Diversity of Arthropod at Soybean (Glycine max l. Merr) With Different Planting Distances

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Diversity of Arthropod at Soybean (*Glycine max* l. Merr) With Different Planting Distances

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ABSTRACT

This study observed the spacing effect on arthropod diversity in soybean from November 2017 to January 2018. The treatments were arranged in a randomized block design, with five replications and five different spacings: A - 20x20 cm, B - 20x30 cm, C - 20x40 cm, D 20x50 cm, and E - 20x60 cm. The highest arthropods were found at the narrowest spacing (20x 20 cm) and the lowest at the broadest spacing (20x60 cm). Soybean plantations in the study area had a medium category for diversity index (H'), a fairly even category for evenness index (E), and a low category for dominance index (D). All types of relative index values did not differ between treatments.

Keywords: arthropod, diversity, plant spacing

1. Introduction

2 One of the biotic components that compose the soybean agroecosystem is the arthropod group. Plants and arthropods are the critical components of ecosystem function and stability. Plant material may be seen as herbivorous, while pollen and nectar support pollinators and supplement the diet of entomophagous arthropo2s, and plant structures provide shelter for various organisms (Duru *et al.* 2015; Kaiser *et al.* 2017). Arthropods perform as bioindicators for disturbances due to their short cycle times and rapid response to environmental changes (Ghannem *et al.* 2018; Menta and Remelli, 2020). As consumers, arthropods include many critical functional groups, namely herbivores, pollinators, detritivores, predators, and parasitoids.

The arthropod community structure in an ecosystem is constantly changing, as are the components associated with food webs. The interaction between biotic and abiotic components in the ecosystem will affect mortality, natality, and distribution of arthropods in the ecosystem. Therefore the species composition is always dynamic. Improper human intervention in agricultural cultivation systems will cause problems.

The presence of herbivores on agricultural land is influenced by plant varieties, cropping patterns (including spacing), substances that affect arthropod behavior, and pesticides. Different spacing causes different plant densities, thus creating different microclimates. This will affect the number of arthropods in the ecosystem. Determination of the proper spacing in cultivation will provide optimal growth and yields. In addition, it is expected to be able to provide a suitable environment for the life of arthropods, beneficial arthropods, which are expected to develop to suppress the herbivorous population.

2. Materials and Methods

Arthropod samples were collected from soybean plantations in Sukamara Village, Landasan Ulin District, Banjarbaru City, South Kalimantan, Indonesia, from November 2017 to January 2018. The treatments were arranged in a randomized block design with five spacing treatments and five replications. The five treatments were: treatment A as control -20x20 cm, treatment B -20x30 cm, treatment C - 20x40 cm, treatment D-20x50 cm, and treatment E - 20x60 cm. Each plot was 2x2 m with a distance between plots of 1 m.

Arthropods were collected using the pitfall trap and sweep net method. The captured arthropods were collected in vials containing 70% alcohol and identified at the Entomology Laboratory of the Faculty of Agriculture, Lambung Mangkurat University. Identification referred to the identification book according to Lilies (1992), Borror *et al.* (1992), and Suin (1997). Then arthropods were grouped into herbivores, predators, parasitoids, decomposers or other insects.

The samples obtained were then counted their number of orders, families and individuals. The relative density (p_i) of insects was calculated using the comparison between the number of i-th individual and the total number of individuals from all types of families multiplied by 100% (Magurran, 2004). The diversity of insects was calculated based on Shannon-Wiener diversity index (***H'***). The type evenness was calculated based on Shannon-Wiener's evenness Index (***E***) (Krebs 1999). The dominance of insects was calculated based on Simpson dominance index (***D***). The index equation is as follows:

$$pi = \frac{ni}{N} \times 100\%$$

$$H' = -\sum_{i=1}^{s} (pi)(\ln pi)$$

$$E = H'/\ln S$$

$$D = \sum_{i=1}^{s} (ni/N)^2$$

Note:
ni = the i-th individuals in the family
N = The total number of individuals of all types of families
S = The number of types of families

3. Results and Discussion

Arthropod abundance. The total number of arthropods captured by pitfall traps and sweep nets with five sampling times in the five spacing treatment plots was 2353 individuals, included in 10-11 orders and 25-29 families (Table 1). Treatment with a planting distance of 20x20 cm (treatment A) had the highest abundance of arthropods, namely 620 individuals. The least abundance of arthropods was found at a spacing of 20x60 cm (treatment E), which was 373 individuals. The abundance of the order Hymenoptera occupies the highest position among other orders (Table 2).

Table 1. Number of individuals, orders and families of Arthropods in soybean with different spacing

Number of Arthropods	Treatment					Total of
	A	B	C	D	E	Individuals
Individual	620	506	427	427	373	2353
Order	11	10	11	10	10	-
Family	28	25	29	25	26	-

Note : A-20x20 cm, B -20x30 cm, C - 20x40 cm, D-20x 50 cm, E - 20x 60 cm

Table 2. The abundance of orders in Arthropod in soybean with different spacing

No	Order	Abundance of Arthropod (individual)				
		A	B	C	D	E
1	Orthoptera	110	87	88	57	59
2	Hemiptera	63	63	52	69	48
3	Lepidoptera	47	43	28	29	26
4	Coleoptera	58	44	44	45	36
5	Diptera	4	3	3	3	2

6	Odonata	1	3	2	1	1
7	Hymenoptera	**278**	215	171	176	138
8	Sclopendromorpha	1	0	1	0	0
9	Araneae	36	31	24	25	46
10	Dermaptera	9	7	5	5	7
11	Diplopoda	13	10	9	17	10
	Total	620	506	427	427	373

Relative Population Density. The order Hymenoptera had the highest relative population density for arthropods in soybean cultivation (44.84%) (Table 3). The Formicidae family of the order Hymenoptera had the highest relative density (Table 4).

Table 3. Relative population density of arthropod orders in soybean with different spacing

No	Order	Relative population (%)				
		A	B	C	D	E
1	Orthoptera	17.74	17.19	20.61	13.35	15.82
2	Hemiptera	10.16	12.45	12.18	16.16	12.87
3	Lepidoptera	7.58	8.50	6.56	6.79	6.97
4	Coleoptera	9.35	8.70	10.30	10.54	9.65
5	Diptera	0.65	0.59	0.70	0.70	0.54
6	Odonata	0.16	0.59	0.47	0.23	0.27
7	Hymenoptera	44.84	42.49	40.05	41.22	37.00
8	Sclopendromorpha	0.16	0.00	0.23	0.00	0.00
9	Araneae	5.81	6.13	5.62	5.85	12.33
10	Dermaptera	1.45	1.38	1.17	1.17	1.88
11	Diplopoda	2.10	1.98	2.11	3.98	2.68

Table 4. Relative population density of arthropod families in soybean with different spacing

No	Family	Relative population (%)				
		A	B	C	D	E
	Orthoptera					
1	Tetrigidae (Her)	5.48	5.34	6.56	5.39	4.56
2	Pyrgomorphidae (Her)	10.81	9.68	11.94	6.79	9.38
3	Grylllidae (Pre)	1.45	2.17	2.11	1.17	1.88
	Hemiptera					
4	Miridae (Her)	3.39	3.95	1.41	2.81	4.02
5	Pentatomidae (Her)	1.94	2.96	2.58	2.11	2.68
6	Aleyrodidae (Her)	0.32	0.00	0.47	0.23	0.27
7	Alydidae (Her)	2.90	4.35	6.56	9.37	4.83
8	Aphididae (Her)	0.16	0.20	0.00	0.00	0.00
9	Pseudococcidae (Her)	1.45	0.99	1.17	1.64	1.07
	Lepidoptera					
10	Lymantriidae (Her)	2.10	1.58	0.70	0.94	0.54
11	Pieridae (Her)	0.16	0.20	0.47	0.00	0.54
12	Nymphalidae (Her)	0.81	0.40	0.70	0.70	0.54
13	Pyralidae (Her)	3.23	3.16	3.28	3.04	3.75
14	Noctuidae (Her)	1.29	3.16	1.41	2.11	1.61
	Coleoptera					

15	Chrysomelidae (Her)	0.32	0.59	0.23	0.47	0.54
16	Coccinellidae (Pre)	2.26	2.96	3.28	2.34	4.02
17	Staphylinidae (Pre)	4.84	3.16	5.62	5.39	3.22
18	Carabidae (Pre)	1.94	1.98	1.17	2.34	1.88
	Diptera					
19	Agromyzidae (Her)	0.16	0.40	0.47	0.47	0.54
20	Syrphidae (Pre)	0.48	0.20	0.23	0.23	0.00
	Odonata					
21	Chlorogomphidae (Pre)	0.00	0.59	0.23	0.00	0.27
22	Coenagrionoidae (Pre)	0.16	0.00	0.23	0.23	0.00
	Hymenoptera					
23	Formicidae (Pre)	44.35	42.29	39.11	40.75	35.66
24	Braconidae (Par)	0.00	0.00	0.47	0.23	0.54
25	Bethylidae (Par)	0.16	0.00	0.23	0.00	0.27
26	Eulophidae (Par)	0.32	0.20	0.23	0.23	0.54
	Sclopendromorpha					
27	Sclopendridae (Pre)	0.16	0.00	0.23	0.00	0.00
	Araneae					
28	Lycosidae (Pre)	5.81	6.13	5.62	5.85	2.33
	Dermaptera					
29	Anisolabididae (Pre)	1.45	1.38	1.17	1.17	1.88
	Diplopoda					
30	Juluidae (Dec)	2.10	1.98	2.11	3.98	2.68

Note : Herbivore (Her), Predator (Pre), Parasitoid (Par), Decomposer (Dec)

Diversity index (H'), evenness index (E), and dominance index (D). The diversity index (H') in soybean plantations with spacing treatment was categorized as moderate (H'= 2.22-2.40). Evenness index (E) in soybean planting with spacing treatment ranged from 0.67-0.74. The Simpson index value (D) obtained on soybean plantations with spacing treatment was categorized in the low range (D = 0.16-0.22) (Table 5).

Table 5. Diversity (H') , Evenness (E) and Dominance (D) Index in Soybean with different spacing

Indeks	Treatment				
	A	B	C	D	E
H'	2.22	2.28	2.33	2.30	2.40
E	0.67	0.71	0.69	0.71	0.74
D	0.22	0.20	0.19	0.19	0.16

The Ecological Role of Arthropods. The proportions of each arthropod role are presented in Table 6. The highest proportion is occupied by arthropods that act as predators and follows by herbivores.

Table 6. Proportion of arthropods in soybean with different spacing

Role of arthropod	A	B	C	D	E
	Proportion (%)	Proportion (%)	Proportion (%)	Proportion (%)	Proportion (%)
Predator	62.90	60.87	59.02	59.48	61.13
Parasitoid	0.48	0.20	0.94	0.47	1.34
Herbivore	34.52	36.96	37.94	36.07	34.85
Decomposer	2.10	1.98	2.11	3.98	2.68

The highest abundance of arthropods was found in the treatment with the closest spacing (treatment A) and the lowest abundance was found in the treatment the wides spacing (treatment E). Presumably it occurred because the spacing in treatment A was the densest, which provide abundant food, especially in the early or vegetative phase, and the temperature tended to be lower. A high plant population and close spacing will make the plants grow very lush. It causes a microclimate in crops and increases vulnerability to the development of herbivorous populations, and also affects the development of predators (Nurindah, 2006). The wides spacing , the availability of food for pests is low because the spacing in treatment E is wide enough. Insect pests tend to move and choose places with high plant populations, and predatory arthropods will choose places where the presence of prey, insect pests, is abundant (Albatsi *et al*, 2018).

It is also supported by the research of McPherson *et al*. 1988; McPherson and Bondari 1991; Buchanan *et al*., 2015 on soybean plants; Albatsi *et al*. 2018 on rice; and Momtaz *et al*., 2018 on cotton, which stated that spacing affected the abundance of arthropods, i.e., narrow spacing showed a higher abundance of arthropods. However, several other studies (Anderson and Yeargan. 1998; Lam and Pedigo, 1998) did not show any effect of plant spacing on the abundance of predatory and herbivorous arthropods. The interpretation of these previous studies indicates that there is no definite conclusion drawn as to whether plant spacing can have a significant effect on the abundance of arthropods. The effect of plant spacing on the abundance of herbivores and arthropods has never been established in one literature. Some species are more abundant in conventional plant spacing; some are more abundant in narrow plant spacing, while many other studies do not show significant differences (Mayse, 1984). The effect of row spacing on arthropod abundance is not consistent across all arthropod functional groups (Buchanan *et al*., 2015). This phenomenon is caused by many factors, including plant density related to the spatial structure/plant canopy (Lam & Pedigo, 1998) and habitat structure or microclimate (temperature and relative humidity) (Buchanan *et al*., 2015; Momtaz *et al*, 2018).

The presence of Hymenoptera in agricultural ecosystems generally acts as natural enemies, namely predators and parasitoids. Natural enemy groups can influence the population dynamics of herbivorous insects in the soybean agroecosystems and prevent the development of herbivorous insect populations from reaching a detrimental status (Purwanta and Rauf, 2000; Liu *et al*., 2004). The presence of natural enemies will be affected by the presence of herbivores and the presence of herbivores will be influenced by the presence of host plants in an ecosystem. (Abrams, 2000; Inayat *et al*., 2011).

Hymenoptera and Formicidae are orders and families with the highest relative densities. Formicidae is a member of the order Hymenoptera that behaves in colonies on or in the soil (Borror *et al*., 1996) and is known as a common and widespread insect. Formicidae has a vast range and very diverse types of feed (Wetterer, 2008), making it possible to survive and breed more rapidly than others. Some of the roles of the Formicidae group are as decomposers, pollinators, soil watermakers, and predators (Falahudin, 2013; Tawatao, 2014). Due to their roles, Formicidae is almost scattered in all habitats, such as in agricultural ecosystems such as rice plants (Kurniawati, 2015), vegetables (Nunilahwati and Khodijah, 2014; Annam and Khasanah, 2017, and Putra and Utami, 2020), peanuts (Apriliyanto and Sarno, 2018), cassava (Elhayati *et al*., 2017), and plantations such as oil palm (Fitria, 2013; Romarta *et al*., 2020). According to Borror *et al.* (1996), Formicidae is the most successful family of all insect groups. They are practically found in a variety of terrestrial habitats and outnumber most other land animals.

Diversity index (H') in soybean with spacing treatment was categorized as moderate. Odum's (1996) statement, the diversity in the population is stated to be moderate if $1<H'\leq3$, which means that the types of arthropods in the five treatments are quite diverse, and the ecosystem is in a stable condition. The moderate diversity in the research area could occur because chemical and non-chemical controls were not carried out. Pest management with pesticides also affects the decline in species diversity (Tulung *et al*., 2000). The natural diversity of arthropods is also closely related to plants' phenology or climatic and environmental aspects in the community (Pedigo, 1991).

The value of evenness index (E) in soybean with spacing is close to 1, meaning that the distribution of individuals is quite even, but the condition of the community is less stable. According to Kreb (1999), if $0.5<E\leq0.75$, then the community is in a less stable condition. According to Astriyani (2014), the value of E ranges from 0-1. The greater the value of E and close to 1, then no type of individual dominates. On the contrary, the smaller the value of E, the smaller the population uniformity. It means that the distribution of individuals in each species is different, and there is a tendency for one individual to dominate. According to Oka (2005), the evenness value will tend to be high if the population of one

family does not dominate other families. On the other hand, evenness tends to be low when one family dominates another population.

The higher the value of E, the better the state of the ecosystem. However, when the E value is higher than one continuously, an adverse effect on carnivorous insects (predators) for the next generation will occure. This is because the population will drop drastically if there is a shortage of prey for a long time (Mahrub, 1998).

Index value dominance (D) on soybean with spacing treatment was categorized in the low range. Odum (1996) stated that if the value is $0<D\leq0.5$, then the dominance is categorized as low. It indicates that this soybean crop has diverse arthropod species and no arthropod species dominates. It is in line with the statement of Odum (1996) and Sanjaya & Dibiyantoro (2012), which stated that if the dominance index value is <1, then the insect species is categorized as diverse. On the contrary, if the dominance index value =1, then the insect species are not diverse.

The index value of each treatment is in the same category, both the diversity index, the evenness index, and the dominance index. This means that the difference in plant spacing does not provide a significant difference to all index values.

Arthropods have a vital role in the food chain, especially as decomposers, because nature will not be able to recycle organic matter without these organisms. Moreover, arthropods act as predators for other small predators so that they will maintain the survival of other arthropods. Identifying the abundance and diversity of species is essential to understand the role of organisms in the environment.

Arthropods associated with soybeans in the research area have different roles, including predators, parasitoids, herbivores, and decomposers. It reveals that the diversity of communities will form food webs. It is explained by Oka (2005) that the more species that make up a community, the more diverse the community. The types of arthropods in the population will interact with each other to form a food web.

The predator population follows the prey population (herbivores). This high population of herbivores attracts predators to come and live in the area so that the level of predation also increases. The presence of abundant prey makes it easy to find by predators. Sunarno (2012) stated that the high predator population is closely related to the prey population. Natural enemies, including predators, are one of the determining factors for high and low pest populations. On the contrary, the abundance of hosts will affect the abundance of natural enemies (Hamid, 2009).

Arthropods that act as parasitoids are found in small numbers because their habitat and life activities are not always on the ground surface. According to Kevan (1955), parasitoids on the soil surface are only for laying eggs, and then when they are adults, they will come out of the soil.

4. Conclusions

The highest abundance of arthropods was found at the narrowest plant spacing (20x20 cm) and the lowest at the broadest plant spacing (20x60 cm). Soybean plantations in the study area had a medium category for diversity index (H'), a fairly even category for evenness index (E), and a low category for dominance index (D). All types of relative index values did not differ between treatments.

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