Effect of different rates of filter cake against bruchids (Zabrotes subfasciatus (Boheman) and Callosobruchus maculatus (Fabricius) (Coleoptera: Chrysomelidae) on common bean and cowpea

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Storage of common bean and cowpea is limited due to different species of bruchids. Zabrotes subfasciatus and Callosobruchus maculatus are the most important species of bruchids attacking stored common beans and cowpeas, causing yield losses reaching up to 38-100%. Two experiments, one on the effect of different rates of Filter Cake against Z. subfasciatus on common bean, and the other experiment on the effect of different rates of Filter Cake against C. maculatus on cowpea were conducted at Melkassa in 2015, 2016 and 2017. Half liter capacity transparent plastic bags were used for the experiment. About 0-12 h old ten unsexed Z. subfasciatus adults were introduced to common bean seeds. For cowpea experiment, 0-12 h old 10 C. maculatus were used with similar procedures with that of common bean. The experiment was laid out in a Completely Randomized Design. Different crops and insect related data were collected. The results obtained demonstrated that significant differences (P<0.05) were observed among the treated and untreated seeds. The rate of mortality was significantly (P<0.05) higher in all the rates of filter cake when compared to the untreated check 3 days after treatment application. Percent weight loss was nil in all the treatments on common bean and cowpea, while it was above 10% in the untreated check. The germination percentage was not impaired by the treatments. From the current result, it can be concluded that Filter Cake can be used for the control of Z. subfasciatus and C. maculatus.

Key words: Callosobruchus maculatus, common bean, cowpea, filter cake, mung bean, Zabrotes subfasciatus.

INTRODUCTION

Common bean (Phaseolus vulgaris L.) and cowpea (Vigna unguiculate) (L.) Walp are among the most important food and cash crops in Eastern and Southern Africa (Abate and Ampofo, 1996; Schmale et al., 2002; Aliyu and Wachap, 2014; Bhattarai and Mehlenbacher, 2017; Boukar et al., 2016)). Pre-harvest and post-harvest

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damage by insect pests are the major limiting factors of common bean and cowpea (Wright et al., 1989). Stored beans and peas suffer heavy losses in terms of both quality and quantity mostly by bean bruchids (Negasi, 1994; Abate and Ampofo, 1996). Zabrotes subfasciatus (Boheman) and Callosobruchus maculatus (Fabricius) are the most important species of bruchids attacking stored beans and peas, causing yield losses ranging from 38-100% (Schoonhoven and Cardona, 1986; Adane and Abraham, 1995; Abraham et al., 1994).

Bruchid infestation results in quantity, quality and viability losses (Adane and Abraham, 1995). The degree of losses depends on the storage period and storage conditions. Ahmed (2017a) reported an average grain loss of 60% within 3-6 months of storage period due to bruchids on common beans. Losses on cowpea reach 100% in 3 months’ time in the storage which shares the same species of bruchids, C. maculatus (Emana et al., 2003; Swella and Mushobozy, 2007). A number of pest control methods which range from cultural control methods (use of inert materials, mixing with small seeded grains for storage, etc.), use of different botanicals, use of tolerant/resistant varieties and use of insecticides among others were tried (Strong and Suber, 1968; Abraham, 2003; Emana et al., 2018; Mulatwa et al., 2017). However, the level of control arrived at could not keep the pest below economic injury level. The use of filter cake on Sitophilus zeamais (Motsch) was effective (Abraham, 2003). Hence, the objective of the current experiment is to see the efficacy of different rates of filter cake on two species of bruchids attacking common bean and cowpea under laboratory condition.

MATERIALS AND METHODS

Description of the study area

Melkasa Research Centre is found at 130 km away from Addis Ababa to the East. It is located on the road side of Asella at an elevation of 1500 m above level and coordinates of 8°24’N and 39°21’E. The experiment was conducted at 40-50% relative humidity and a mean daily temperature of 28±0.5°C.

Experimental procedures

Common bean and cowpea seeds used for the experiment were obtained from Melkassa Lowland Pulse Research and multiplied in the center to obtain sufficient amount of seeds required for the experiment. The treatments (T1-T8) include different rates of filter cake (T1 = 0.03% w/w, T2 = 0.05% w/w, T3 = 0.08% w/w, T4 = 0.09% w/w, T5 = 0.188% w/w, T6 = 0.37% w/w, T7 = 0.75%w/w, and T8=Untreated check). Filter cake was obtained from Awash Melkassa Aluminium Sulphate and Sulphuric Acid Factory.

Adult bruchids were collected from stores holding common bean and cowpea to establish cultures of Z. subfasciatus and C. maculatus of similar age (0-12 h) bruchids for the experiment. A susceptible variety, Aregene was used for mass rearing of bruchids under an average room temperature of 28°C and a relative humidity of 50%. The experiment was intentionally set between March and May as these months were found to be the pick infestation periods of bruchids which is aligned with high temperatures of the months. One hundred and fifty gram seeds were put in 250 cm³ capacity glass jars with brass screen lids that permit ventilation. Adult bruchids were introduced in each jar at the ratio of one bruchid to 15 g of seeds, which was equivalent to 10 unsexed adult bruchids to each jar. Treatments were applied accordingly and the experiments (1 common bean and 1 cowpea experiments) were laid out in a completely randomized design (CRD) in three replications.

Data collection

Dead bruchids were counted at the 3rd and 7th days after infestation. At the 7th day, both dead and live bruchids were counted and removed and the grains were kept under the same conditions for emergence of F1 progenies. The F1 progenies were counted and removed each day until emergence ceased. Additional data were collected on number of adult bruchid mortality, number and weight of damaged and undamaged grains. Percent weight losses were calculated using count and weigh method.

\[
\% \text{ Weight loss} = \left( \frac{(W_u \times N_d) - (W_d \times N_u)}{W_u (N_d + N_u)} \right) \times 100
\]

Where, WU= weight of undamaged seed, Nu=Number of damaged seed, Wd= weight of damaged grains, Nd= Number of damaged seed.

Germination of seeds was tested by randomly taking one hundred seeds from each jar and placing them on moist filter paper in a Petri dish for five days. Then seeds germinated against non-germinated seeds were counted.

Statistical analysis

All data were subjected to statistical analyses using SAS version 9.0 computer software. Mean separations were done using Student-Newman-Keuls (SNK) Range Test.

RESULTS AND DISCUSSION

Mean adult mortality of Z. subfasciatus 3 days after treatment application (ATA), mean number of F1 progeny of Z. subfasciatus, percent weight loss and percent seed germination 90 days (ATA) in common bean in 2015, 2016 and 2017 are shown in Tables 1 to 3. All rates of filter cake significantly (P<0.05) resulted in almost 100% adult Z. subfasciatus mortality 3 days ATA. No F1 progeny was recorded in all filter cake treatments, but 26 mean F1 progeny was recorded in the untreated check. With respect to percent weight loss there was no significant differences among the filter cake treatments. However, all rates of filter cake significantly different from the untreated check on which economic losses (10.32%) were recorded. All common bean seeds treated with different rates of filter cake germinated 90 ATA which was significantly (P<0.05) different from the untreated check in which 15% germination reduction was recorded (Table 1).

Mean adult mortality of Z. subfasciatus 3 days after
Table 1. Effect of different rates of filter cake on the adult mortality of Z. subfasciatus 3 days after treatment application (ATA), mean number of F1 progeny, percent weight loss and percent germination 90 days ATA in common bean, 2015.

| Different rates of filter cake | Adult mortality 3 days ATA | Number of F1 progeny | Percent weight loss 90 days ATA | Percent seed germination 90 days ATA |
|-------------------------------|----------------------------|----------------------|-------------------------------|-----------------------------------|
| 0.03                          | 9.50±0.1 a                  | 0.00±0.00            | 0.03±0.01 a                   | 100.00±3.4 a                     |
| 0.05                          | 9.50±0.1 a                  | 0.00±0.00            | 0.17±0.01 a                   | 100.00±3.4 a                     |
| 0.08                          | 9.30±0.1 a                  | 0.00±0.00            | 0.06±0.01 a                   | 100.00±3.4 a                     |
| 0.09                          | 10.00±0.3 a                 | 0.00±0.00            | 0.00±0.01 a                   | 100.00±3.4 a                     |
| 0.188                         | 10.00±0.3 a                 | 0.00±0.00            | 0.00±0.01 a                   | 100.00±3.4 a                     |
| 0.37                          | 10.00±0.3 a                 | 0.00±0.00            | 0.01±0.01 a                   | 100.00±3.4 a                     |
| 0.75                          | 10.00±0.3 a                 | 0.00±0.00            | 0.00±0.01 a                   | 100.00±3.4 a                     |
| Untreated check               | 0.00±0.00 b                 | 26.00±1.65           | 10.32±0.01 b                  | 85.00±2.8 b                      |

Means (±se) followed by the same letter (s) within a column are not significantly different from each other at 5%, Student-Newman-Keul’s Range Test.

Table 2. Effect of different rates of Filter Cake on the adult mortality of Z. subfasciatus 3 days after treatment application (ATA), mean number of F1 progeny, percent weight loss and percent germination 90 days ATA in common bean, 2016.

| Different rates of filter cake | Adult mortality 3 days ATA | Number of F1 progeny | Percent weight loss 90 days ATA | Percent seed germination 90 days ATA |
|-------------------------------|----------------------------|----------------------|-------------------------------|-----------------------------------|
| 0.03                          | 10.00±0.1 a                 | 0.00±0.00            | 0.00±0.00 a                   | 100.00±3.4 a                     |
| 0.05                          | 10.00±0.1 a                 | 0.00±0.00            | 0.00±0.00 a                   | 100.00±3.4 a                     |
| 0.08                          | 10.00±0.1 a                 | 0.00±0.00            | 0.00±0.00 a                   | 100.00±3.4 a                     |
| 0.09                          | 10.00±0.1 a                 | 0.00±0.00            | 0.00±0.00 a                   | 100.00±3.4 a                     |
| 0.188                         | 10.00±0.1 a                 | 0.00±0.00            | 0.00±0.00 a                   | 100.00±3.4 a                     |
| 0.37                          | 10.00±0.1 a                 | 0.00±0.00            | 0.00±0.00 a                   | 100.00±3.4 a                     |
| 0.75                          | 10.00±0.1 a                 | 0.00±0.00            | 0.00±0.00 a                   | 100.00±3.4 a                     |
| Untreated check               | 0.00±0.00 b                 | 25.00±2.54           | 11.33±0.1 b                   | 80.00±2.6 b                      |

Means (±se) followed by the same letter (s) within a column are not significantly different from each other at 5% level, Student-Newman-Keul’s Range Test.

treatment application (ATA), percent weight loss and percent seed germination 90 days (ATA) in common bean in 2016 are shown in Table 2. In terms of mean adult mortality, percent weight loss and percent germination, similar results with that of 2015 recorded such that all rates of filter cake resulted in 100% adult mortality 3 days ATA, no effect on germination and no weight loss 90 days ATA. About 20% germination reduction was recorded in the untreated check. There was no F1 progeny recorded in all Filter Cake treatments, but 25 mean F1 progenies were recorded in the untreated check.

Table 3 shows the results of 2017. Results obtained were similar to the results of 2015 and 2016 except the figure that changed. All filter cake treatments significantly killed Z. subfasciatus 3 days ATA. However, no adult mortality was recorded 3 ATA in the untreated control. No F1 progeny was recorded in all filter cake treatments, but 35 mean F1 progeny was recorded in the untreated check. Percent weight loss 90 days ATA was insignificant and/or absent, but it was 17.6% in the untreated check. Percent seed germination was 100% 90 days ATA, but it was 76.5% in the untreated check.

The effect of different rates of filter cake on the management of C. maculatus on cowpea in 2015, 2016 and 2017 are shown in Tables 4 to 6. C. maculatus mean adult mortality was 100% in all filter cake treatments, but 0% in the untreated check 3 days ATA in cowpea in 2015. Number of F1 progeny emerged from all the treatments of filter cake, but 22 mean number of progenies emerged from the untreated check which was significantly (P<0.05) different from the treated seeds of cowpea with filter cake. Percent weight loss was not recorded in all filter cake treatments, but significant (P<0.05) economic loss of 12.43% was recorded in the untreated check. Cowpea seeds treated with filter cake germinated by 100%, 90 days ATA, but 24% germination reduction were recorded in the untreated check (Table 4). Results obtained in 2016 (Table 5) and 2017 (Table 6) were similar to results of 2015 in terms of C. maculatus adult mortality, number of F1 progeny, percent weight loss and percent seed germination 90 days ATA; adult mortality was 100% (10/10 dead), number of F1 progeny and percent weight loss were nil and percent seed
Table 3. Effect of different rates of Filter Cake on the adult mortality of \(Z.\ subfasciatus\) 3 days after treatment application (ATA), mean number of F1 progeny, percent weight loss and percent germination 90 days ATA in common bean, 2017.

| Different rates of filter cake | Adult mortality 3 days ATA | Number of F1 progeny | Percent weight loss 90 days ATA | Percent seed germination 90 days ATA |
|-------------------------------|-----------------------------|----------------------|---------------------------------|-------------------------------------|
| 0.03                          | 10.00±0.1\(^a\)             | 0.00±0.00\(^a\)      | 0.00±0.0\(^a\)                  | 100±3.5\(^a\)                      |
| 0.05                          | 10.00±0.1\(^a\)             | 0.00±0.00\(^a\)      | 0.00±0.0\(^a\)                  | 100±3.5\(^a\)                      |
| 0.08                          | 10.00±0.1\(^a\)             | 0.00±0.00\(^a\)      | 0.00±0.0\(^a\)                  | 100±3.5\(^a\)                      |
| 0.09                          | 10.00±0.1\(^a\)             | 0.00±0.00\(^a\)      | 0.00±0.0\(^a\)                  | 100±3.5\(^a\)                      |
| 0.188                         | 10.00±0.1\(^a\)             | 0.00±0.00\(^a\)      | 0.00±0.0\(^a\)                  | 100±3.5\(^a\)                      |
| 0.37                          | 10.00±0.1\(^a\)             | 0.00±0.00\(^a\)      | 0.00±0.0\(^a\)                  | 100±3.5\(^a\)                      |
| 0.75                          | 0.00±0.00\(^b\)             | 25.00±2.54\(^b\)     | 13.50±0.4\(^b\)                 | 71±1.5\(^b\)                       |

Means (±se) followed by the same letter (s) within a column are not significantly different from each other at 5% level, Student-Newman-Keul’s Range Test.

Table 4. Effect of different rates of Filter Cake on the adult mortality of \(C.\ maculatus\) 3 days after treatment application (ATA), mean number of F1 progeny, percent weight loss and percent germination 90 days ATA in cowpea, 2015.

| Different rates of filter cake | Adult mortality 3 days ATA | Number of F1 progeny | Percent weight loss 90 days ATA | Percent seed germination 90 days ATA |
|-------------------------------|-----------------------------|----------------------|---------------------------------|-------------------------------------|
| 0.03                          | 10.00±0.1\(^a\)             | 0.00±0.00\(^a\)      | 0.00±0.0\(^a\)                  | 100±3.5\(^a\)                      |
| 0.05                          | 10.00±0.1\(^a\)             | 0.00±0.00\(^a\)      | 0.00±0.0\(^a\)                  | 100±3.5\(^a\)                      |
| 0.08                          | 10.00±0.1\(^a\)             | 0.00±0.00\(^a\)      | 0.00±0.0\(^a\)                  | 100±3.5\(^a\)                      |
| 0.09                          | 10.00±0.1\(^a\)             | 0.00±0.00\(^a\)      | 0.00±0.0\(^a\)                  | 100±3.5\(^a\)                      |
| 0.188                         | 10.00±0.1\(^a\)             | 0.00±0.00\(^a\)      | 0.00±0.0\(^a\)                  | 100±3.5\(^a\)                      |
| 0.37                          | 10.00±0.1\(^a\)             | 0.00±0.00\(^a\)      | 0.00±0.0\(^a\)                  | 100±3.5\(^a\)                      |
| 0.75                          | 10.00±0.1\(^a\)             | 0.00±0.00\(^a\)      | 0.00±0.0\(^a\)                  | 100±3.5\(^a\)                      |
| Control                       | 0±0.0\(^b\)                 | 22.00±2.21\(^b\)     | 12.43±0.3\(^b\)                 | 76±2.7\(^b\)                       |

Means (±se) followed by the same letter (s) within a column are not significantly different from each other at 5%, Student-Newman-Keul’s Range Test.

Table 5. Effect of different rates of Filter Cake on the adult mortality of \(C.\ maculatus\) 3 days after treatment application (ATA), mean number of F1 progeny, percent weight loss and percent germination 90 days ATA in cowpea, 2016.

| Different rates of filter cake | Adult mortality 3 days ATA | Number of F1 progeny | Percent weight loss 90 days ATA | Percent seed germination 90 days ATA |
|-------------------------------|-----------------------------|----------------------|---------------------------------|-------------------------------------|
| 0.03                          | 10.00±0.1\(^a\)             | 0.00±0.00\(^a\)      | 0.00±0.0\(^a\)                  | 100±3.5\(^a\)                      |
| 0.05                          | 10.00±0.1\(^a\)             | 0.00±0.00\(^a\)      | 0.00±0.0\(^a\)                  | 100±3.5\(^a\)                      |
| 0.08                          | 10.00±0.1\(^a\)             | 0.00±0.00\(^a\)      | 0.00±0.0\(^a\)                  | 100±3.5\(^a\)                      |
| 0.09                          | 10.00±0.1\(^a\)             | 0.00±0.00\(^a\)      | 0.00±0.0\(^a\)                  | 100±3.5\(^a\)                      |
| 0.188                         | 10.00±0.1\(^a\)             | 0.00±0.00\(^a\)      | 0.00±0.0\(^a\)                  | 100±3.5\(^a\)                      |
| 0.37                          | 10.00±0.1\(^a\)             | 0.00±0.00\(^a\)      | 0.00±0.0\(^a\)                  | 100±3.5\(^a\)                      |
| 0.75                          | 10.00±0.1\(^a\)             | 0.00±0.00\(^a\)      | 0.00±0.0\(^a\)                  | 100±3.5\(^a\)                      |
| Control                       | 0.00±0.00\(^b\)             | 26.00±1.31\(^b\)     | 26.35±1.35\(^b\)                | 75±2.42\(^b\)                      |

Means (±se) followed by the same letter (s) within a column are not significantly different from each other at 5%, Student-Newman-Keul’s Range Test.

From the results obtained, it can be inferred that different rates of filter cake can effectively control the two species of bruchids: \(Z.\ subfasciatus\) and \(C.\ maculatus\). Filter cake is an industry waste product which may not be used by the industry except in rare cases; but if the material can be used for the management of important insect pests like these ones it can cause up to 100% germination.
losses in 6 to 9 months storage periods. In addition to its efficacy, materials like filter cake have no and/or little damage to the non-target organisms including those natural enemies associated to stored grain insect pests. Materials like filter cake can be used to protect grains that can be stored as seed materials for the next planting season though it can be used to protect seeds that can be consumed by human beings and animals. A number of authors reported the efficacy of filter cake in the management of stored grain insect pests which is in line with the current findings (Abraham, 2003; Ahmed, 2017a, b; Mulatwa et al., 2017; Emana et al., 2018). There is no single bullet to control any insect pests like Z. subfasciatus and C. maculatus, but looking for alternatives which can be pulled together in the form of integrated pest management the current fashion of pest management (Emana et al., 2018). In this regard the use of filter cake at the minimum rate is of paramount importance.

Conclusion

In the current study, filter cake at the minimum rate is found to be effective against Z. subfasciatus and C. maculatus on common bean and cowpea. Hence, farmers who are growing common bean and cowpea in Ethiopia can use filter cake for the management of pest as an option of integrated pest management.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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| Different rates of filter cake | Adult mortality 3 days ATA | Number of F1 progeny 90 days ATA | Percent weight loss 90 days ATA | Percent seed germination 90 days ATA |
|-----------------------------|-----------------------------|-------------------------------|-------------------------------|-----------------------------------|
| 0.03                        | 10.00±0.1a                  | 0.00±0.00a                    | 0.00±0.00a                    | 100±3.5a                         |
| 0.05                        | 10.00±0.1a                  | 0.00±0.00a                    | 0.00±0.00a                    | 100±3.5a                         |
| 0.08                        | 10.00±0.1a                  | 0.00±0.00a                    | 0.00±0.00a                    | 100±3.5a                         |
| 0.09                        | 10.00±0.1a                  | 0.00±0.00a                    | 0.00±0.00a                    | 100±3.5a                         |
| 0.188                       | 10.00±0.1a                  | 0.00±0.00a                    | 0.00±0.00a                    | 100±3.5a                         |
| 0.37                        | 10.00±0.1a                  | 0.00±0.00a                    | 0.00±0.00a                    | 100±3.5a                         |
| 0.75                        | 10.00±0.1a                  | 0.00±0.00a                    | 0.00±0.00a                    | 100±3.5a                         |
| Control                     | 0.00±0.09b                  | 32.00±2.22b                   | 14.38±0.5b                    | 72±1.9b                          |

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