Effectiveness of Bagasse and Rice Straw Ashes against Postharvest Pest, *Sitophilus zeamais* on Maize Seed

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Abstract. *Sitophilus zeamais* (Motschulsky) (Coleoptera: Curculionidae) is the main pest on maize seed in the storage. In general, postharvest pest control uses synthetic insecticides. However, the use of these synthetic insecticides causes insect resistance and negative impact on human health. This study aimed to determine the effectiveness of rice straw and bagasse ashes as inert dust in postharvest pest management of *S. zeamais*. This study was conducted at the Laboratory of Entomology, Faculty of Agriculture, Universitas Hasanuddin. This study used two treatments with four different doses *i.e.*, 2, 4, 6, 8 g, and untreated (control). The results showed that complete (100%) of adult mortality at highest dose (8 g/kg seed) of bagasse ash in three days after infestation, while in the higher doses (6 and 8 g/kg seed) of rice straw ash killed 99.15%. The use of inert dust also causes typical symptoms in mortality in the form of wings coming out of the elytra, which is different from adult mortality without treatment.

1 Introduction

Maize (*Zea mays* Linnaeus) is one of the most economically valuable food commodities in Indonesia. Maize is generally stored in the form of pipeline in storage warehouses where the stored maize aims to provide seed, feed, and food. One of the obstacles in storage is the attack of postharvest pests that cause damage and reduce the weight of stored commodities [1, 2].

One of the postharvest pests that attack maize seed is *Sitophilus zeamais* (Motschulsky) (Coleoptera: Curculionidae). This pest can reduce the quality and quantity of seed in storage. In general, this pest causes 20–90% weight loss and seed viability decrease [3].

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Commonly, control of postharvest pest by using chemical insecticides (fumigation) [4]. The use of these chemical insecticides can cause negative impacts, namely resistance to pests and cause high residues in the environment. Nowadays, alternative pest management are need eco-friendly. One of the environmentally friendly insect management that can be used is utilizing plant waste such as inert dust as a seed protective in postharvest pest attack [5].

Plant wastes that can be utilized as inert dust are bagasse and rice straw ashes that contain high silica content that cause mortality on *Corcya cephalonica* (Stainton) (Lepidoptera: Pyralidae) and *Rhyzopertha dominica* (Fabricius) (Coleoptera: Bostrichidae) [6–9]. This study aimed to determine the effectiveness of bagasse and rice straw ashes as inert dust materials on the maize weevil.

2 Materials and methods

2.1 Rearing of insect

Insects rearing was done using sterilized rice (IR-46 variety) as rearing diet and using cold sterilization with a freezer (–15 °C) for a week then transferred to a refrigerator (5 °C) for a week [10]. Acclimatization was carried out at laboratory condition (28±2 °C; 45±5% r.h.) for a week. One kilogram of sterilized rice put into a glass jar (Ø= 14.5 cm; h= 23.5 cm) and infested with 200 *S. zeamais* adults. Initial insect was obtained from Laboratory of Entomology, Department of Plant Pest and Disease, Faculty of Agriculture, Universitas Hasanuddin. The glass jar covered with organza and tighted with a rubber band. After a week of infestation, all adults removed from the jar [11].

2.2 Preparation of inert dust

Bagasse and rice straw wastes were sun-dried and burned using a pot and torch into ashes, separately. The ashes were sieved using a 100 mesh sieve, then dried in an oven (60 °C) for an hour to reduce moisture content and stored in hermetic plastic at room temperature [12].

2.3 Content analysis of inert dust

One gram of bagasse and rice straw ashes were analysed the minerals content by X-Ray Fluorescence (XRF) instrument. This analysis was done at the Laboratory of Science Research and Development, Faculty of Mathematics and Natural Sciences, Hasanuddin University.

2.4 Insect bioassay

The research was arranged in completely randomized design with an untreated (control), five treatments (2, 4, 6, and 8 g/kg seed) and four replications based on previous research. Inert dusts were admixed throughly with 50 g of maize seed (Bisma variety) within three minutes in capped glass jar (Ø= 7 cm; h= 11.5 cm). Maize seed was obtained from the Agricultural Instruments Standardization Agency in Maros, South Sulawesi. Maize seed was cold sterilized and water content was measured 14.5%. All treatments were infested 15 pairs of *S. zeamais* adults (1–2 weeks old) and covered with organza and sealed with rubber band [7].

2.5 Adult mortality

Observation was done by counting the number of dead adults in each treatment daily to seven days after infestation. All dead adults were removed from glass jar. Adult mortality was calculated using the equation as follows [13]:

$$\text{Adult mortality (\%)} = \frac{\text{Number of dead adult}}{\text{Number of infested adult}} \times 100\% \quad (1)$$

3 Results and discussion

Two tested inert dusts were well-covered on maize seed surface and it act as grain protectant (Fig. 1b and 1c). There were no symptom of *S. zeamais* adults attack on treated seed and a hole by insect feeding activity was showed on untreated (control) (Fig. 1).

(a) (b) (c)

Fig. 1. Untreated and treated maize seeds by inert dusts (a) Untreated seed showed a hole caused by *Sitophilus zeamais*, (b) Treated seeds covered by highest dose of bagasse ash and (c) Treated seeds covered by highest dose of rice straw ash.

Based on the observation from 1 to 7 days after treatment (DAT) showed a significantly different on adult mortality (Table 1). The highest adult mortality was found in the treatment with bagasse ash at 8 g/kg completely kill 100% adult of maize weevil in 3 DAT compared to other treatments. Meanwhile, rice straw ash at 6 and 8 g/kg could kill 99.15% adults and this showed that there is no significant difference between these treatments as well as bagasse ash at 4 and 6 g/kg.

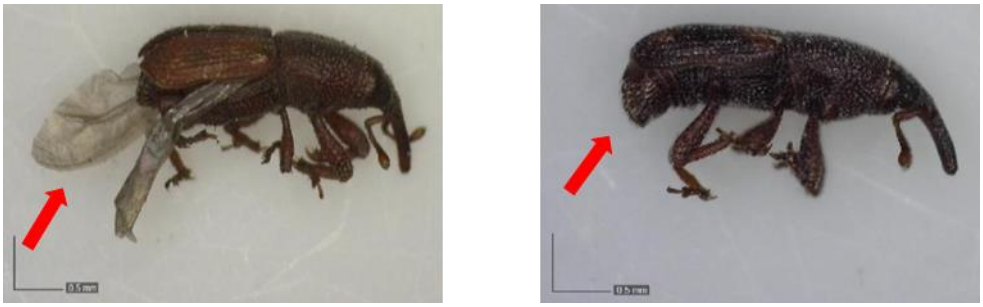
The treatment of rice straw ash at 2 g/kg was the lowest adult mortality compared to the other treatments at 3 DAT but it was not significantly different from the bagasse ash at 2 g/kg. The presence of inert dust particles cause dehydration of adult, this is due to inert dust particles from rubbing against the insects' body so that the insect loss their water content in its body and culminating in death.

The analysis of the silicon dioxide or silica (SiO_2) content showed that in the bagasse and rice straw ashes were 58.59% and 58.51% respectively. The silica content in inert dust treatment has a significant effect on the effectiveness of the use of inert dust due to hygroscopic characteristic of silica thus the higher silica content in inert dust, the higher mortality rate of adults. Astuti *et al*. and Mario *et al*. also stated that when insects pass through the inert dust particles, it can cause the insect cuticle layer to be eroded and the insects experience excessive evaporation and dehydration which can cause death [7, 14].

Table 1. Adult mortality of *Sitophilus zeamais* caused by two inert dusts

Treatment (Ash)	Dose (g/kg)	Days After Treatment (%)						
		1	2	3	4	5	6	7
Untreated	0	0.00 f	0.00 g	0.00 c	0.00 c	0.00 c	0.50 c	0.50 d
Rice Straw	2	14.15 e	18.30 f	79.12 b	85.83 b	87.47 b	89.97 b	93.30 c
	4	20.78 cde	29.12 de	94.12 a	96.62 a	97.47 a	98.30 a	99.15 b
	6	28.30 bcd	45.80 bc	99.15 a	100.00 a	100.00 a	100.00 a	100.00 a
	8	34.15 ab	49.95 ab	99.15 a	100.00 a	100.00 a	100.00 a	100.00 a
Bagasse	2	18.30 de	21.62 ef	83.30 b	87.47 b	89.97 b	92.45 b	94.97 bc
	4	29.98 abc	35.80 cd	97.47 a	99.15 a	99.15 a	100.00 a	100.00 a
	6	38.30 ab	49.12 ab	98.33 a	99.15 a	100.00 a	100.00 a	100.00 a
	8	39.12 a	57.48 a	100.00 a	100.00 a	100.00 a	100.00 a	100.00 a
F-value		32.94	67.34	289.32	537.77	765.55	1304.44	1332.24
df		8; 35	8; 35	8; 35	8; 35	8; 35	8; 35	8; 35
HSD 5%		5.46	5.38	4.50	3.33	2.80	2.17	2.13

Typical symptom of dead adult exposed to inert dust was unfolded membranous wings and erected out of the elytra (Fig. 2a) and vice versa in untreated adult to inert dust (Fig. 2b). In addition, Doumbia *et al*. showed that *S. zeamais* exposed to inert dust causes the pest to move less actively and showed their typical symptoms [15].



(a) (b)

Fig. 2. Death symptom of *Sitophilus zeamais* adult, (a) Death caused by inert dust, (b) Natural death.

These ashes also contain calcium oxide (CaO) in bagasse and rice straw ashes were 5.96% and 7.65% respectively. Furthermore, the content of phosphorus pentoxide (P_2O_5) in bagasse ash was 3.04% and rice straw ash was 1.60%. Golob *et al.* and Andersen *et al.* described that CaO and P_2O_5 compounds are hygroscopic. High adult mortality in both ashes as a result of these compounds (CaO and P_2O_5) were synergize with the silica content in both ashes to cause faster death [16, 17].

4 Conclusion

Bagasse ash treatment at a higher dose (8 g/kg) could completely kill 100% of maize weevil adults in 3 DAT. Likewise, higher doses (6 and 8 g/kg) of rice straw ash causes 99.15% adult mortality.

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