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Mechanisms of antixenosis, antibiosis, and tolerance of fourteen soybean genotypes in response to whiteflies (*Bemisia tabaci*)

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Abstract. *Sulistyo A, Inayati A. 2016. Mechanisms of antixenosis, antibiosis, and tolerance of fourteen soybean genotypes in response to whiteflies (*Bemisia tabaci*). Biodiversitas 17: 447-453.* The attack of whiteflies (*Bemisia tabaci*) in soybean cultivation in Indonesia is one of the limiting factors in increasing the national soybean production. Planting resistant varieties could reduce yield losses due to the damage caused by these pests. This study was conducted to evaluate the resistance of 14 soybean genotypes to the whiteflies. A free-choice and no-choice test was conducted in a green house to study the antixenosis and antibiosis. Meanwhile, field evaluation was conducted to determine the tolerance of soybean genotypes to the whiteflies. Determination of the resistance of soybean genotypes to whiteflies based on the intensity of leaf damage that occurs on fifth weeks after infestation. The results showed that in free-choice test, Gema, IAC-100/Kaba-6, Malabar/IAC-100-85, Kaba/IAC-100//Burangrang-60, and Kaba/IAC-100//Burangrang-63 showed antixenosis mechanism which correlates with length and low density of leaf trichomes as well as leaf thickness. In the no-choice test, antibiosis mechanism can be seen from the small number of adults that develop from nymphs. IAC-100/Kaba-8 and IAC-100/Kaba-14 showed a high degree of antibiosis. In addition, the results of field experiment showed that Gema, IAC-100/Kaba-14, and Tanggamus/Pangrango-78 demonstrated a tolerance to whiteflies. It is shown on a slightly decreasing in yield of these three genotypes (17.33, 19.31, and 19.85%, respectively).

Keywords: decreasing in yield, *Glycine max*, host plant resistance, non-preference, resistance mechanism
Abbreviations: LDI = leaf damage intensity, RC = resistant category, R = resistant, MR = moderately resistant, S = susceptible, HS = highly susceptible, YD = yield decreasing,

INTRODUCTION

Soybean is one of the most important food commodities in Indonesia and ranks third after rice and maize. As a raw material in the food industry in Indonesia, soybean usually processed into tempe, tofu, bean sprouts, soy sauce, and soy milk (Ginting et al. 2009). These five types of processed soybean foods are source of vegetable protein and consumed daily for the majority of Indonesian people. It makes soybean has a strategic role and economic value. According to Sudaryanto and Swastika (2007), soybean consumption in Indonesia reached an average rate of 8.12 kg per year and soybean demand to consumption is expected increase an average of 2.44% per year. Unfortunately, the domestic soybean production is only able to meet 33.33% of the national soybean demand and the rest (66.67%) is met through imports (AMIS 2015). Soybean imports continuously going to make Indonesia relies on imported soybean and can be a serious threat to national food security (Supadi 2009). Increasing the national soybean production is one solution to reduce dependence on imported soybeans.

The efforts to increase soybean production in Indonesia often face of various problems in the field, such as interference from plant intruder organism (pests and diseases) as well as a lack of water as a consequence of the cultivation of soybean that usually falls in dry season following cropping pattern of rice-rice-soybean. The pests on soybean can attack the leaves, pods and stems. One of the pests that attack the leaves of soybean is whiteflies (*Bemisia tabaci* Genn.). Whiteflies can lead to damage either directly or indirectly (Hoodle 2013). Direct damage occurred when the stylet of whiteflies piercing the leaves and suck the liquid that causes chlorosis in plants (Gulluoglu et al. 2010a). While the indirect damage occurs due to the accumulation of honey dew that trigger the growth of sooty mold on the entire surface of the leaf and disrupted the process of photosynthesis (Hilje and Morales 2008). In addition, the whiteflies are also known to play a role as vectors of cowpea mild mottle virus (CMMV) on soybean plants (Rodrigues et al. 2014).

Until now, controlling pests in soybean by spraying insecticides is a method that widely adopted by farmers (Song and Swinton 2009). However, Palumbo et al. (2001) argue that the control of whiteflies by spraying chemical insecticides has not given satisfactory results. According to Norris et al. (2003) this was due to new strains of whiteflies easily formed with increasing levels of resistance to pesticides. Additionally, Bueno et al. (2011) found that the prophylactic use of insecticides in the soybean does not lead to higher productivity in the field when compared with the technique of integrated pest management (IPM) and biological control. Excessive insecticide applications also have a negative impact on the environments, one of them is impairing the efficiency of all existing biological control agents for soybeans (Carmo et al. 2010). One of pest control techniques in accordance with the principles of IPM is the use of resistant varieties, because this method can be combined with other control techniques that are environmentally friendly, such as the application of biological pesticide or biological agents (Ellsworth and Martinez-Carrillo 2001; Stansly and Natwick 2010; Vieira et al. 2011).

Breeding programs for improvement of soybean varieties that resistant to whiteflies has not been much done in Indonesia (Sulistyo 2014). It can be seen from 84 varieties of soybeans that have been released by the Indonesian government, there is only one variety (Tengger variety) was described as moderately resistant to whiteflies. However, previous studies shown that four out of eight soybean varieties classified as moderately resistant to whiteflies (Sulistyo and Inayati 2014). Resistance information of soybean genotypes to the whiteflies is important to be known by soybean breeders as a guide in selecting source of resistance genes to be used in the improvement of soybean varieties resistant to whiteflies. There are several methods to determine the resistance of soybean genotypes to the whiteflies, among others, by counting the number of population of whiteflies (eggs, larvae, and pupae) per leaf (Gulluoglu et al. 2010b), or the number of nymphs per leaf (Xu et al. 2005; Amro et al. 2007; Xu et al. 2009; Xu 2009), and based on the intensity of leaf damage due to the attack of whiteflies (Inayati and Marwoto 2012; Taggar et al. 2013). The success of the utilization of soybean genotypes that resistant to whiteflies has been reported by researchers in Turkey (Gulluoglu et al. 2010b). The aim of this study was to determine the resistance of soybean genotypes to whiteflies.

MATERIALS AND METHODS

This study consists of two parts, i.e. greenhouse experiments and field experiment. Greenhouse experiments were conducted at Indonesian Legumes and Tuber Crops Research Institute (ILETRI) in Malang district, meanwhile field experiment was done at Muneng Experiment Station, in Probolinggo district. Plant genetic material used was 14 soybean genotypes consisting of 12 lines and two varieties. The two soybean varieties in these research used as a moderately resistant check (Gema), and susceptible check (Anjasmoro) according to previous study (Sulistyo and Inayati 2014). Meanwhile, the 12 lines tested were the offspring of IAC 100 which used as a source of resistance genes to whiteflies (Lima and Lara 2004, Pinheiro et al. 2005).

Greenhouse experiment

The greenhouse experiment was performed through two methods, i.e. free-choice test (tests of attractiveness and preference for oviposition) and no-choice test.

Free-choice test

The entire of plant genetic materials used were grown in plastic pots. Each genotype were planted in 15 plastic pots and arranged in randomized completely block design with three replicates, each replicates consist of five plastic pots. In free-choice test, each replicate caged in a bamboo cage which covered with tile fabric (200 cm of height x 150 cm of width x 350 cm of length) for the purpose of limiting the movement of whiteflies from one replicate to another replicates, but still allows for whiteflies to move from one genotype to another genotypes in accordance with its preferred. Infestation of whiteflies performed at 2-weeks-old plants by laying 10 whiteflies adults on the surface of leaves each individual plant (Mansaray and Sundufu 2009). Weekly observations were carried out on population of whiteflies (egg, nymph, pupae, and adult) following the method of Vieira et al. (2011). Determination of the resistance of soybean genotypes to whiteflies based on the intensity of leaf damage that occurs on fifth weeks after infestation. The intensity of leaf damage was calculated based on a scale of leaf damage following the scores made by Inayati and Marwoto (2012).

No-choice test

This test was done to confirm the resistance of a genotype due to preference or other factors. All of the tested genotypes grown in 15 plastic pots and arranged as randomized completely block design with three replicates. In no-choice test, each plastic pot was individually caged in a bamboo cage which covered with tile fabric (50 cm of diameter x 120 cm of height) with the intention of preventing whiteflies moved to other plant and forced to breed in that plants. Whiteflies infestation and observations of whiteflies population and the intensity of leaf damage was done as in free-choice test which has been described previously.

Field experiment

The field experiment was conducted in the dry season from June to September in 2012. Each genotype were planted on plots measuring width of 2 m and length of 3 m, and laid out as randomized completely block design with three replicates. Planting spacing used was 40 cm between rows and 15 cm within rows, two plants per hole. Fertilization was conducted at planting time to the dose given in accordance with the recommendation, i.e. 50 kg ha^{-1} Urea, 100 kg ha^{-1} SP36, and 100 kg ha^{-1} KCl. Irrigation was done four times, i.e. at planting time, on 3 weeks after planting, during flowering and pods filling. In this study, there were no artificial infestations of whiteflies, but whiteflies allowed to attacking naturally. Therefore, pest control was only performed for other pests besides whiteflies with the purpose of conditioning the whiteflies stress in the field. For the purposes of calculating the percentage of decreasing in soybean yields due to the attack of whiteflies, then a set of the same study conducted in the same time and same location, but separate from the first study with performed pest control optimally including whiteflies. Pest control on this plot carried out by spraying Alika® once a week from 21 to 42 days after planting (dap), and followed by spraying Pegasus® from 49 to 70 dap. Observations were carried out on the intensity of leaf damage due to whiteflies and yield per plot.

Data analysis

The data obtained was statistically analyzed using SAS v.9 software. Duncan Multiple Range Test (DMRT) was done when the F test showed significantly differences among the 14 soybean genotypes tested.

RESULTS AND DISCUSSION

Greenhouse experiment

Observations on free-choice test showed that there are significantly differences in the intensity of leaf damage. The intensity of leaf damage of 14 soybean genotypes varied from 35.18% to 76.59% (Table 1). Anjasmoro as check susceptible showed leaf damage with the most severe intensity. Three lines (G100H/9305//IAC-100-195, IAC 100/Kaba-17, and IAC 100/Kaba-5) showed the intensity of leaf damage with the level of damage as severe as Anjasmoro. Meanwhile, Gema as check moderately resistant indicate the smallest intensity of leaf damage. None of the 12 genotypes with the intensity of leaf damage which is smaller than Gema. Based on the intensity of leaf damage that occurs, then soybean genotypes were tested can be classified into resistant (IAC-100/Kaba-8 and Gema), moderately resistant (IAC-100/Kaba-6, IAC-100/Kaba-14, Malabar/IAC-100-85, Kaba/IAC-100//Burangrang-60, and Kaba/IAC-100//Burangrang-63), susceptible (G100H/9305// IAC-100-271, IAC-100/Burangrang-11, IAC-100/Kaba-5, IAC-100/Kaba-17, and Tanggamus/Pangrango-78), and highly susceptible (G100H/9305//IAC-100-195 and Anjasmoro) (Table 1).

In the free-choice test, differences in resistance of soybean genotypes to whiteflies can be explained by considering the relationship between the number of whiteflies infestations (eggs, nymphs, and adults) with the characteristics of the leaves. Gema and IAC-100/Kaba-8 that classified as resistant to whiteflies (Table 1) have a long leaf trichomes with low density (Table 2). The numbers of eggs were observed on both genotypes relatively small, 2.33 and 1.33 eggs respectively (Table 1). Similarly, the genotypes that is moderately resistant to whiteflies (IAC-100/Kaba-6, Malabar/IAC-100-85, Kaba/IAC-100//Burangrang-60, and Kaba/IAC-100//Burangrang-63) shows the same relationship between the numbers of eggs with the characteristics of trichomes such as those found in Gema and IAC-100/Kaba-8. This indicates that the characteristics of the leaf trichomes determine the preference of whiteflies for oviposition.

In addition, the thickness of the leaves affects the whiteflies in forming colony on the leaf surface of soybean genotypes tested. The leaves were thick, such as those found in all genotypes that classified as resistant and moderately resistant to whiteflies, prevents the colonization of nymphs and adults of whiteflies. This is most noticeable on IAC-100/Kaba-6, IAC-100/Kaba-14, Malabar/IAC-100-85, and Gema which has thick leaves (Table 2). A small number of nymphs or adults that recorded on that four soybean genotypes indicates an antixenosis mechanism (Table 1). It is contrary to Anjasmoro variety, a small amounts of nymphs and adults cause more severe damage up to 76.59% indicating the sensitivity of Anjasmoro to whiteflies.

Observations on no-choice test showed that there are significantly differences in the intensity of leaf damage (Table 3). Among the 14 soybean genotypes tested, the highest intensity of leaf damage was recorded on G100H/9305//IAC-100-195 (61.38%), followed by IAC-100/Burangrang-11 (52.27%), and G100H/9305//IAC-100-271 (51.40%). In this test, the intensity of leaf damage on Anjasmoro variety are 45.15% and not significantly different with the previous three genotypes. Meanwhile, the lowest intensity of leaf damage was found on IAC-100/Kaba-14 (24.85%), followed by Gema variety (26.16%) and Malabar/IAC-100-85 (30.32%). Based on the intensity of leaf damage that occurs, then the soybean genotypes were tested can be categorized as resistant (IAC-100/Kaba-14, Malabar/IAC-100-85, and Gema), moderately resistant (IAC-100/Kaba-5, IAC-100/Kaba-8, IAC-100/Kaba-17, and Tanggamus/Pangrango-78), susceptible (G100H/9305//IAC-100-271, IAC-100/Kaba-6, Kaba/IAC-100//Burangrang-60, Kaba/IAC-100//Burangrang-63, and Anjasmoro), and highly susceptible (G100H/9305//IAC-100-195 and IAC-100/Burangrang-11) (Table 3).

Table 3 shows the number of nymphs, pupae, and adults of whiteflies that found on each surface of the leaves of soybean genotypes in no-choice test. The high intensity of leaf damages which occurs in both susceptible and highly susceptible genotypes is due to the colonization of nymphs. On Anjasmoro variety, although only few number of nymphs and adults were recorded, but it has caused damage as severe as in susceptible and highly susceptible genotypes. This indicates the sensitivity of Anjasmoro to the whiteflies. While in the group of genotypes resistant and moderately resistant to whiteflies, it appears the failure of nymphs to develop into adults. This suggests a mechanism of antibiosis on these genotypes. Antibiosis with high degree was found in IAC-100/Kaba-8 and IAC-100/Kaba-14. The number of nymphs in both genotypes was 66.67 and 53.67, respectively. However, the number of adult were observed on the following observations is only as many as 0.33 for each genotypes (Table 3).

Field experiment

The results of the field test showed that the intensity of leaf damage of 14 soybean genotypes tested varies from 14.10% to 19.12% (Table 4). Based on these results there are three genotypes resistant (IAC-100/Kaba-14, IAC-100/Kaba-17, and Kaba/IAC-100//Burangrang-63), four genotypes moderately resistant (IAC-100/Burangrang-11, IAC-100/Kaba-5, IAC-100/Kaba-6, and Gema), four genotypes susceptible (IAC-100/Kaba-8, Malabar/IAC-100-85, Kaba/IAC-100//Burangrang-60, and Tanggamus/ Pangrango-78), and three genotypes highly susceptible (G100H/9305//IAC-100-195, G100H/9305//IAC-100-271, and Anjasmoro). When compared with the results obtained in free-choice test and no-choice test, it appears that Anjasmoro consistently susceptible and Gema consistently resistant to whiteflies. This means that both varieties can indeed be used as a susceptible check (Anjasmoro) and resistant check (Gema) against whiteflies.

Table 1. The resistance differences of 14 soybean genotypes to whiteflies on free-choice test

Genotype	LDI	RC	Eggs	Nymphs	Adults
G100H/9305//IAC-100-195	68.47^{ab}	HS	1.00^{cde}	44.00^{a}	6.00^{de}
G100H/9305//IAC-100-271	53.54^{bcd}	S	5.00^{b}	16.00^{efg}	4.00^{f}
IAC-100/Burangrang-11	53.98^{bcd}	S	1.33^{cde}	17.00^{ef}	10.33^{c}
IAC-100/Kaba-5	61.14^{abc}	S	0.33^{e}	17.33^{ef}	9.33^{c}
IAC-100/Kaba-6	50.19^{bcd}	MR	2.33^{c}	19.67^{de}	7.33^{d}
IAC-100/Kaba-8	37.34^{d}	R	1.33^{cde}	28.67^{c}	5.67^{e}
IAC-100/Kaba-14	43.41^{cd}	MR	7.00^{a}	16.33^{efg}	4.00^{f}
IAC-100/Kaba-17	61.45^{abc}	S	0.67^{de}	36.00^{b}	3.33^{fg}
Malabar/IAC-100-85	44.17^{cd}	MR	0.67^{de}	16.00^{efg}	1.00^{h}
Kaba/IAC-100//Burangrang-60	53.31^{bcd}	MR	2.00^{cd}	4.33^{h}	4.67^{ef}
Kaba/IAC-100//Burangrang-63	50.34^{bcd}	MR	0.33^{e}	12.33^{g}	1.33^{h}
Tanggamus/Pangrango-78	55.62^{a-d}	S	4.00^{b}	16.00^{efg}	30.67^{a}
Anjasmoro	76.59^{a}	HS	4.33^{b}	23.00^{d}	2.33^{gh}
Gema	35.18^{e}	R	2.33^{c}	15.00^{fg}	16.33^{b}

Note: Means within a column and followed by the same letter (s) are not significantly different based on DMRT at 5%, LDI = leaf damage intensity, RC = resistant category, R = resistant, MR = moderately resistant, S = susceptible, HS = highly susceptible

Table 2. Characteristics of leaf trichomes and leaf thickness of 14 soybean genotypes

Genotype	Length of leaf trichomes (μm)	Number of leaf trichomes	Thickness of leaves (μm)
G100H/9305//IAC-100-195	105^{b}	101^{b}	147^{de}
G100H/9305//IAC-100-271	107^{b}	139^{a}	173^{bcde}
IAC-100/Burangrang-11	89^{cd}	68^{d}	233^{a}
IAC-100/Kaba-5	82^{d}	63^{de}	157^{cde}
IAC-100/Kaba-6	93^{c}	67^{d}	227^{ab}
IAC-100/Kaba-8	94^{c}	56^{def}	143^{de}
IAC-100/Kaba-14	90^{cd}	44^{f}	203^{abc}
IAC-100/Kaba-17	93^{c}	67^{d}	150^{cde}
Malabar/IAC-100-85	156^{a}	65^{d}	220^{ab}
Kaba/IAC-100//Burangrang-60	108^{b}	61^{de}	187^{abcde}
Kaba/IAC-100//Burangrang-63	109^{b}	54^{def}	173^{bcde}
Tanggamus/Pangrango-78	95^{c}	57^{de}	193^{abcd}
Anjasmoro	108^{b}	84^{c}	137^{e}
Gema	107^{b}	51^{ef}	203^{abc}

Note: Means within a column and followed by the same letter (s) are not significantly different based on DMRT at 5%

Table 3. The resistance differences of 14 soybean genotypes to whiteflies on no-choice test

Genotype	LDI	RC	Nymphs	Pupae	Adults
G100H/9305//IAC-100-195	61.38^{a}	HS	32.00^{de}	23.00^{d}	1.67^{b}
G100H/9305//IAC-100-271	51.40^{ab}	S	20.67^{fg}	0.33^{h}	0.00^{c}
IAC-100/Burangrang-11	52.27^{ab}	HS	21.00^{fg}	56.00^{a}	0.00^{c}
IAC-100/Kaba-5	41.04^{b-e}	MR	35.00^{cd}	23.00^{d}	5.00^{a}
IAC-100/Kaba-6	48.55^{abc}	S	27.00^{ef}	0.67^{h}	0.00^{c}
IAC-100/Kaba-8	41.07^{b-e}	MR	66.67^{a}	36.00^{c}	0.33^{c}
IAC-100/Kaba-14	24.85^{e}	R	53.67^{b}	44.33^{b}	0.33^{c}
IAC-100/Kaba-17	35.05^{b-e}	MR	22.00^{fg}	0.33^{h}	0.00^{c}
Malabar/IAC-100-85	30.32^{cde}	R	9.00^{i}	4.67^{g}	0.33^{c}
Kaba/IAC-100//Burangrang-60	43.82^{a-d}	S	16.00^{gh}	15.00^{e}	0.00^{c}
Kaba/IAC-100//Burangrang-63	49.91^{ab}	S	38.67^{c}	15.00^{e}	0.00^{c}
Tanggamus/Pangrango-78	35.08^{cde}	MR	24.00^{f}	0.33^{h}	0.33^{c}
Anjasmoro	45.15^{abc}	S	12.33^{hi}	8.33^{f}	0.33^{c}
Gema	26.16^{de}	R	8.00^{i}	0.00^{h}	0.00^{c}

Note: Means within a column and followed by the same letter (s) are not significantly different based on DMRT at 5%, LDI = leaf damage intensity, RC = resistant category, R = resistant, MR = moderately resistant, S = susceptible, HS = highly susceptible

Table 4. The resistance differences of 14 soybean genotypes to whiteflies on field experiment

Genotypes	LDI	RC	Yield		YD
			Pesticide	Non-pesticide	
G100H/9305//IAC-100-195	17.72[abc]	HS	935[a]	597[cd]	39.34[abc]
G100H/9305//IAC-100-271	18.26[ab]	HS	920[a]	720[abc]	21.42[bc]
IAC-100/Burangrang-11	15.05[bcd]	MR	1,066[a]	858[ab]	20.38[c]
IAC-100/Kaba-5	15.32[bcd]	MR	1,063[a]	838[ab]	21.57[bc]
IAC-100/Kaba-6	16.05[abcd]	MR	1,068[a]	765[abc]	28.61[bc]
IAC-100/Kaba-8	16.34[abcd]	S	1,126[a]	773[abc]	31.96[bc]
IAC-100/Kaba-14	14.10[d]	R	1,113[a]	899[a]	19.31[c]
IAC-100/Kaba-17	14.76[cd]	R	953[a]	746[abc]	22.85[bc]
Malabar/IAC-100-85	16.65[abcd]	S	941[a]	517[d]	45.54[ab]
Kaba/IAC-100//Burangrang-60	16.50[abcd]	S	972[a]	696[bc]	26.46[bc]
Kaba/IAC-100//Burangrang-63	14.71[cd]	R	1,065[a]	824[ab]	22.76[bc]
Tanggamus/Pangrango-78	16.71[abcd]	S	999[a]	805[ab]	19.85[c]
Anjasmoro	19.12[a]	HS	524[b]	182[e]	56.43[a]
Gema	15.63[bcd]	MR	985[a]	809[ab]	17.33[c]

Note: Means within a column and followed by the same letter (s) are not significantly different based on DMRT at 5%, LDI = leaf damage intensity, RC = resistant category, YD = yield decreasing, R = resistant, MR = moderately resistant, S = susceptible, HS = highly susceptible

The grain yield of 14 soybean genotypes in the control plot (whiteflies controlled with pesticide) and treatment plot (non pesticide) shown in Table 4. The results showed that Anjasmoro producing the lowest seed in the control plot, while 12 genotypes tested capable of producing seeds that are not significantly different with Gema. Whiteflies attack that occurred on treatment plots causing damage to the leaves of soybean genotypes tested. As a result, the process of forming and filling seed disrupted and resulting in loss of grain yield. The highest grain yield decrease was found in Anjasmoro, amounting to 56.43%, while the lowest grain yield loss encountered in Gema (17.33%), followed by IAC-100/Kaba-14 (19.31%), and Tanggamus/Pangrango-78 (19.85%). The loss of grain yield in small amounts indicates tolerance of the three soybean genotypes to whiteflies.

Discussion

The mechanism of a host plant resistance against insect herbivores divided into three, namely antixenosis, antibiosis, and tolerance (Emden 2002). Antixenosis refers to the absence of the host plant attractiveness for insects to laying eggs and feeding. In other words, antixenosis cause adverse effects on insect behavior. Antibiosis refers to adverse biologically consequences on the life cycle of pests as a result of feeding activity on resistant host plant. Symptoms of antibiosis mechanism among others are the larval mortality, increased mortality of pupae, failure of the adult out of pupae, the low fertility of adult, short life cycle of insects, and other forms of abnormality. While, tolerance is defined as the ability of resistant host plant to produces seeds better than susceptible host plant at the same level of attack of pest.

One of the mechanisms antixenosis affected by the length and density of leaf trichomes. These results are in line with Ihsan-ul-Haq et al. (2003) who found that the leaf trichome is one of the leaf morphology affecting soybean resistance to whiteflies. In this research, genotypes that are resistant to whiteflies have long leaf trichomes with low density. Characteristics leaf trichomes like this are not favored by the whiteflies for oviposition. Lima and Lara (2004) reported the same result that the number of eggs on the soybean genotypes with high density of trichomes is significantly higher when compared to the soybean genotypes with low density of trichomes. Vieira et al. (2011) explained that leaf trichomes with high density preventing the eggs blown off and keep it on the leaf surface. Valle et al. (2012) added that the interaction between the density, size, and angle of inclination of leaf trichomes will determine the resistance of soybean genotypes to the whiteflies. According to War et al. (2012), leaf trichomes function mechanically by disrupting the movement of insect herbivores on the leaf surface, thereby reducing access to the leaf epidermis.

The thickness of the leaves on soybean genotypes that resistant and moderately resistant to whiteflies were also affects antixenosis mechanisms that were found in this study. Thicker leaf would complicate the stylet of whiteflies to penetrate the epidermis of leaves and interrupt the feeding process. It is possible reasons that may explain the small number of colonies of nymphs were found on soybean genotypes that resistant and moderately resistant to whiteflies. These results were contradictory to those reported on other legumes crop. Lakshminarayan et al. (2008) reported that green gram (*Vigna radiata*) genotypes that are resistant to whiteflies have a thin leaf lamina. Similarly in the black gram (*Vigna mungo*), Taggar and Gill (2012) reported that a small amount of whiteflies found in genotypes that moderately resistant with a thin leaf lamina characteristic. Leaves with thinner lamina both in green gram and black gram might be were less succulent and thus were less preferred by whiteflies for feeding and oviposition.

Antibiosis symptom that found in this study is the failure of nymphs to develop into adults. The resistance antibiosis that found on IAC-100/Kaba-8 and IAC-

100/Kaba-14 allegedly originated from IAC-100. Lima and Lara (2004) reported that IAC 100 affect negatively on whiteflies by prolonging the period of nymphs and reducing the appearance of adults. Another antibiosis symptom that has been reported in soybean includes least amount of eggs that hatch into nymphs (Vieira et al. 2011), and the short life cycle of whiteflies (Silva et al. 2012). According to Taggar et al. (2014), a negative correlation between the content of tannins and flavonols with whiteflies population indicate that an increase in the content of these biochemical contribute to the bio-protection of host plants against whiteflies.

The tolerance of host plants against insect herbivores indicated by the ability of the host plants to produce seeds that are relatively stable during the attack of pests. In this study, it was shown by the decrease of grain yield that slightly between the plot with optimal pest control and the plot with no pest control. According to Tiffin (2000), tolerance mechanisms of the host plant may be through increased photosynthesis process, compensatory growth, utilization of stored reserves, and phonological delays. Based on grain yield on two plots with two different treatments (optimal control and non pesticide) in this study, it seems the tolerance of soybean genotypes that tested following the first mechanism (increased photosynthetic activity). The results of field observations showed that the leaves on tolerant genotypes suffered a little damage compared to the susceptible genotypes. This causes tolerant genotypes are still capable of producing seeds. Baldin (2004) reported the same tolerance mechanism in genotype KS-4202. The results of further studies on the genotype KS-4202 demonstrated that the main cause of tolerance on this genotype is not from oxidative enzymes (Cruz 2015).

Based on the results obtained in this research, it was conclude that there are different responses of 14 soybean genotypes tested against whiteflies (*Bemisia tabaci*). The mechanism of resistance of these genotypes can be either antixenosis nor antibiosis, and tolerance. Soybean genotypes resistant to whiteflies can be used as a source of resistance genes in the assembly of the soybean varieties resistant to whiteflies.

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