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Correlation of Pests Resistance Levels and Seed Chemical Concentrations of Soybean Genotypes

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ABSTRACT

Background: Pests and diseases infestations reduce the quantity and quality of seed yields. The objective of this study was to identify the correlation value between level of resistance to pests and chemical (fat and protein) concentrations of soybean genotypes.

Methods: A total of 15 soybean genotypes were planted in field and glass house environments in 2017. Observations were made on the infestation intensity of pest and disease, dry seed yield, yield components and chemical (fat and protein) concentrations.

Result: Soybean genotype DG-91-8 showed resistant (R) category to pod borer and pod sucker, while DM-122-35-17 showed resistant (R) category to army worm and pod borer. Two highest yielding genotypes (DG-91-8 and DG-99-32-14) had 15% higher seed yield than check variety Dering 1 (2.41 t/ha), with higher 100 seeds weight and pod number/plant. Fat concentration showed a significant positive correlation value with leaf rust disease. Pod suckers showed a significant positive correlation value with pod borer infestation, indicating that they had the same preference for soybean pods. Soybean genotypes DG-91-8 showed high seed yield (2.70 t/ha) and resistant (R) level to pod borer and pod sucker.

Key words: Chemical concentrations, Genotypes, Pest, Resistance, Soybean.

INTRODUCTION

In Indonesia, soybean (*Glycine max*) is important source of protein. The low productivity of soybean is mainly due to pests and diseases infestations that reduce the quantity and quality of crop yields. With the global climate change, developing of soybean superior variety that resistant to pests and diseases is the one of determinant factors of the area expanding accomplishment (Suhartina and Kuswantoro, 2011).

As much as 15-20% of soybean production in Indonesia is lost directly or indirectly by pest each year (Rustam, 2016). Three major soybean insect pests that reduce yield productivity are pod borer (*Etiella zinckenella* Treitschke), pod sucker (*Riptortus linearis* Hemiptera: Alydidae) and armyworm (*Spodoptera litura* F.). While the major soybean disease is leaf rust (*Phakopsora pachyrizi)*. Pod borer, pod sucker and armyworm caused seed yield losses ranges 79%-100% (Baliadi *et al.,* 2008; Sari and Suharsono, 2011; Motaphale *et al*., 2016; Marwoto *et al*., 2017). In mungbean, the 36-75% yield loss was due to pod borer (Umbarkar *et al*., 2011; Indiati *et al*., 2021).

Planting resistant legume varieties is a long-term problem solving in controlling pests due to its economically sound, easy to use and can be integrated with other means of pest control as eco safe method of pest-plant management (Shanower *et al*., 1999; Soundararajan *et al*., 2013).

In soybean, resistant variety to pod sucker was controlled by genetic factors (Asadi *et al*., 2012), therefore, resistant varieties is very important due to differences in efficacy of different insecticides againts pest (Lekha *et al.* 2017) and different response of varieties to planting seasons (Soundararajan and Chitra 2017). Breeding of soybean lines tolerant to drought has been conducted at the ILETRI and 13 soybean promising lines were obtained. This study was aimed to identify the correlation between level of resistance to pests and seed chemical concentrations of these soybean genotypes.

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MATERIALS AND METHODS

Field study

Field research was conducted at the ILETRI Reseach Farm in Malang, East Java, Indonesia from April - August 2017. A total of 15 soybean genotypes consisted of 13 lines and two check varieties (Dering 1 and Grobogan) were planted in the field and glass house environments (Table 1). The genotypes were arranged in a randomized block design (RBD) with four replications. Dering 1 was resistant to pod borer and leaf rust while Grobogan was susceptible. Each line was planted on a plot of 3.2 m × 4.5 m, plant spacing of 40 cm × 15 cm and two plants per hole.

Evaluation of pests and disease

Evaluation of pod borer (*Etiella zinckenella* Treitschke), pod sucking (*Riptortus linearis* Hemiptera: Alydidae) and armyworm (*Spodoptera litura*, F.) insect pests as well as is leaf rust (*Phakopsora pachyrizi)* disease were conducted at ILETRI glass house environments in Malang, East Java, Indonesia from April-August 2017. A totalof 15 soybean genotypes were arranged in a completely randomized trial design, repeated three times. The no choice test method was used by artificial investment in gauze cages. The tested genotypes were planted in a polybag containing 10 kg of soil two plants/polybag. At the age of 60 days an imago investment was made.

Observation of the intensity of leaf damage due to armyworm attack in each clump was carried out at the age of 7 days after investment. Leaf damage was observed based on the 0-4 scoring method, with the following criteria:
Score 0: Healthy leaves (no armyworm attack).
Score 1: ¼ the leaves were attacked by armyworms.
Score 2: ½ of the leaves were attacked by armyworms.
Score 3: ¾ the leaves were attacked by armyworms.
Score 4: 1 part of the full leaves were attacked by armyworms.

The intensity of damage was calculated using the formula:

$$P = \sum \frac{ni \times vi}{ZN} \times 100\%$$

Where,
P = Percentage of leaf damage.
ni = The number of leaves indicating the i^{th} score.
vi = Score of leaves i (i: 0-4).
Z = Highest score (4).
N = Number of leaves observed.

Parameters observed were damage intensity (DI) based on the amount of damage to pods and seeds. The criteria for resilience were determined based on average and standard deviation (SD) according to the method of Chiang and Talekar (1980), then grouped into 5 categories:

1. Highly resistant (HR) : $X_i < (\bar{X} - 2\ SD)$
2. Resistant (R) : $(\bar{X} - 2\ SD) \leq X_i \leq (\bar{X} - SD)$
3. Moderate resistant (MR) : $(\bar{X} - SD) \leq X_i \leq \bar{X}$
4. Susceptible (S) : $\bar{X} \leq X_i \leq (\bar{X} + SD)$
5. Highly susceptible (HS): $X_i\ X \geq (\bar{X} + 2\ SD)$

Where,
X_i = Pod damage or seed damage of each genotype or accession.
$\bar{X}$ = Mean of pod damage or seed damage.
SD = Standard deviation.

The source of the initial inoculum was rust stained soybean leaves from farmers' fields.

Observations were made on all tested plants at the age of 8 weeks using the International Working Group of Soybean Rust (IWGSR) method developed by Shanmugasundaram (1977).

Protein and fat content analysis

Analysis of protein and fat content using the Kjeldahl Micro method (AOAC, 2005 No. 12.1.07) by direct extraction method with Soxhlet (SNI 01-2891-1992) (BSN, 1992).

RESULTS AND DISCUSSION

Resistance to pests and disease

The intensity of armyworm infestation on the tested soybean lines showed difference categories ranged from very susceptible to resistant (Table 2). Two soybean lines AGm-29-3-2 and DM-122-35-17 showed resistant (R) level against armyworm pests which were equivalent to that of Grobogan check variety and more resistant than that of Dering 1 check variety which was classified as moderately resistant (MR) (Table 2). One soybean line (DG-91-8) and eight soybean lines showed resistant (R) and moderately resistant (MR) categories, respectively to pod suckers (*Riptortus linearis*). While the check varieties Grobogan and Dering 1 showed highly susceptible (HS) and moderately resistant (MR), respectively (Table 2).

Three soybean lines (DG-91-8, DG-100-33-15 and DM-122-35-17) showed resistant (R) category to pod borer (*Etiella zinckenella*). While the check varieties Grobogan and Dering 1 showed highly susceptible (HS) and susceptible (S) categories, respectively (Table 2). All genotypes showed moderately resistant (MR) category to leaf rust disease *(Phakopsora pachyrhizi)*.

There was no soybean line showed resistant (R) category based on resistant level to three major pests above. Soybean line DG-91-8 showed resistant (R) category to

Table 1: Drought-tolerant soybean lines and their parents used in the study.

Code	Genotypes	Parents of crosses
G1	DG-91-8	Dering 1 × Grobogan
G2	AGm-29-3-2	Arg/GCP × Gema
G3	DG-97-10-5	Dering 1 × Grobogan
G4	AGm-37-29	Arg/GCP × Gema
G5	TGm-161-25-10	Tanggamus × Gema
G6	DG-99-32-14	Dering 1× Grobogan
G7	DG-100-33-15	Dering 1 × Grobogan
G8	DM-122-35-17	Dering 1 × Malabar
G9	TGm-288-38-19	Tanggamus × Gema
G10	AGm-293-20-8	Arg/GCP × Gema
G11	AB-157-41-22	Arg/GCP × Baluran
G12	DG-235-42-23	Dering 1 × Grobogan
G13	DG-240-44-25	Dering 1 × Grobogan
G14	Dering 1*	Davros × MLG 2984
G15	Grobogan*	Local of district Grobogan, Central Java

*Dering 1 is resistant to pod borer and leaf rust; grobogan is resistant to armyworm.

pod borer and pod sucker, while DM-122-35-17 showed resistant (R) category to army worm and pod borer. Three soybean lines (TGm-161-25-10, AB-157-41-22 and DG-240-44-25) showed moderately resistant (MR) category to three major pest above (Table 2). Two soybean lines (DG-91-8 and DG-240-44-25) showed improvement on resistance level to three major pest above compared to check varieties Grobogan and Dering 1 as their parents in their pedegree crosses (Table 1).

Based on the value of the percentage of seed damage, there were two resistant genotypes, however, based on the value of the percentage of pod damage, only one genotype showed a resistant level that was G511H/Anjasmoro// Anjasmoro-2-8. A very high natural population of pod sucking

Table 2: The resistance levels of 13 drought tolerant soybean lines and 2 check varieties to the main pests and rust disease. Malang, 2017.

Genotypes	Army worm [a)]		Pod sucker [a)]		Pod borer [a)]		Leaf rust [a]		
	Intensity of leaf damage (%)		Intensity of seed damage(%)		Intensity of seed Leaf rust [a]		Number of pustule/cm^2		
DG-91-8	42.1	S[b)]	33.8	R[b)]	26.4	R[b)]	12	232 [c)]	MR[b)]
AGm-29-3-2	34.9	R	68.5	HS	43.9	MR	13	232	MR
DG-97-10-5	50.2	HS	54.2	MR	51.0	S	14	232	MR
AGm-37-29	38.2	MR	62.2	S	60.4	S	15	232	MR
TGm-161-25-10	37.6	MR	53.3	MR	33.4	MR	19	242	MR
DG-99-32-14	47.2	HS	58.9	S	47.7	S	16	232	MR
DG-100-33-15	47.9	HS	54.2	MR	22.1	R	23	242	MR
DM-122-35-17	35.5	R	54.3	MR	19.9	R	21	242	MR
TGm-288-38-19	37.3	MR	59.9	S	37.5	MR	14	232	MR
AGm-293-20-8	47.3	HS	67.9	HS	88.0	HS	17	242	MR
AB-157-41-22	37.2	MR	49.4	MR	39.7	MR	19	242	MR
DG-235-42-23	49.6	HS	56.5	MR	62.0	S	20	242	MR
DG-240-44-25	38.9	MR	48.0	MR	41.0	MR	14	232	MR
Dering 1 (cek)	38.6	MR	80.5	HS	78.3	HS	12	232	MR
Grobogan (cek)	35.6	R	54.6	MR	53.6	S	15	242	MR
Average	41.2		57.1		47.0		16.3		

[a)] Armyworm (*Spodoptera litura*), pod suckers (*Riptortus linearis*), pod borer (*Etiella zinckenella*), leaf rust disease (*Phakopsora pachyrhizi*).

[b)] HR = Highly resistant; R = Resistant; MR = Moderately resistant; S = Susceptible; HS = Highly susceptible.

[c)] Score of leaf rust disease.

Table 3: Seed yield, yield components, protein and fat concentrations of 13 drought tolerant soybean genotypes. Malang, 2017.

Genotypes	Seed yield (t/ha)	100 seeds weight (g)	Branch number /plant	Pod number /plant
DG-91-8	2.70 ab	14.3	3.7	39.7
Agm-29-3-2	2.57 abcd	11.9	3.1	44.6
DG-97-10-5	2.67 ab	12.3	3.8	71.2
AGm-37-29	2.32 abcd	11.8	4,1	53.4
TGm-161-25-10	2.11 d	10.4	5.0	42.0
DG-99-32-14	2.76 a	12.7	3.4	43.3
DG-100-33-15	2.62 abc	11.7	3.9	45.1
DM-122-35-17	2.34 abcd	12.6	3.6	49.1
TGm-288-38-19	2.26 bcd	11.9	3.9	41.4
AGm-293-20-8	2.15 cd	13.7	4.4	32.1
AB-157-41-22	2.68 ab	14.9	3.8	44.3
DG-235-42-23	2.34 abcd	11.8	3.2	40.7
DG-240-44-25	2.45 abcd	14.0	3.7	44.0
Dering 1 (cek)	2.41 abcd	10.9	4.5	36.9
Grobogan (cek)	1.47 e	18.2	2.5	28.8
Average	2.39	12.9	3.7	43.8
LSD 5%	0.50			

* and ** = Significant at 5% and 1% levels, respectively.

bug was recorded in the field with the average number of damaged pod in full protection environment (L1) and insecticide control until 50 dap (L2), *i.e.* 41.45% and 60.16%, respectively. Genotype of G511H/Anj//Anj-2-8 was consistently resistant to pod sucking bug both in L1 and L2 (Krisnawati *et al.*, 2016; 2017; 2018).

Seed yield and yield components

The seed yield of 13 soybean lines ranged from 2.11 to 2.76 t/ha. Seven lines showed higher seed yield than check varieties (Dering 1 and Grobogan). Two highest yielding line (DG-91-8 and DG-99-32-14) had 15% higher seed yield than check variety Dering 1 (2.41 t/ha). These two lines also had higher seed size (100 seeds weight) and pod number/plant (Table 3). Soybean line DG-91-8 also showed resistant (R) category to pod borer and pod sucker (Table 2).

Protein and fat concentrations

The range of protein and fat concentrations of soybean lines are presented in Table 4. The highest protein and fat concentrations was showed by TGm-288-38-19 (41.47%) and AB-157-41-22 (19.74%), respectively. These concentrations were higher than the check varieties Dering 1 and Grobogan.

Table 4: Protein and fat concentrations of 13 soybean genotypes. Malang, 2017.

Genotypes	Protein (%)	Fat (%)
DG-91-8	38.14 d	14.88 i
Agm-29-3-2	38.94 cd	16.23 g
DG-97-10-5	36.60 ef	17.51 e
AGm-37-29	40.23 abc	15.32 h
TGm-161-25-10	38.48 d	18.21 cd
DG-99-32-14	38.60 d	17.24 f
DG-100-33-15	38.66 d	18.30 c
DM-122-35-17	40.49 ab	17.46 ef
TGm-288-38-19	41.47 a	15.17 h
AGm-293-20-8	38.18 d	18.65 b
AB-157-41-22	35.96 f	19.74 a
DG-235-42-23	38.75 cd	17.97 d
DG-240-44-25	38.04 de	17.37 ef
Dering 1 (cek)	38.72 cd	17.52 e
Grobogan (cek)	39.51 bcd	17.99 d
Average	38.72	17.30
LSD 5%	1.53	0.24

Correlation among characters

The correlation among characters of soybean lines are presented in Table 5. The correlation between protein content and fat concentration shows a significant negative value, but did not show a significant correlation with the intensity of infestation of the three pest types. Fat concentration shows a significant positive correlation with leaf rust disease. Pod suckers showed a significant positive correlation with the intensity of pod borer infestation, indicating that these two types of pests had the same preference for soybean pods. Seed yield and number of pods showed significant positive correlation value. This finding agrees with the study reported by San *et al.* (2022) that there was a negative relationship between biological attributes of *H. armigera* and protein content in different chickpea genotypes.

The different response of genotype to pod borer attack could be influenced by various factors, including pod morphology (wall thickness of pods, number of pods/ cluster, angle between pods in one cluster, trichome pods, length, density and position of trichome pods, pod length and pod width). In addition to differences in pod morphology, the content of compounds or plant nutrients can also affect the level of pod borer attack (Sunitha *et al.,* 2008; Halder and Srinivasan 2007; 2011).

Plant resistant to insect pest may expressed in a morphological characters such as dense and rigid, irregular trichome structure, the thicker leaves and stem and harder pod shell (Suharsono 2009; Suharsono and Sulistyowati 2012). Resistance to pod sucking pests associated with pod morphological factors (antixenosis) as well as antibiosis factors (Haq *et al.,* 2003; War *et al.,* 2012). The angle between the pods and the widt h of the pods showed a negative correlation with pod damage of pegeon pea genotypes (Halder and Srinivasan 2011). The level damageof soybean pod do tue pd sucking bug on soybean varieties Kipas Merah and Anjasmoro determined by the number of trichomes, wide surface pod and number pod per nodes (Hendrival *et al.*, 2013).

Table 5: Correlation among soybean traits of 15 soybean genotypes.

	Fat conc.	Army worm	Pod sucker	Pod borer	Leaf rust	Seed yield	Pod number/plant
Protein conc.	-0.552*	-0.373	0.267	-0.105	-0.010	-0.448	-0.244
Fat conc.	-	0.228	0.080	0.175	0.600*	-0.136	-0.154
Army worm		-	-0.064	0.241	0.257	0.343	0.257
Pod sucker			-	0.676**	-0.169	-0.167	-0.154
Pod borer				-	-0.328	-0.254	-0.256
Leaf rust					-	-0.070	0.004
Seed yield (t/ha)						-	0.513*

* Significant at 5% probability level.

CONCLUSION

Two highest yielding line (DG-91-8 and DG-99-32-14) had 15% higher seed yield than check variety Dering 1 (2.41 t/ha), with higher seed size (100 seeds weight) and pod number/plant. Fat concentration showed a significant positive correlation value with leaf rust disease. Pod suckers showed a significant positive correlation value with the intensity of pod borer infestation, indicating that these two types of pests had the same preference for soybean pods. Soybean line DG-91-8 was the most ideal line since it showed high seed yield (2.70 t/ha) and resistant (R) category to pod borer and pod sucker.

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