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Susceptibility of Maize Genotypes to Maize Weevil *Sitophilus zeamais* Motsch. (Coleoptera: Curculionidae)

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ABSTRACT

One possibility to protect the maize from storage pests is by developing genotypes that resistant to maize weevil (*Sitophilus zeamais* Motsch). The research was aimed to evaluate the susceptibility of several maize genotypes including local variety to the maize weevil. Six genotypes i.e. SJA, G10-12-20, G10-1-3, G10-1-7, G10-1-20 and G10-1-17 and Tosari as local variety were used. No-choice assay under laboratory condition with observed variables was laid an egg and F_1 progeny number, the median time of development and weight loss of infested kernel. The susceptibility index was assessed using Dobie's susceptibility index. Results showed that the number of eggs laid by five females and infested samples weight loss were not significantly different between six maize genotypes as well as local variety. In contrast, the number of F_1 progeny emerged was significantly different. Based on the susceptibility index, the maize genotype of G10-1-3 and G10-1-17 were resistant to the weevil. While other maize genotypes and local variety were considered as moderate resistant. Based on analysis of chemical and physical characteristic revealed that maize genotypes with higher of the total phenolic compound and physical hardness tend to resist from weevil damaged.

Keywords: Dobie's susceptibility index; maize genotype; resistance; *Sitophilus zeamais*

INTRODUCTION

Maize is well-known as the main staple food in the world and also a major food in Indonesia. In global, maize is an important crop for a small-scale farmer as food and feed resource (Mwololo et al., 2012). According to Muzemu, Chitamba, & Mutetwa (2013), maize is also the most important crop in Africa that significantly contributes to the national production. Markham, Bosque-Perez, Borgemeister, & Meikle (1994) mentioned that in Africa, losses by storage insect pests i.e.: *Sitophilus zeamais* Motsch determined as a progressively main problem.

In Indonesia, production of maize is not sufficient to meet the national demand and as consequence, the government imported the maize from other countries. Between 2010 and 2013, Indonesian government imported the maize with total volume reached 10.24 million tons, equivalent to the US $ 3.09 billion (Ministry of Agriculture, 2014). To overcome the dependence of imports, the government's effort to the improvement of production, one way is the plant breeding program.

Maize Research Center (MRC), University of Brawijaya is one of research center that have mission to increase maize productivity and it takes the main role in improving food safety at household level. Constraints that can affect the productivity of maize are pests and diseases damage. Demissie, Tefera, & Tadesse (2008) reported that infestation by the pests can occur on the field, but the greatest damage has happened in storage. The quantitative and qualitative deterioration was caused by a number of pests that attacked and damaged the stored maize (Goftishu & Belete, 2014). Among maize insect pests in storage, the weevil *S. zeamais* was the major pest in Indonesia (Kalshoven, 1981).

Due to the attack of *S. zeamais,* corn seeds grow with viability loss and declining nutritional quality (Danho, Gaspar, & Haubruge, 2002). How to control against *S. zeamais* during maize seed stored is to regulate the seed moisture content, sanitation warehouses also conducted periodic fumigation. The excesses that arise from the use of insecticides in deposits is the residue material in seeds, costly and it can kill non-target organisms (Cherry, Banito, Djegui, & Lomer, 2004). To reduce the negative effects, it is needed another safe way to control the environment, namely the use of corn genotypes that are resistant to *S. zeamais*. The aim of this research was to evaluate the resistance character of maize genotypes in Indonesia against *S. zeamais* based on the index of susceptibility.

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MATERIALS AND METHODS

Characteristic of Maize Genotypes

We used six genotypes and a local variety in this study that the genotypes were developed by Maize Research Centre (MRC), University of Brawijaya. The maize genotypes were SJA, G10-12-20, G10-1-3, G10-1-7, G10-1-20 and G10-1-17 and local variety was Tosari (Table 1). Characteristics of maize were observed both of physical (hardness) and chemical content. The hardness of maize genotype was determined using universal testing machine Type Zwick/ZO.5. For chemical contents, the phenolic compound was analyzed using spectrophotometer, while protein and other chemical contents were analyzed using Kjeldahl and Lowry Method.

Susceptibility Experiment

Susceptibility experiment of several maize genotypes to *S. zeamais* was done by no choice assay at Laboratory of Plant Pest, Department of Plant Pests and Diseases, University of Brawijaya from January to March 2015. The laboratory condition was at 26 ± 2 °C temperature and 65 ± 5 % relative humidity (RH). Before the experiment, maize samples were cleaned at 40 °C for four hours and then removed to room temperature at least for 24 hours before use in the experiment (adapted from Heinrich, Kronenberg, Potts, & Habener, 1984). *Sitophilus zeamais* reared in the laboratory were utilized in this study.

Fifty grams of each sterilized maize variety were placed in glass vials (9 cm x 6.5 cm) then three weeks old of five *S. zeamais* adult pairs from the stock culture were transferred and covered on top with lint cloth. The adults of *S. zeamais* allowed to infest each of three 50 g replicated of each maize variety for ten days (Keba & Sori, 2013). At ten days, oviposition period of *S. zeamais* was discharged and the number of the egg was counted. The maize samples with eggs of *S. zeamais* then kept under the experimental conditions to assess the number of larvae, pupae and the emergence of F_1 progeny. To assess the numbers of egg, larvae, and pupae were used destructive observation. Every assessment day, the emergence of progeny was counted in each vial. The observation conducted until all F_1 progeny was expected to have emerged but before the start the F_2 generation (Bashir, 2002). As a control, each of maize variety without *S. zeamais* adult was kept under similar conditions. Completely randomized design with three replications was adopted in experiments.

Data Analysis

Analysis of variance (ANOVA) was used to analyze data such as mortality of adult weevil, number of eggs, the number of larvae, the number of pupae, the number of adults and median development time between genotypes. The correlation was adopted to determine the relationship between the physical and chemical characteristic of maize with susceptibility of maize genotypes to *S. zeamais*. Both analyses were run using R statistic software (R Development Core Team, 2016).

The susceptibility index was calculated using the method of Dobie & Kilminster (1977) which described as $(\log_e F)/D \times 100$, where F and D respectively are the number of F_1 insects developing from eggs laid by five couples of *S. zeamais* adults for ten days and the median development period, estimated as the time (days) from middle of the oviposition period to the emergencies of 50 % of the F_1 generation. There were four categories i.e.: resistant (from 0 to 3), moderately resistant (from 4 to 7), susceptible (from 8 to 10), and highly susceptible (≤ 11) used to categorize maize genotypes based on the susceptibility index ranged from 0 to 11 (Dobie, 1974).

Table 1. Characteristic of maize genotypes in this study

Genotype	Physical	Chemical					
	F-max	Total Phenol (mg g^{-1})	Protein (%)	Fat (%)	Water (%)	Ash (%)	Carbohydrate (%)
SJA	322.473	0.280	10.78	2.67	13.44	1.32	71.79
G10-12-20	402.615	0.714	8.95	3.83	15.76	1.39	70.07
G10-1-3	401.012	2.567	10.94	4.04	10.07	1.33	73.62
G10-1-7	370.171	1.480	9.36	3.79	14.68	1.44	70.73
G10-1-20	312.405	1.676	9.22	4.32	13.76	1.61	71.09
G10-1-17	354.381	0.126	11.13	4.91	10.36	1.42	72.18
Tosari	215.760	0.565	9.92	4.40	13.66	1.22	70.80

RESULTS AND DISCUSSION

Weevil Development in Different Maize Genotype

Our result showed that maize genotypes did not significantly affect weevil development. Maize genotypes have no influence on the mortality, the number of eggs, larvae, and pupae as well as median development time of *S. zeamais*, except the number of adults emerged ($F_{6,14}$=7.587, P=0.001) (Fig. 1). It means that the seven maize genotypes were included in the category of resistance to *S. zeamais*, despite the difference in the number of adults emerged. The difference in the number of adults might not only be determined by nutrient content and physical properties of each maize genotype but also caused by life behavior of *S. zeamais*. According to Abebe, Tefera, Mugo, Beyene, & Vidal (2009), the differences of adults emerged was not evidence to determine the sensitivity of insects to feed, because imago *S. zeamais* was able to survive a few days even without eating. Another reason may also be caused by similar of physical and chemical characters on corn seed. Although, the characters of corn seed are not merely affected by maize genotypes but also the soil condition which have availability to support plants on the absorption of nitrogen fertilizer (Kuswanto, Wicaksono, Sudakir, & Begliomini, 2013). In addition, the defense mechanism of plants from pests is also influenced by factors such as physical or chemical plant phenolic compounds. The low population of insects and low gain weight loss can be used as an indicator of resilience seeds against insects (Shafique & Chaudry, 2007).

Until now the mechanism of resistance to seed saved from insects is still being debated (Dobie, 1974; Shafique & Chaudry, 2007; Abebe, Tefera, Mugo, Beyene, & Vidal, 2009). In general, the theory of physical characteristics of the seed such as color, hardness, thickness, and seed size is known to influence the resistance of cereal genotype to infestation by the insect pest (Ivbiljaro, 1981; Ashamo, 2001; Lale, Zakka, Atijegbe, & Chukwu, 2013; Akpodiete, Lale, Umeozor, & Zakka, 2015). The observation of physical and chemical properties of the seven genotypes tested showed similar of properties, meaning that all maize genotypes tested resistant to attack *S. zeamais*.

Susceptibility of Maize Genotypes to Weevil

Based on susceptibility index (Table 2), the resistance category of maize genotypes was only moderately resistant to resistant. Maize genotypes were categorized as resistant is G10-1-3 and G10-1-17, while corn genotypes were categorized enough resistant is SJA, G10-12-20, G10-1-7, G10-1-20 and Tosari. In addition, analysis of the seed weight loss also showed that between the genotypes, there were no significant differences ($F_{6,14}$= 2.217, P=0.103). It means that all tested maize genotypes tend to be resistant to maize weevil due to seed weight loss is one of the most important variables to determine the level of maize genotypes resistance against *S. zeamais* (Mwololo et al., 2012). In general, maize resistant genotypes were indicated by low weight loss, low seed damage and reduced the number of adult insects emerged. The resistance of seed is influenced by two factors i.e. physical factors (seed hardness) and chemical factors that are toxic to insects (Siwale, Mbata, Microbert, & Lungu, 2009).

Table 2. Susceptibility index of maize genotypes

Genotypes	Susceptibility Index	Categories
SJA	4.00	Moderately resistant
G10-12-20	4.04	Moderately resistant
G10-1-3	3.85	Resistant
G10-1-7	4.14	Moderately resistant
G10-1-20	4.12	Moderately resistant
G10-1-17	3.79	Resistant
Tosari	4.46	Moderately resistant

Although the weight losses of maize genotypes were not significantly different, based on the correlation analysis showed the relationship between weight loss and susceptibility index ($F_{1,5}$= 9.172, P=0.029) (Fig. 2). Increasing susceptibility index of maize affected on increasing weight loss due to maize weevil. In addition, the relationship was also shown between susceptibility index and seed harness with F-max ($F_{1,5}$=7.186, P=0.044) (Fig. 2). This proved that the stored grains with less physical characteristics (less hardness) are susceptible from the maize weevil attack. Therefore, in the breeding program is recommended to not solely aim to increase productivity, but also to consider how their susceptibility to pests in storage material (the pest of storage products) (Throne, Baker, Messina, Kramer, & Howard, 2000). The physical properties of seeds such as color, hardness kernel, shell thickness and the size of the seeds are also well-known have influenced the level of sensitivity to seed attack by *S. zeamais* (Akpodiete, Lale, Umeozor, & Zakka, 2015; Throne & Eubanks, 2015).

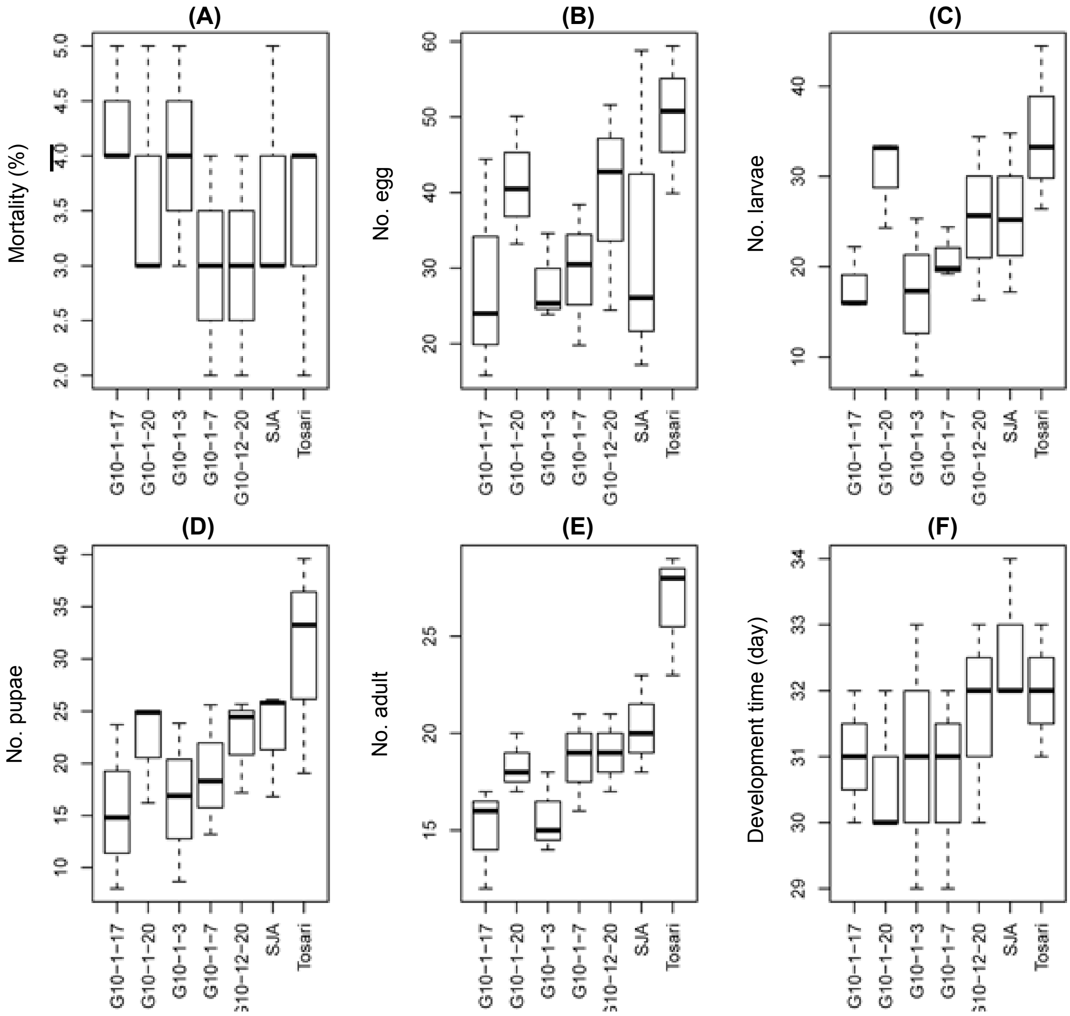

Fig. 1. Susceptibility of maize genotypes to S. zeamais based on (a) mortality of adult weevil ($F_{6,14}$= 0.712, P=0.646), (b) number of eggs ($F_{6,14}$=1.221, P=0.352), (c) number of larvae ($F_{6,14}$=2.404, P=0.083), (d) number of pupae ($F_{6,14}$=1.564, P=0.229), (e) number of adult ($F_{6,14}$=7.587, P=0.001) and (f) median development time ($F_{6,14}$=0.9, P=0.522)

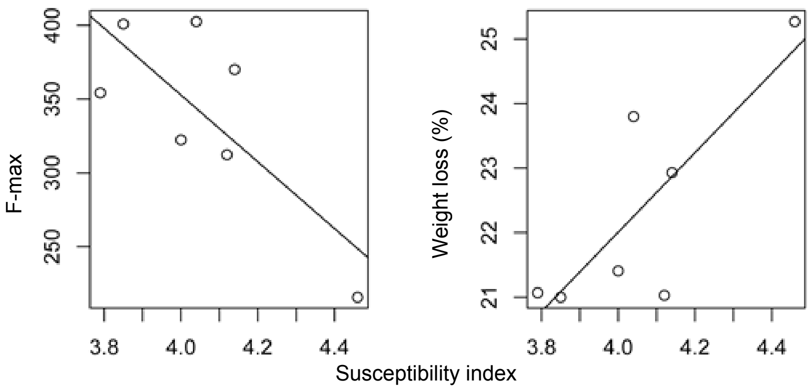

Fig. 2. Relationship between susceptibility index of maize genotypes with (a) physical characteristic of genotype, F-max ($F_{1,5}$=7.186, P=0.044) and (b) weight loss ($F_{1,5}$= 9.172, P=0.029)

CONCLUSION

The number of eggs, larva, pupa, and adults emerged can be used to determine the index susceptibility of maize beetle *S. zeamais*. Based on the susceptibility index value, the genotype G10-1-3 and G10-1-17 are resistant to *S. zeamais*, while genotype SJA, G10-12-20, G10-1-7, G10-1-20, and Tosari are quite resistant to *S. zeamais*.

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