 2019. The research was carried out in Tegal Arum village, Landasan Ulin District, Banjarbaru City, South Kalimantan. The method used was an experimental method with a Randomized Block Design (RBD), one factor with five treatments and 4 replications. The variables observed were diversity index, evenness index, species wealth index & dominance index and arthropod types. The results showed a diversity of arthropod species from highest to lowest, namely in the treatment of Kepayang seed extract (2.03), Galam leaf extract (2.00), Kirinyu leaf extract (1.80), Chemical Pesticides (active ingredient Monosultap) of (0.78) and control (2.31). Arthropods were found in as many as 19 species from 10 orders. Four species act as pests, one species as a vector and the others as predators and decomposers.

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Introduction

Shallots (*Allium ascalonicum* L.) belong to the category of horticultural crops that have high economic value. An important constraint in the process of shallot production is the attack of pest organisms, especially from the arthropod phylum such as leaf feeders and thrips (*Thrips tabaci*) (Wibowo, 2006).

Arthropods are detrimental to plants and some are beneficial, so the use of chemical pesticides to control plant pests needs attention. It must be ensured not to harm beneficial organisms such as an arthropod, including natural enemies. Not all cases of pest attacks can be overcome with pesticides; some reported damage cannot be handled (Oka, 2005). Therefore this study wants to examine whether the use of botanical pesticides to control pests and diseases on shallots will affect the presence of arthropods in the shallot crop.

Materials and methods

The study was conducted from April-August 2019. The research was carried out in Tegal Arum village, Landasan Ulin District, Banjarbaru City, South Kalimantan and at the FMIPA ULM Basic Laboratory for the extraction of botanical pesticides as well as at the Laboratory of Agroecotechnology Production at the Faculty of Agriculture, Lambung Mangkurat University, Banjarbaru. For arthropod identification. Arthropod identification is made by reference to the book Key to Insect Determination (Lilies, 2017) and Pests of crops in Indonesia (Kalshoven, 1981). The study used a one-factor Randomized Block Design (RBD), which consisted of five treatment levels with four replications so that there were 20 experimental units. Pesticide treatment factors used: P_0: Control Treatment, P_1: 2 mL Chemical pesticides Active ingredient Monosultap L^{-1}, P_2: 1 mL Kirinyu extract L^{-1}, P_3: 1 mL Kepayang extract L^{-1}, P_4: 1 mL Galamextract L^{-1}. The parameters observed were abundance and type of arthropods. Arthropod sampling in the field using three pitfall traps every treatment and placed according to a diagonal pattern. Arthropod sampling was carried out six times, namely once before planting and after that, sampling was done once a week as much as five times at intervals of three days after the application of botanical pesticides. The formula calculates species diversity.

$$H' = -\sum_{i=1}^{S} Pi \ln Pi$$

H′= Shannon-Wiener Species Diversity Index & Pi=The number of individuals of species/total number of species (∑ni/N)

Calculation of species wealth using the Margalef type wealth index formula (Margalef, 1958 in Pranata, 2018), as follows

$$R = \frac{(S-1)}{\ln N}$$

R= Index of species richness according to Margalef
S= The whole type of arthropods
N= The total number of organisms of all species

For evenness of species used is Pielou entanglement index (Pielou, 1966 in Annam and Nur, 2017), with the formula

$$E = \frac{H'}{\ln S}$$

E = The evenness of species
H' = Index of species diversity
S = The whole type of arthropods

Index of Dominance (D) according to Simpson (Southwood, 1978 & Ludwig &Reynold, 1988), with the formula

$$D = \sum_{i=1}^{Sobs} \left(\frac{ni}{N}\right)^2$$

D= Index of dominance
ni= The total number of species i
N= The total number of organisms of all species

Results and discussion

Diversity of Soil Surface Arthropods (H′)

Arthropod diversity (H') in shallot plantations has different levels of diversity with the application of some Botanical pesticide treatment on peatlands. The highest level of diversity lies in the control treatment with a moderate diversity index, while the lowest level of diversity lies in the planting of shallots that are applied with chemical pesticides with active ingredients Monosultap. Based on further tests using the Duncan Multiple Range Test, the planting of shallots which became a control plot, was significantly different compared to the other treatments. In plots that are not applied with both plant and synthetic pesticides, they have a higher diversity index compared to shallot plantations which are applied with synthetic pesticides and botanical pesticides derived from Kirinyu leaf extracts. However, the diversity index of arthropods in plants applied with botanical pesticides derived from Kirinyu extracts, plantations applied with botanical pesticides derived from kepayang extracts and plantations applied with botanical pesticides derived from Galam leaf extracts did not show significant differences (Fig. 1).

Table 1. Types of arthropods found in shallot plantations applied with three types of vegetable pesticides.

Ordo	Family	Species	Category	Treatment plot
Orthoptera	Gryllidae	*Teleogryllus commodus*	Pest	Control, Chemical pesticide, Chirinyu extract, kepayang extract, galam extract
	Acrididae	*Heteropternis obscurella*	Vector	
	Blatidae	*Blattella germanica*	Predator	
Hymenoptera	Formicidae	*Azteca instabilis*	Predator	Control, Chemical pesticide, Chirinyu extract, kepayang extract, galam extract
		Dolichoderus thoracicus	Predator	
Hemiptera	Nepidae	*Laccotrephe spfeiferiae*	Predator	Chirinyuextract
Coleoptera	Scarabaeidae	*Scarabae ussacer*	Decomposer	Control, Chemical pesticide, Chirinyu extract, kepayang extract, galam extract
	Carabidae	*Mochterus tetraspilotus*	Predator	
	Chrysomelidae	*Pleuraltica cyanea*	Predator	
Spirobolida	Trigoniulidae	*Trigoniulus corallinus*	Decomposer	Control, Chemical pesticide, Chirinyu extract, kepayang extract, galam extract
Homoptera	Delpacidae	*Sulix tasmani*	Decomposer	Control,Chirinyu extract, kepayang extract
Diplura	Campodeidae	*Campodea staphylinus*	Decomposer	Control, kepayang extract, galam extract
Aracnida	Clobionidae	*Clobiona sp.*	Predator	Control, Chemical pesticide, Chirinyu extract, kepayang extract, galam extract
	Gnaphosidae	*Agelenaca byrinthica*	Predator	
	Flubionidae	*Sirachantium* sp.	Predator	
Lepidoptera	Noctuidae	*Spodoptera litura* F.	Pest	Control, kepayang extract
Diptera	Tipulidae	*Nephrotoma*	Pest	Control, Chemical pesticide, Chirinyu extract, kepayang extract, galam extract
	Drosophilidae	*Drosophila melanogaster*	Pest	
	Asilidae	*Lephria macquarti*	Predator	

The highest species diversity was in the Control treatment of 2.31. This is due to the peatland area used as the site of this study never using chemicals to control plant-disturbing organisms so that the ecosystem is not disturbed. A uniform population of a single species of plants adapted to a particular environment is more at risk of environmental changes occur. A more diverse population consisting of many species of plants has a better chance of including individuals that might be able to adapt to changes in the environment. The treatment of chemical pesticides with active ingredients Monosultap has the lowest level of arthropod species diversity, which is 0.78 with a low diversity index (Fig.1) compared to other botanical pesticide treatments. This is due to the chemical content exposed to peat areas that can reduce the diversity of arthropod species. According to Herlinda *et al.* (2008), the use of chemicals in the processing of agricultural land can cause exposure of these materials in the environment, which causes certain arthropod species to die or leave the place. This can result in an abundance and diversity of arthropods that are applied to synthetic insecticides below.

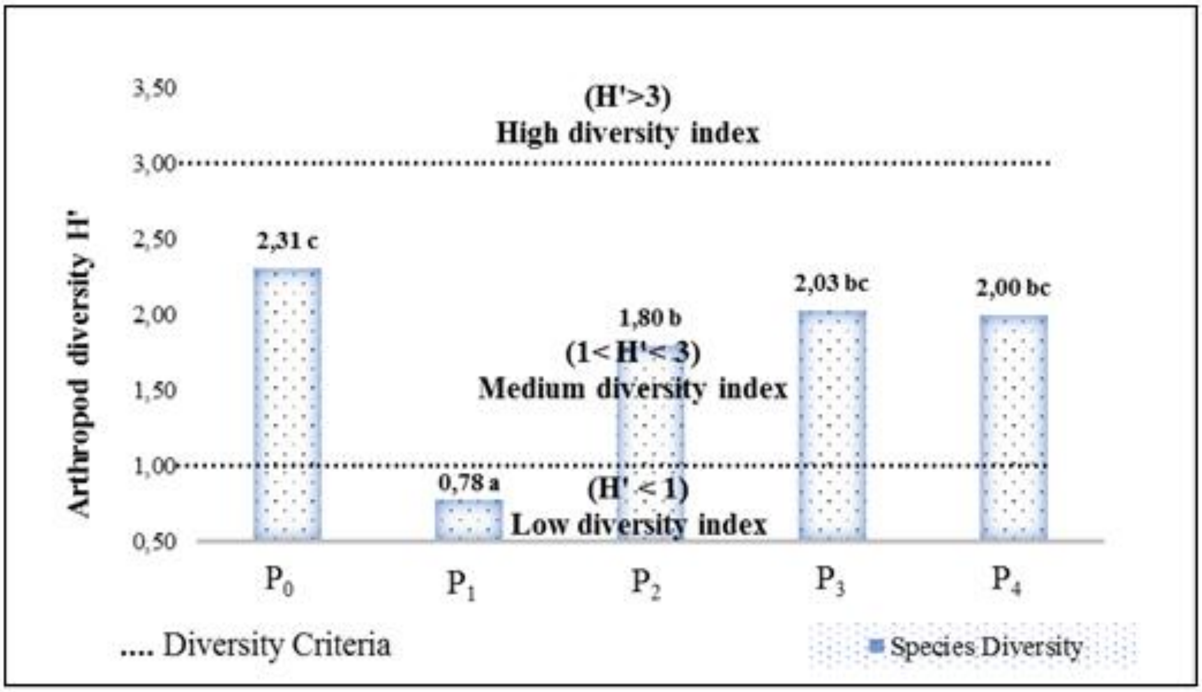
Table 2. The abundance of captured arthropods and their classification as predators, parasitoids, pests, vectors, and decomposer.

Treatment/replication	Percentage (%) of arthropod				
	Predator	Parasitoid	Pest	Vector	Decomposer
Control 1	26,67	0,00	53,33	0,00	20,00
Control 2	7,69	0,00	76,92	15,38	0,00
Control 3	35,71	0,00	35,71	0,00	28,57
Control 4	20,00	0,00	70,00	0,00	10,00
Sub Total	90,07	0,00	235,97	15,38	58,57
Average	22,52	0,00	58,99	3,85	14,64
2 ml Chemical Pesticide L^{-1} / active ingredient Monosultap 1	94,85	0,00	2,06	1,03	2,06
2 ml Chemical Pesticide L^{-1} / active ingredient Monosultap 2	42,86	0,00	19,05	0,00	38,10
2 ml Chemical Pesticide L^{-1} / active ingredient Monosultap 3	33,33	0,00	50,00	0,00	16,67
2 ml Chemical Pesticide L^{-1} / active ingredient Monosultap 4	21,43	0,00	28,57	28,57	21,43
Sub Total	192,46	0,00	97,62	29,60	78,25
Average	48,12	0,00	24,40	7,40	19,56
1 mL Kirinyu Leaf Extract L^{-1}/ 1	38,10	0,00	52,38	4,76	4,76
1 mL Kirinyu Leaf Extract L^{-1}/ 2	28,57	0,00	42,86	28,57	0,00
1 mL Kirinyu leaf Extract L^{-1}/ 3	56,25	0,00	31,25	0,00	12,50
1 mL Kirinyu Leaf Extract L^{-1}/ 4	61,54	0,00	23,08	0,00	15,38
Sub Total	184,46	0,00	149,57	33,33	32,65
Average	46,11	0	37,39	8,33	8,16
1 mL Kepayang Seed Extract L^{-1}/ 1	28,57	0,00	42,86	0,00	28,57
1 mL Kepayang Seed Extract L^{-1}/ 2	0,00	0,00	33,33	33,33	33,33
1 mL Kepayang Seed Extract L^{-1}/ 3	50,00	0,00	25,00	6,25	18,75
1 mL Kepayang SeedvExtract L^{-1}/ 4	33,33	0,00	33,33	33,33	0,00
Sub Total	111,90	0,00	134,52	72,92	80,65
Average	27,98	0	33,63	18,23	20,16
1 mL Galam Leaf Extract L^{-1} 1	42,86	0,00	14,29	14,29	28,57
1 mL Galam Leaf Extract L^{-1}/ 2	60,00	0,00	20,00	0,00	20,00
1 mL Galam Leaf Extract L^{-1}/ 3	22,22	0,00	38,89	11,11	27,78
1 mL Galam Leaf Extract L^{-1}/ 4	33,33	0,00	22,22	11,11	33,33
Sub Total	158,41	0,00	95,40	36,51	109,68
Average	39,60	0	23,85	9,13	27,42

In plantations that are applied with botanical pesticides derived from Kirinyu extracts, crops that are applied with botanical pesticides derived from kepayang seed extracts and crops that are applied with botanical pesticides derived from extracts of aloe plant have no significant differences; this is thought to be caused by the use of plant extracts from kepayang botanical pesticides which are not completely poisonous and biodegradable. Dadang and Djoko (2011) stated that botanical pesticides are easily biodegradable and relatively safe for natural enemies. Therefore applications must be made several times and require a long time interval to get the effectiveness of pest control.

Species Richness of Ground Surface Arthropods (R)

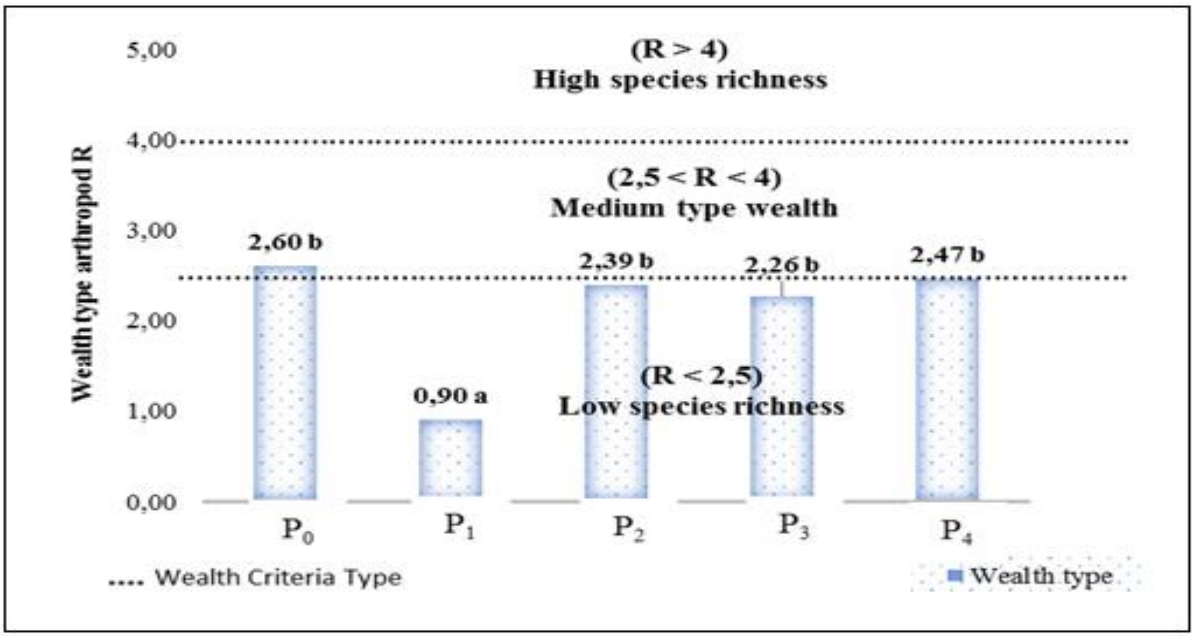
Species richness has a role in the stability of the agroecosystems; the analysis shows that species richness (R) arthropods have a high level of species richness in the control treatment with a maximum index of species richness (2.5<R<4). Based on the results of statistical analysis, treatment with chemical pesticides with active ingredients Monosultap is very significantly different from other treatments.



Note: P_0 (Control / without pesticide), P_1 (2 mL Chemical Pesticide L $^{-1}$ / active ingredient Monosultap), P_2 (1 mL Kirinyu Leaf Extract L $^{-1}$), P_3 (1 mL Kepayang Seed Extract L $^{-1}$), P_4 (1 mL Galam Leaf Extract L $^{-1}$).

Fig. 1. Histogram of the diversity of soil surface arthropods in shallot plants which are applied by several botanical pesticides on peatlands.

However, the control treatment was not significantly different from the treatment with botanical pesticides derived from Kirinyu leaves extracts, plantations that were applied with botanical pesticides derived from kepayang seed extracts and plantations which were applied with botanical pesticides derived from Galam leaf extracts. The Richness of arthropod types is presented in Fig. 2.



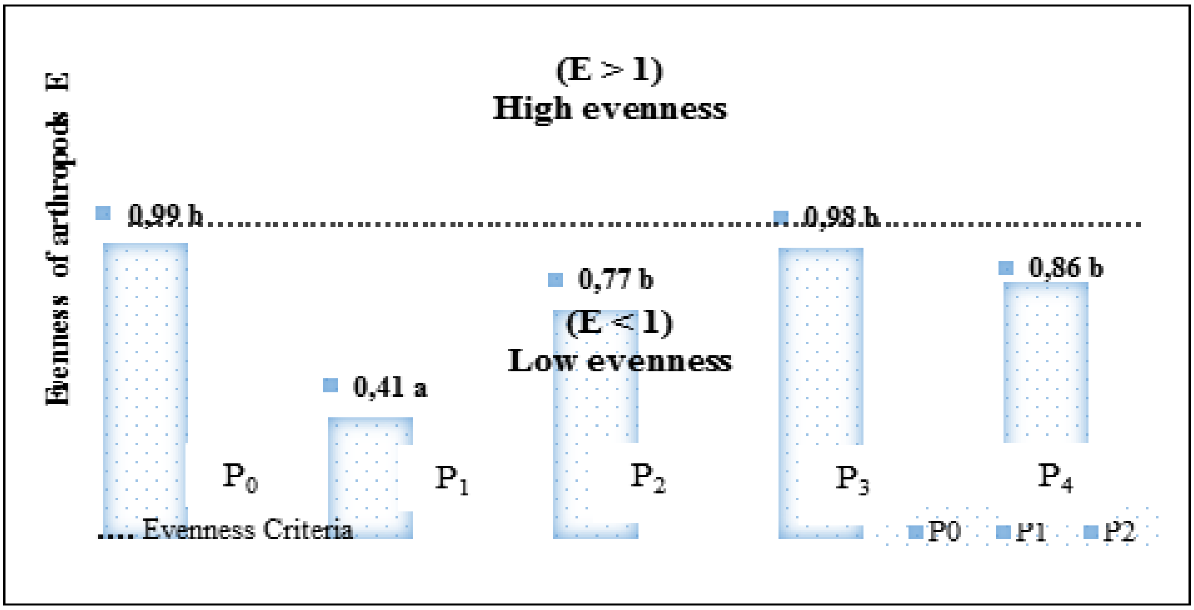
Note: P_0 (Control / without pesticide), P_1 (2 mL Chemical Pesticide 240 L $^{-1}$ / active ingredient Monosultap), P_2 (1 mL Kirinyu Leaf Extract L $^{-1}$), P_3 (1 mL Kepayang Seed Extract L $^{-1}$), P_4 (1 mL Galam Leaf Extract L^{-1}).

Fig. 2. Histogram of soil surface arthropod species richness in shallot plantations which has been applied by several botanical pesticides on peatlands.

The Richness of arthropod species indicates the magnitude of various types of arthropod populations that live in a particular ecosystem. Species richness is the main thing in studying biodiversity because species richness is a component to determine species diversity in a community (Kunarso and Fatahul, 2013).

Each treatment has a different type of wealth level. The highest species richness is in the treatment without pesticides, with a large spread of 2.60 (Fig. 2). Based on the statistical analysis, control treatment was very significantly different from the other treatments. This can be said because in the treatment without pesticides, the land is not polluted by chemicals that can damage the ecosystem of arthropods. According to Agus (2007), the natural state of ecosystems has a high level of diversity compared to ecosystems on agricultural land.

In shallot plants without pesticides, the level of arthropod species is not significantly different from the treatment with botanical pesticides derived from Kirinyu leaf extracts, crops applied with botanical pesticides derived from kepayang seeds extracts and shallot applied with botanical pesticides derived from Galam leaf extracts, the provision of botanical pesticides is not different from the control treatment, therefore plant pesticides with natural content can maintain the Richness of arthropod species in the ecosystem. Kirinyu leaf contains alkaloids, triterpenoids, and steroids.



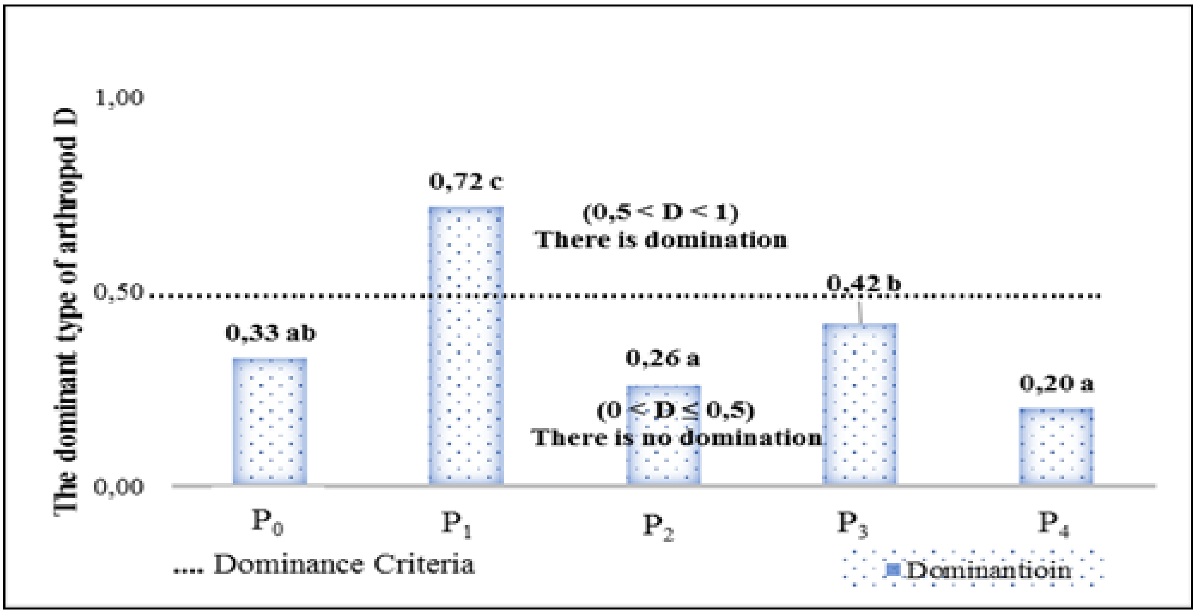
Note: P_0 (Control / without pesticide), P_1 (2 mL Chemical Pesticide L^{-1} / active ingredient Monosultap), P_2 (1 mL Kirinyu Leaf Extract L^{-1}), P_3 (1 mL Kepayang Seed Extract L^{-1}), P_4 (1 mL Galam Leaf Extract L^{-1}).

Fig. 3. Index of evenness of soil surface arthropods in onion plants applied by several botanical pesticides on peatlands.

This compound is widely used to control pests, which disrupts the biological activity of pests that inhibits appetite (antifeedant), as an antiparasitic and as a biopesticide (Harbone, 1987 *in* Nurhasbah *et. al.* 2017). Based on research by Willes (2015), Kepayang extract can kill *Plutella* larvae with 80.0% mortality. Kepayang contains Pyrethrin compounds which can disturb the nervous system of insects and cause insects to faint. According to Asikin and Maulia (2018), galam extract contains antifeedant substances and allelochemicals depending on the dose. Essential oils contained in the galam leaves can affect the appetite of *Plutella caterpillar* larvae.

Index of Evenness (E)

Index of evenness of arthropod species on shallot plantations in peatlands has a low rate of spread in each treatment with an evenness index of less than one. However, there is one crop of shallot that is applied with chemical pesticides that have the highest level of evenness compared to other treatments, namely 0.99. The control treatment was not significantly different when compared with botanical pesticides derived from Kirinyu leaf extracts, and plantations applied with botanical pesticides derived from plant extracts and plantations that were applied with botanical pesticides derived from galam leaf extracts (Fig. 3).



Note: P_0 (Control / without pesticide), P_1 (2 mL Chemical Pesticide L $^{-1}$ / active ingredient Monosultap), P_2 (1 mL Kirinyu Leaf Extract L $^{-1}$), P_3 (1 mL Kepayang Seed Extract L $^{-1}$), P_4 (1 mL Galam Leaf Extract L $^{-1}$).

Fig. 4. Histogram of the predominance of soil surface arthropods on shallot plants applied by several botanical pesticides on peatlands.

The results of the analysis of the arthropod evenness index at the ground surface in each treatment were in a low category. However, in the treatment without chemical pesticides (Control), there is the evenness with the highest value (0.99), but it is still classified as low, followed by the treatment of Kepayang seed extracts (0.98), Galam leaves extract (0.86), Kirinyu leaves extract (0.77)) and chemical pesticides Monosultap active ingredients (0.41).

Control treatment has the highest evenness index. This is caused by the increasingly widespread distribution of species in a habitat in a natural ecosystem that can make arthropods have a high alignment value. The large number of soil surface arthropods found is thought to be a result of the environment that supports the life of arthropods and the influence of supporting components of the ecosystem such as food around the land because, according to Pelawi (2010), the presence of soil arthropods in a place depends on environmental factors, namely water, air, sunlight, soil, topography, and climate.

Index of Domination (D)

The dominance of arthropods (D) on the planting of shallots in peatlands, there was significant in each treatment given, the highest dominance in the Galam leaves extract treatment, followed by chemical pesticides treatment of active ingredients Monosultap, then the treatment is given Kepayang seed extract and control treatment and Kirinyu leave extract. The control treatment was significantly different from the crop applied with chemical pesticides, but it was not significantly different from the crop that was applied with Kirinyu leaves, kepayang and galam leave extract (Fig. 4). The dominance of arthropods in onion cultivation in peatlands was found to reach the criteria (0.5<D<1) at each application week, but there was the highest dominance in the treatment without botanical pesticides. Whereas plantations that were applied with Galam leaves, extract produced a dominance index of 0.78. Domination occurs due to the dominance of one type of arthropod with the Orthoptera, which belongs to the Gryllidae family.

The higher the dominance of certain species in an environment, the lower the diversity of arthropod species, and vice versa, the lower the dominance in the environment, the higher diversity of arthropod species (Ilhamiyah, 2019; Ilhamiyah *et al.* 2019). The diversity of arthropod types in the treatment without pesticides has a high diversity value, inversely proportional to the dominance of arthropods, which shows that the treatment without pesticides has a low arthropod dominance value.

Arthropods types

The arthropod category that was found consisted of four roles, namely as a pest (*Teleogryllus commodus*/ Gryllidae, *Spodoptera litura* F/ Noctuidae, *Nephrotoma* sp./ Tipulidae, *Drosophila melanogaster*/ Drosophilidae), as vectors (*Heteropternis obscurella*/ Blitar), *Nephrotoma* sp., *Azteca instabilis*/ Formicidae, *Laccotrephes pfeiferiae*/ Formicidae, *Mochterus tetraspilotus*/ Carabidae, *Pleuraltica cyanea*/ Chrysomelidae, *Clobiona* sp/ Clobionidae, *Agelena cabyrinthica*/ Gnaphosidae/ Carabidae, *Pleuraltica cyanea*/ Chrysomelidae, *Clobiona* sp./ Clobionidae, *Agelena cabyrinthica*/ Gnaphosidae/ Siraban theidida/ Scarabeidae/ Scarletium/ Scarcee, *Trigoniulus corallinus*/ Trigoniulidae, *Sulix tasmani*/ Delpacidae, and *Campodea staphylinus*/ Campodeidae) (Table 1). Application of chemical pesticides, the arthropod category in the predator group had the highest composition of 94.85%, and no arthropods containing parasitoids were found. The highest composition of pest category in the control setting was 76.92%, in the highest composition vector group was 33.33% in onion crop applied with Kepayang extract and other arthropod groups, the maximum amount was 38.10% if chemical pesticides were used. The percentage results for arthropod categories can be seen in Table 2.

The parasitoid group had a lower percentage in which no arthropods were found, which acted as parasitoids in all treatments. This is thought to be caused by adverse environmental conditions during the study; according to Nugraha *et al.* (2014), the state of the ecosystem can affect the diversity and effectiveness of parasitoid communities as natural enemies of arthropod pests, the application of pesticides can also reduce the diversity and performance of parasitoids on agricultural land.

The chemical pesticide treatment had the highest percentage in the predator arthropod group category of 94.85% compared to the treatment of various other types of Botanical pesticides. This is due to chemical pesticides that have active ingredients Monosultap are contact, stomach and systemic toxins in the form of solutions in water so that they are thought to be effective in reducing the presence of pests in shallots.
Arthropods as a remodel of organic material are not commonly found at ground level. This is caused by peatlands originating from the remains of plants buried in, both those that have been decomposed or not yet will continue to accumulate organic matter so that the decomposition process is hampered by anaerobic conditions or environmental conditions that cause low levels of development of biota for organic material removers. In accordance with the statement of Arya *et al.* (2017) said that the condition of the thickness of litter or mucuna (ground cover plants) affects the abundance of macrofauna, which acts as a decomposer.

Conclusion

The use of vegetable pesticides affects the diversity of soil surface arthropod species, respectively from the highest to the lowest, namely the treatment of Kepayang seed extract (2.03), Galam leaf extract (2.00), Kirinyu leaf extract (1.80), Pesticides Chemistry (active ingredient Monosultap) of (0.78) and control (2.31). Arthropods were found in as many as 19 species from 10 orders. Four species act as pests, one species as a vector and the rest as predators and spearheads. The arthropod category in the predator group had the highest composition of 94.85%, and no arthropods were found that acted as parasitoids. Followed by the pest group by 76.92%, then the vector group by 33.33% and other arthropod groups by 38.10%

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