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Efficacy of filter cake and Triplex powders from Ethiopia applied to wheat against *Sitophilus zeamais* and *Sitophilus oryzae*

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The efficacy of filter cake and Triplex powders applied to wheat was evaluated in the laboratory against the maize weevil, *Sitophilus zeamais* Motschulsky and rice weevil, *Sitophilus oryzae* (Linnaeus)—two most common insect pests associated with stored grain in Ethiopia. Efficacy of these powders was determined by exposing 20 adults of each species to 100 g of wheat treated with 0, 100, 500, 700 and 1000 mg/kg of filter cake and Triplex. Adult mortality was determined 7 and 14 d after exposure. In addition, adult progeny production, percentage of insect damaged kernels, and percentage of grain weight loss at each species-powder-concentration-time combinations were determined after 42 d. The 7 and 14 d mortality was 100% for adults of both species exposed to 1000 mg/kg of filter cake; only the 14 d mortality of *Sitophilus* species was 100% for adults exposed to 700 mg/kg. Mortality of *S. oryzae* adults was 100% when exposed for 14 d to1000 mg/kg of Triplex. Mortality of *S. zeamais* never reached 100% in any Triplex treatments. Adult progeny production of *S. zeamais* was completely suppressed at filter cake concentrations of 700 and 1000 mg/kg, whereas 1000 mg/kg was necessary for complete suppression of *S. oryzae* adult progeny production. Complete suppression of adult progeny production was not observed in any Triplex treatments. Complete reduction in percentage of insect damaged kernels and percentage of grain weight loss were obtained when *S. zeamais* and *S. oryzae* adults were exposed to 1000 mg/kg of filter cake; similar reductions with *S. zeamais* occurred only at 1000 mg/kg of Triplex. In the case of *S. oryzae*, complete reduction of insect damaged kernels and grain weight loss were not achieved at any concentration of Triplex. These powders can be used as alternatives to chemical insecticides for management of *Sitophilus* species.

1. Introduction

Food security is a major challenge for low income sub-Saharan Africa farmers (Abate et al., 2015). Factors contributing to food insecurity include low productivity, difficulty adapting to climate change, inability to handle the burden of high food or fuel prices, lack of accessibility to credit, and increased dependence on food aid (Zorya et al., 2011). Food security can be achieved by increasing food production and most importantly by reducing postharvest losses (Obeng-Ofori, 2011; Zorya et al., 2011). Postharvest losses reduce the amount of food available for consumption by smallholder farmers of sub-Saharan Africa (Sheahan and Barrett, 2017). Insect pests and toxigenic molds cause quantitative and qualitative losses to grain in storage at the farmer level (Kadjo et al., 2016). Grain losses due to insect pests in sub-Saharan Africa are very high, and the magnitude of losses vary from country to country and from region to region (Abate et al., 2015). In countries like Ethiopia, about 80% of all grain produced is estimated to be stored at the farm or village level (Tadesse and Eticha, 2000). Grain storage losses in Ethiopia due to insect pests were estimated to be in the range of 10–21% (Abraham et al., 2008). The common storage structures used by most Ethiopian farmers are traditional storages with poor construction, which exposes the grain to insect pests (Tadesse and Eticha, 2000; Mezgebe et al., 2016; Hengsdijak and De Boer, 2017). These traditional storages include above-ground structures like *gota* and *gotera* and in underground pits (Tadesse and Eticha, 2000; Blum and Bekele, 2001; Dessalegn et al., 2017). Reducing storage losses will significantly improve food security in countries like Ethiopia (Godfray et al., 2010; Van Gogh et al., 2017).

Chemical pesticides, regardless of their inherent hazards, are used extensively in the fast changing agricultural sector of Ethiopia (Negatu et al., 2016). Ethiopia is confronted with a number of

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problems related to unsafe handling of pesticide distribution and use, improper training in safe use of pesticides, and inadequate infrastructure to regulate safe use of pesticides (Mengistie et al., 2017).

A survey of sorghum farmers by Mendesil et al. (2007) showed that 32% ($n = 138$) of farmers surveyed had access to synthetic pesticides to control insect pests of stored sorghum. The pesticides reported by 4% of farmers were pirimiphos-methyl, DDT, and malathion; 28% of farmers could not tell which pesticides they used on their stored sorghum. A total of 70 out of 100 farmers storing maize in Ethiopia used synthetic pesticides to control stored-product insects, and 66% could not indicate which pesticides they used (Tadesse and Basedow, 2004). DDT, malathion, and pirimiphos-methyl were reported as the pesticides used on maize. In another survey, 106 farmers in Ethiopia were interviewed regarding their on-farm grain storage practices (Blum and Bekele, 2001). Contrary to other surveys, the surveyed farmers had difficulty in using pesticides recommended by extension service personnel for postharvest pest control because they were expensive, not available, or past their shelf life. Mengistie et al. (2017) reported that hazardous and unknown pesticides are common in retail stores in Ethiopia. Retailers sold all classes of pesticides to farmers irrespective of their suitability or effectiveness. Pesticides are sold illegally by untrained people in the village markets. Additionally, in Ethiopia farmers prefer to buy small amounts of pesticides rather than the original container/package, and therefore there is no information regarding the type of pesticide and how it should be diluted and applied. In countries like Ethiopia and Ghana, unsafe handling of pesticides has resulted in ill health episodes, hospitalizations, and fatalities soon after a pesticide application (Williamson et al., 2008).

There is a need to explore products that are safe and effective in controlling insects in smallholder farmer's traditional storages in Ethiopia. Two such products are filter cake and Triplex (Girma et al., 2008a; b; Tadesse and Subramanyam, 2018). Filter cake is a by-product of aluminum sulfate factory (Awash Melkassa Aluminium Sulphate & Sulphuric Acid Share Company, Melkassa Awash, Ethiopia (AMASSASC)). Triplex is a by-product of Mohammed International Development Research and Organization Companies (MIDROC) soap factory (Star Soap and Detergent Industries (SSDI Private Limited Company), Addis Ababa, Ethiopia). A study on elemental composition of both powders using energy-dispersive X-ray spectroscopy indicated that silicon

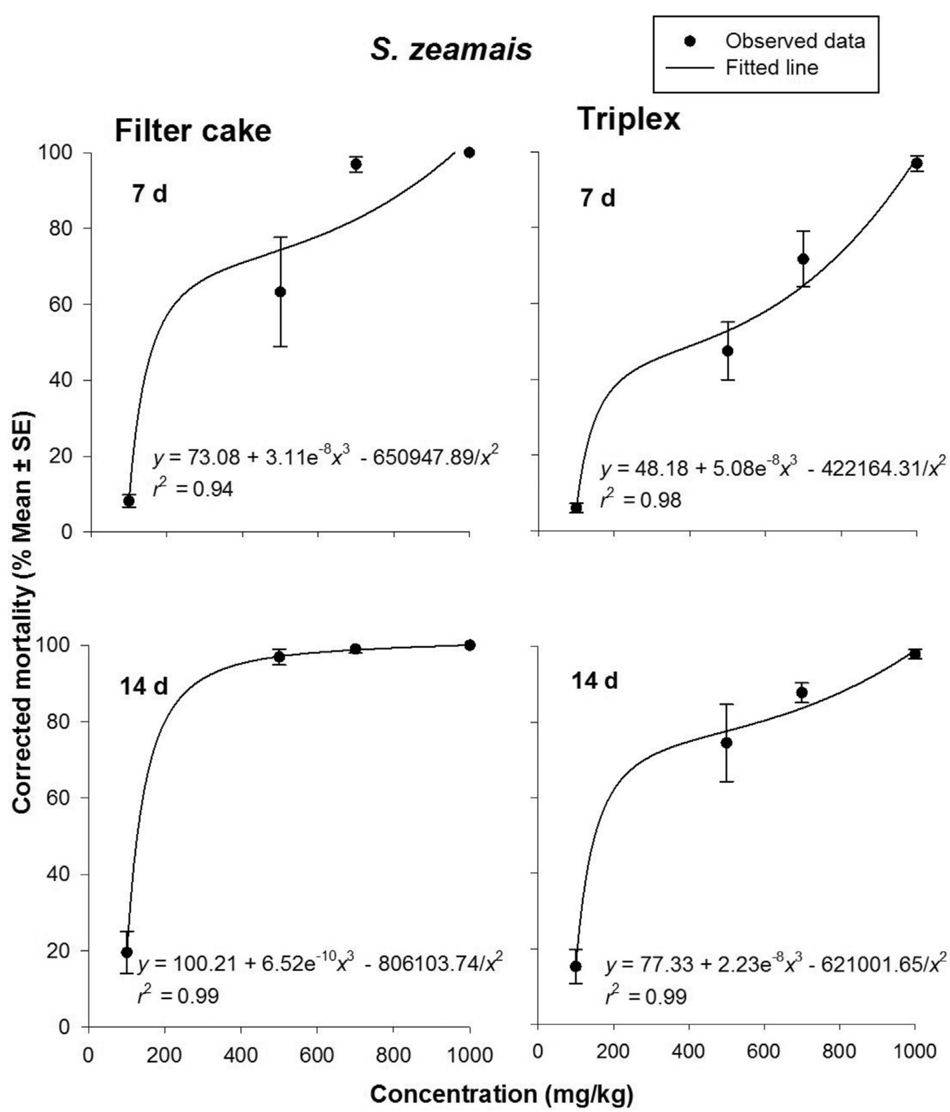

Fig. 1. Corrected 7 and 14 d mortality data of *S. zeamais* adults after exposure to filter cake and Triplex treated wheat at concentrations of 100, 500, 700, and 1000 mg/kg.