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Effect of the Number of Rows and Cultivars of Soybeans on Damage Intensity of Pest and Predator Populations in Corn-Soybean Intercropping, South Sulawesi Indonesia

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ABSTRACT

Background: Soybean productivity in Indonesia remains low yield due to the occurrence of pests and diseases. Here, our study aimed to determine the number of soybean rows and varieties in the soybean-corn intercropping system and the damage level, pest and predator populations.

Methods: The study used a split-plot design with three replications. The main plot was soybean varieties (Dena-1, Detap-1 and Deja-1) and the subplots consisted of monoculture (soybean); three rows of soybeans and two rows of corn; four rows of soybean and two rows of corn; six rows of soybean and two rows of corn.

Result: The six rows of soybeans and two rows of corn showed the lowest attack rate of *Spodoptera litura* and *Etiella zinckenella*, the lowest population of *Aphis glycines* and *Riptortus linearis*, the highest predatory population of *Crocothemis servilia* and *Coccinella* sp. and the highest predator populations of *Euborellia annulata.* The highest attack rate of *S.litura* was in Dena-1. In contrast, the highest intensity of *E.zinckenella* pest damage was in Dena-1 and Deja-1. The corn-soybean intercropping was recommended as the best practice for sustainable agriculture production due to facilitating in the increase of growth of predator population and reducing the level of crop damage due to pest attacks.

Key words: Corn, Damage intensity, Intercropping, Pests, Predators, Soybean.

INTRODUCTION

Indonesia is a tropical country and its climate is favorable for the growth and occurrence of crops pests and diseases. The main soybean pests in Indonesia are *S.litura* F (Lepidoptera: Noctuidae), *Etiella zinckenella* (Tr), *Aphis glycines* M (Homoptera: Aphididae) and *Riptortus linearis* F (Hemiptera: Alydidae). The same thing happened in India, the pests on legumes (*Lablab purpureus* L.) were most commonly found, including the pod borer *Etiella zinckenella*, aphid and *Nezara viridula* (Chopkar *et al.* 2020). Similarly, what was revealed by Soundararajan *et al*. (2013) is that pests that are commonly found on legumes in India include the armyworm *S. litura*, aphid, *Riptortus* spp. pod borer *Maruca vitrata* (Geyer), pod borer *Helicoverpa armigera* (Hubner).

In Indonesia, according to Kuswantoro *et al*. (2017), one of the limiting factors in increasing soybean productivity is the high attack of pod borer pests. Heinrichs and Muniappan (2018) stated that the extent of damage to pods and soybean yield loss caused by *E. zinckenella* could reach 80%. At the same time, the level of soybean leaf damage caused by *S. litura* in Indonesia could reach 32.69% within the vegetative phase (Fattah *et al*., 2020a). Yield losses due to soybean pod-sucking *R. linearis* could reach can be reached as much as 79% (Sari and Suharsono, 2011). According to Sinaga *et al*. (2016), the level of damage to soybean pods due to the attack of *R.linearis* could reach as much as 81.88%.

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According to Lithourgidis *et al.* (2011), intercropping sorghum with fodder cowpea could improve the concentration of N, P and K in the soil while suppressing grass growth. Intercropping is also beneficial in improving the pest control of plants' natural enemies (Siagian *et al*., 2018). According to Rizk and Gyar (2014), a higher spider population was found in the intercropping of wheat with faba beans than in monoculture (wheat).

Rutledge and O'Neill (2006) suggested that the level of the predator population largely determined the aphid mortality rate. In the corn-soybean intercropping system, the Mantidae population is higher than in the monoculture system (Rahmi *et al*., 2013). According to Siagian *et al*. (2018), leek-green bean intercropping has a lower rate of pod borer attack (1.15%) than monocultures (3.42%), while pod suckers are 1.18% in the intercropping systems and 3.38% in monocultures. Pest losses can be reduced by 50% when corn and soybeans are intercropped together (Arifin *et al*., 2016). According to Lingga *et al.* (2015), the highest number of filled pods was obtained when three rows of green beans, four rows, five rows and six rows of green beans and one row of sweet corn were intercropped; the highest number was achieved when three and four rows of green beans and one row of sweet corn were intercropped (86.44 pods and 84.04 pods).

Combining resistant varieties with an intercropping system of soybean + corn is expected to reduce the damage level caused by pest attacks. Studies related to the synergy of the number of lines and soybeans varieties are essential. Thus, the present study aimed to determine the effect of the intercropping system between soybeans and corn on pests, predators and yields of several soybean varieties.

MATERIALS AND METHODS

Field experiment

This research was conducted at the Experimental Field, Indonesian Assesment Institute for Agricultural Technology in Maros South Sulawesi from April to December 2019. This research used split-plot designs with three replications, main plots were soybean varieties: 1) Dena-1, 2) Detap-1 and 3) Deja-1, whereas subplots were several soybean rows in the soybean and corn intercropping system: 1) monoculture (soybean) (control), 2) three rows of soybeans and two rows of corn, 3) four rows of soybean and two rows of corn and 4) six rows of soybeans and two rows of corn, Soybeans were grown using a spacing of 40 cm × 15 cm with two seeds per planting hole, whereas corn (variety Hj-21) was planted using a spacing of 70 cm × 20 cm with one seed per planting hole.

Parameters observed

Observation of damage symptoms caused by *S. litura* attack was carried out at the age of 35 days after planting, while damage symptoms due to *R. linearis* pod borer attack was carried out at 75 days after planting. Observations of *Aphis* sp. population and predatory populations of *C. servillia*, *Coccinella* sp. and *E. annulata* were carried out 55 days after planting. The way to observe the pest attack is that each sub-plot is taken diagonally as many as 15 clumps of soybean plants. The pod-sucking population of *R. linearis*, predatory populations of *Coccinella* sp. and *E. annulata* (Dermaptera: Anisolabididae) sampled 2 m^2 in three places in one subplot to measure the level of damage to the leaves caused by *S. litura* F., the level of attack of the soybean pod borer *E.zinckenella* Tr (Lepidoptera: Pyralidae). Meanwhile, a 6 m^2 sample area per plot was used to evaluate the predatory dragonfly *C. servillia* (Crocothemis: Libellulidae). The rate of damage to the leaves is calculated based on the formula (Apriani *et al*. 2021):

$$I = \frac{\sum_{i=0}^{z}(n1 \times v1)}{Z \times N} \times 100\%$$

I : Intensity of damage.
ni : The number of leaves with a v_i scale.
N : Number of leaves observed.
Z : The higher v_i.
Scale value, v_i:
0 : No damage on leaves
1 : Leaf damage >0%-20%
3 : Leaf damage >20%-40%
5 : Leaf damage >40%-60%
7 : Leaf damage >60%-80%
9 : Leaf damage >80%-100%

Statistical analysis

Data were analyzed using Analysis of Variance (ANOVA). If the treatment were significantly different, a test of the least significant difference (LSD) at the 0.05 level was performed.

RESULTS AND DISCUSSION

S. litura, *E. zinckenella* and *C. servillia* pest predator populations

The mean damage intensity results of armyworms of *S.litura*, *E. zinckenella* and *C. servillia* populations varied in the three soybean varieties The highest level of damage caused by *S. litura* was in Dena-1 (10.89%) and the lowest was in Deja-1 (5.99%) (Table 1). The Deja-1 variety is resistant to *S.litura*, according to the report of the Indonesian Legume and Tuber Crops Research Institute, ILETRI (2016), which is mentioned in the Description of Varieties of Soybean Crops.

The current investigation discovered that the Detap-1 type had the highest population of *Aphis* sp. (4.08 adults per plant) and the Deja-1 type had the lowest (3.33 adults per plant) (Table 1). According to Widaryanto *et al*.(2017), the population of *Aphis* sp. might cause seed yield loss has reached 58%. One method for controlling *Aphis* sp. pests is to utilize a predator. The predator Coccinellidae is the most common in soybeans, followed by Syrphidae, Mantidae, Chrysopidae and lynx spiders (Radiyanto *et al*.,2017). *Coccinella* sp. can prey on up to 23 *Aphis* sp. per day (Efendi *et al*., 2018). *C.tranversalis* dragonflies, in addition to the types of *Coccinella* sp. as *Aphis* sp. predators, play a significant role in managing the *Aphis* sp. pest. *C. transversalis* is the most abundant predator in soybean, preying on *Aphis* sp. and *Bemisia tabaci* (Widaryanto *et al*., 2017).

The planting of four models evaluated for the pest *S. litura* revealed substantial variances (Table 2). Pest leaf damage was highest in the *S. litura* monoculture system (11.35%) and lowest in the six rows of soybean+two rows of corn intercropping system (5.02%). According to Indiati and Marwoto (2017), ecosystem structure includes plant species composition, pests, natural enemies and a group of other

Table 1: The average damage intensity of armyworm *S.litura*,*E. zinckenella* and *C.servillia* populations in three soybean varieties.

Soybean varieties	Damage intensity (%) *S. litura*	Damage intensity (%) *E. zinckenella* (%)	*C.servillia* population (adult/6 m^2)	*Aphis* sp. Population (adults $plant^{-1}$)	*Coccinella* sp. population (adults/2 m^2)
• Dena-1	10.89a	10.98a	3.58ab	3.00a	2.58a
• Detap-1	7.41b	8.86b	4.08a	3.42a	2.83a
• Deja-1	5.99c	12.15a	3.33b	2.83a	2.08a

The column number (followed by a similar letter) has no significant difference at the 5% LSD test.

Table 2: The average damage intensity of armyworm *S.litura*, *E. zinckenella* and the population of *C. servillia* in four soybean cropping models.

Soybean cropping model	Damage intensity (%) *S. litura*	Damage intensity (%) *E. zinckenella*	The population of *C. servillia* (adults per 6 m^2)	The population of *Aphis* sp. (adults $plant^{-1}$)	The population of *Coccinella* sp. (adults per 2 m^2)
• Monoculture	11.35a	11.83a	0.78c	4.56a	2.11c
• Three rows of soybean+ two rows of corn	8.82b	10.70b	2.44b	4.22a	3.11b
• Four rows of soybean+ two rows of corn	7.19c	10.29bc	3.11a	3.33b	3.33b
• Six rows of soybean+ two rows of corn	5.02d	9.84c	3.67a	2.55b	3.78a

The column number (followed by a similar letter) has no significant difference at the 5% LSD test.

Table 3: The average population of *E.annulata* population of *R.linearis* and seeds yield in four soybean cropping models.

Soybean cropping model	Population of adults (per 2 m^2) *E. annulata*	Population of adults (per 2 m^2) *R. linearis*	Seeds yield (t ha^{-1})
Monoculture	1.33c	1.44a	2.61a
Three rows of soybean+two rows of corn	2.78b	1.46a	0.59c
Four rows of soybean+two rows of corn	3.11ab	1.00ab	0.84c
Six rows of soybean+two rows of corn	3.56a	0.78b	1.13b

The column number (followed by a similar letter) has no significant difference at a 5% LSD test.

biotic and abiotic interactions. These interactions between the components of a dynamic management strategy can suppress pest populations at a level that is not detrimental to farmers. The involvement of natural enemies in the ecosystem may range from 65 to 99%, implying that the pest population will be minimal (Arifin *et al*., 2016). Pest management through intercropping soybean with cotton can enhance predator populations like ladybugs and spiders (Nurindah, 2006).

The attack pod borer *E.zinckenella* caused the most damage in monoculture (11.83%) and the least damage in six rows of soybean and two rows of corn of intercropping system (9.84%). The lack of predators in eliminating these pests is one of the causes of the high prevalence of pod borer in monoculture. The limited predator role as a pest controller was purportedly owing to low *C. servillia* populations on monocultures, which only reached 0.78 adults per 6 m^2. Compared to the intercropping system with six rows of soybeans and two rows of corn, the predator population of *C. servllia* reached 3.67 adults per 6 m^2. Furthermore, Bhusnar and Sathe (2017) reported that *C. servillia* can prey on the brown planthopper *Nilaparvata* sp. and the *Chilo suppressalis* stem borer larvae.

Table 2 shows the average population of *Aphis* sp. and *Coccinella* sp. in four soybean cropping types. *Aphis* sp. had the maximum population in monoculture (4.56 adults per plant) and the lowest in four rows of soybean + two rows of corn (3.33 adults per plant) and six rows of soybean + two rows of corn (2.55 adults per plant). According to the findings of Siagian *et al.* (2018), the maximum population of aphids pests was found in green bean monocultures (22.71 adults per plant), while the lowest was found in green bean shallot intercropping system (12.09-18.86 adults per plant). According to Fattah *et al*. (2020b), the level of devastation caused by *Aphis* sp. in soybean monoculture is higher (20.15%) than in soybean + chili intercropping (11.23%).

The predator population density of *Coccinella* sp. was highest in six rows of soybeans + two rows of corn intercropping (3.78 adults per 2 m^2) and lowest in soybean monoculture (2.11 adults per 2 m^2) (Table 2). Intercropping soybeans with five rows of soybeans with one row of *Crotalaria juncea* ruffles had better insect diversity (18 species) than those without *C. juncea* (nine species) (Rahayu *et al*. 2018). Kurniawati *et al*. (2015) found that the Coccinellidae population was abudance (34 adults) in polyculture environments (rice and flowering plantation) than in rice monocultures (19 adults).

Table 4: The average population *of E. annulata*, the population of *R. linearis* and the seeds yield on three varieties of soybean.

Type of varieties	The population of adults (per 2m^2)		Seeds yield
	E. annulata	*R. linearis*	(t ha^{-1})
Dena-1	2.41a	1.25a	1.17a
Detap-1	3.08a	0.92a	1.02a
Deja-1	2.58a	1.33a	1.21a

The column number (followed by a similar letter) has no significant difference at the 5% LSD test.

E. annulata predator population deliver found the highest in intercropping corn and lowest in monoculture (Table 3). According to Smith and Sorley (2000), Polyculture enhanced the population of predatory enemies and parasitism. According to Fitriani *et al.* (2011), *E. annulata* may prey *S.litura* F. first instar larvae from 3.33 to 4.00 per hour, second instar larvae from 3.30 to 3.67, third instar larvae from 3.0 to 3.33, fourth instar larvae from 2.0 to 2.33 and fifth instar larvae from 1 to 1.67.

The soybean seed yield

The highest yield of soybean seeds from the three varieties studied wastelands to be higher in the Deja-1 variety (1.21 t h^{-1}) as seen in Table 4. The highest yield of soybean seeds from the three varieties studied was in the Detap-1 variety (2.26 t ha^{-1}). According to Ayu and Suharto (2020), the highest seed yield was found in Detap-1 (3.88 t ha^{-1}), followed by Deja-1 (3.58 ton h^{-1}) and Dena-1 (2.67t ha^{-1}). and Dega-1 (2.50 t ha^{-1}). The description book of the Indonesian Legume and Tuber Crops Research Institute, ILETRI (2016) informs that the highest seed yield potential is the Detap-1 variety (3.58 t ha^{-1}), followed by Dena-1 (2.90 t ha^{-1}) and Deja-1 (2.87 t ha^{-1}).

CONCLUSION

- *S.litura* caused the least amount of damage in Deja-1, while *E.zinckenella* caused the least damage in Detap-1. The lowest population of *Aphis* sp. was found in Deja-1, although the population of *R.linearis* did not differ significantly between varieties. The predator population in each studied variety exhibited no significance. The monoculture system had the highest attack rate and pest population (*S. litura, E. zinckenella, R. linearis, Aphis* sp.) and the lowest intercropping of six rows of soybean + two rows of corn. The highest population density levels for predators of *Coccenella* sp., *E.annulata* and *Coccenella servilla* were found in an intercropping system of four rows of soybeans and two rows of corn. The population density of these predators on the three studied soybean types, on the other hand, did not change significantly.
- The results of this study provided a piece of overall information that the soybean-corn intercropping model, especially with six rows of soybean + one row of corn, may be used as an alternative for the soybean monoculture model in this area. And, economic analysis-based research is important for the future to evaluate in more detail the farmer's income or the benefit by applying the model.

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