Effects of Weaver Ants on Fruitfly and Disease-inflicted Postharvest Losses of Oranges in Small-scale Farming in Tanzania

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Abstract

The objective of this was to evaluate the effect of African weaver ant (Oecophylla longinoda) on fruit fly disease-inflicted postharvest losses of oranges in small-scale farming in Coast region, Tanzania. The treatments consisted of weaver ant population estimated based on the number of nests (0, 2, 5 and 8) of weaver ants per tree and each was replicated three times. Orange fruits were randomly picked from farmers' orchards at color breaker stage and were immediately transported and placed on benches in a postharvest laboratory at Sokoine University of Agriculture with average temperature of 19 and 28 °C during the night and day, respectively. Data were subjected to analysis of variance using GenStat Statistical Programme 12th Edition and treatment means separation was conducted based on LSD test at P ≤ 5 %. Results indicated that the incidence of fruit fly infection in orange fruits significantly (P < 0.05) decreased from 0.8 to 0.4 % as weaver ant population increased from 0 to at 2 nests per tree and the average number of pupae per fruit decreased from 0.58 to 0.04, respectively. Similarly, orange fruit decays significantly (P < 0.05) decreased from 20.4 to 10.2 % as weaver ant population increased from 0 to 2 nests per tree. Specifically, the incidence of decays due to anthracnose (Colletotrichium gloeosporioides Sacc.) decreased from 11.1 to 7.8 % and that caused by green moulds (Penicillium italicum Wehmer) decreased from 9.3 to 2.4 % as weaver ant population increased from 0 to 2 nests per tree. It is concluded that two nests of weaver ants per tree is an optimal population for substantial reduction of orange postharvest losses caused by fruit fly and fungal infections. The use of weaver ants can find wide applications in organic farming and small-scale orange farming where pesticide application is unaffordable. As the number of weaver ants per nest may differ, further studies are recommended to determine the actual number of weaver ants that can effectively reduce fruit fly and disease-inflicted decays, particularly in small-scale mixed cropping systems.

Key words: African weaver ants, Fruit flies, Decays, Oranges

Introduction

Orange production in Tanzania is largely conducted by small-scale farmers and ranks the third in importance with production areas of 52,972 (National Bureau of Statistics, 2012). The crop is grown by small-scale farmers in a mixed cropping system consisting of banana, mangoes and cassava. Tanga, Morogoro and Coast regions are the leading orange producers in Tanzania. A survey with small-scale orange farmers in Morogoro region carried out in 2012 indicated that fruit flies were the most destructive pest followed by decays and mechanical injuries (Horlali, 2012). Fruit direct damage by fruit flies of 30 - 80 % has been reported depending on the fruit type, variety, location and fruiting season (Mwatawala *et al.,* 2006). Similarly, mango fruit losses caused by fruit flies of 60 - 80 % have been estimated in Ghana and Benin (Ekesi and Billah, 2006; Vayssiéres *et al.,* 2008). Losses are usually due to female fruit flies that deposit eggs in the fruits that ultimately hatch into larvae whose internal feeding leads to fruit decays. Fruit flies also cause indirect losses through inhibiting export trade by quarantine pest programs (Niyibigira *et al.,* 2003; Van Mele *et al.,* 2007). Studies carried out in Tanzania have shown five species of fruit flies responsible for the majority of damage in fruits, especially mangoes. These fruit fly species are *Ceratitis*

cocyra (Walker), *C. fasciventris* (Bezzi), *C. rosa* (Karsch) and *C. anonae* (Graham) (Lux, 1999) and *Bactrocera invadens* (Mwatawala *et al.,* 2004). Of the four species *B. invadens* is the most damaging followed by *C. cosyra* and *C. rosa* (Mwatawala *et al.,* 2004).

Different insecticides and baited traps have been developed to manage fruit flies (Lux *et al.,* 2003) but their application in developing countries is still very limited (Lux *et al.,* 2003). Studies in South Asia have shown that the use of weaver ants (*Oecophylla smaragdina* Fab.) significantly reduces the number of eggs deposited by fruit fly *(Bactrocera jarvisi)* and associated losses in mango (Peng and Christian, 2006). Results from mango plantations in Australia show that weaver ants are at least as effective as conventional insecticides in fruit fly control (Peng and Christian 2005). A survey showed that mango orchards with a high abundance of African weaver ants *(O. longinoda)* in Benin had 0.8 % damaged fruits compared with 24.1 % of fruit damage in the orchards without weaver ants (Van Mele *et al.,* 2007). Weaver ants live in trees where they either hunt a variety of insects, including fruit flies or deposit secretions on the leaf and fruit surfaces that inhibit the fruit fly from landing and laying eggs (Van Mele *et al.,* 2009). The puncturing of fruit skin by fruit flies during oviposition further increases incidences of fruit decays. The effect of weaver ants in reducing fruit fly-inflicted fruit damage and losses is largely influenced by the number of weaver ants per tree (Adandonon *et al.,* 2009). However, the number of weaver ants required for effective protection of fruits against fruit fly and decays is hardly known. The objective of this study was to determine the weaver ant population that reduces fruit fly and disease-inflicted postharvest losses of oranges in small-scale orange farming in Tanzania.

Materials and Methods

This study was conducted using farmers' orange orchards in Chang'ombe village in Kisarawe district in the Coast region, Tanzania. Oranges were cultivated in a small-scale level, fragmented and scattered pieces of land and mixed cropping system with other crops such as coconut, cassava and cowpea. The most popular orange varieties were 'Chungwa homa' and "Valencia late" established using unbudded seedlings. The main orange production season was from June to August with the peak production season in July. Orange orchards were poorly managed with almost no weeding, pruning, irrigation and fertilizer application. Burning was the commonest method practiced for weed control.

The experiment was laid out as a complete randomized design with four treatments. The treatments consisted of African weaver ant population at 0, 2, 5 and 8 nests of weaver ants per tree and each treatment was replicated three times. A replication consisted of 100 fruits randomly picked from five orange trees of the cultivar "Valencia Late". The weaver ants were naturally occurring in farmers' orange orchards. Orange fruits at yellow-green color stage were manually harvested using a "pick, drop and catch method" (Samson, 1986), transported and placed on benches in a postharvest laboratory at Sokoine University of Agriculture. The average ambient temperature in the laboratory was 19 and 28 0C during the night and day, respectively.

Orange fruit damage by fruit flies

Oranges on the benches in postharvest laboratory were physically checked for the presence of fruit fly oviposition and decay marks, and those with either oviposition or decay marks were individually kept in a plastic container with sand at the bottom and netted lid on the top. Pupae emerging from the fruits were checked on the sand, counted and identified. Fruits without emerging pupae were further dissected to check for the presence of dead pupae. Fruit fly damage was computed as (i) percentage of the number of fruits with fruit fly pupae over the total number of fruits assessed multiplied by 100 and (ii) the number of fruit fly pupae per fruit.

Disease identification

Disease incidence was scored using a scale of 1 - 5 with 1 and 5 meaning 0 and 91-100 % fruit surface infected, respectively. The diseases were initially identified using a citrus compendium (White *et al.,* 1988). The diseased

orange samples were incubated in nutrient agar (NA) and V8+ streptomycin isolation media for identification of fungi and bacteria, respectively. Fungi of interest were sub-cultured in a selective media to confirm their identity. The fungal isolates were further microscopically observed and identified using standard keys (Mathur and Kongsdal, 2003).

The collected data were subjected to analysis of variance (ANOVA) using GenStat Statistical Programme 12th Edition (Rayne *et al.,* 2009) while treatment means separation was performed based on LSD test at a probability of 5 %.

Results

Effect of weaver ants on fruit fly infestations in oranges

The main fruit fly species identified in incubated orange fruits was *Ceratitis rosa*. The incidence of fruit fly infestation based on pupae emergence from incubation significantly ($P<0.05$) decreased from 0.8 to 0.4 % as African weaver ant population increased from 0 to 2 nests per tree (Table 1). Similarly, the number of fruit fly pupae per fruit decreased from 0.58 to 0.04 as the weaver ant population increased from 0 to 2 nests per orange tree, respectively.

Effect of weaver ants on postharvest decays

Total decays in orange fruits significantly ($P < 0.05$) decreased from 20.4 to 10.2 % as the weaver ant population increased from zero to two nests per tree (Table 2). The main causes of fruit infections were anthracnose (*Colletotrichium gloeosporioides* Sacc.) and green moulds (*Penicillium italicum* Wehmer). The incidence of fruit decays caused by anthracnose and green moulds significantly ($P < 0.05$) decreased from 11.1 to 7.8 % and from 9.3 to 2.4 % as the weaver ant population increased from 0 to 2 nests per tree, respectively.

Table 1: Effect of weaver ant population on fruit fly incidence and severity in oranges

No. of weaver ant nests per tree	Fruit fly pupae incidence based on pupae emergence from incubation (%)	No. of fruit fly pupae per fruit
0 nest (control) per tree	0.80a	0.58a
2 nests	0.40b	0.04b
5 nests	0.21b	0.04b
8 nests	0.00b	0.00b
Mean	0.35	0.16
LSD	0.23	0.05
P-value	0.001	0.001

Numbers bearing the same letters within the column are insignificantly different according to LSD test ($P \leq 0.05$).

Table 2: Effect of weaver ant population on incidences of diseases in orange fruits

No. of weaver ant nests per tree	Total disease incidence (%)	Specific decay incidences (%)	
		Anthracnose	Penicillium
0	20.4a	11.1a	9.3a
2	10.2b	7.8b	2.4b
5	7.9b	6.5b	1.4b
8	5.9b	5.3b	0.6b
Mean	11.10	7.7	3.4
LSD	3.2	2.1	1.9
P-value	<.001	0.02	<.001

Numbers bearing the same letters within the column are insignificantly different according to LSD test ($P \leq 0.05$).

Discussion

The low incidence of fruit fly infestation reported in this study was associated with the prevalence of fruit fly species *(Ceratitis rosa)*, which is less aggressive in comparison to *Bactrocera invadens* (Mwatawala *et al.,* 2004). The incidence of fruit fly infestations in this study decreased as the African weaver ant population increased from 0 to 2 nests per tree. Previous studies indicate Oecophylla ants colonize a wide range of trees (Van Mele and Cuc, 2000; Van Mele, 2008) and reduce fruit fly-inflicted damage in mango, guava and citrus fruits (Mwatawala *et al.,* 2006, Sinzogan et al., 2008). In sweet orange orchards, O. smaragdina is reported to reduce pest infestation and yield losses caused by citrus stinkbug (Rhynchocoris humeralis), aphids (Toxoptera aurantii and T. citricidus), leaf-feeding caterpillars (Papilio spp.) and inflorescence eating insects (Van Mele *et al.,* 2002).

The incidence of orange fruit decays in this study decreased as the weaver ant population increased from trees 0 and 2 nests of ants per tree. This reduction in decays is in agreement with previous studies in which farmers reported decreased fruit decays and increased shelf life in mango fruits harvested from orchards with weaver ants (Van Mele *et al.,* 2007; Sinzogan *et al.,* 2008; Van Mele *et al.,* 2009). It is reported that weaver ants spray formic acid on fruits as they fight with enemies, which seals lenticels (breathing pores) on fruit peels (Peng and Christian, 2013). According to these authors, the blockage of lenticels inhibit the entry points of decay pathogens and therefore reduce the incidence of fruit postharvest decays. The main causes of orange fruit decays in this study were anthracnose and green mould diseases. Several studies have reported anthracnose and green mould diseases as major causes of postharvest decays in citrus fruits (Bali *et al.,* 2008). The presence of wound on fruit surface are the main predisposing condition for these diseases (Fan *et al.,* 2014).

Conclusion

The findings from this study show that at least two nests of weaver ants per tree can substantially reduce the incidences of orange postharvest losses caused by fruit fly infestations and fungal infections. This is the first study where fruit fly infestation in orange fruits is associated with African weaver ant population in small-scale orange orchards. Integrated pest management with weaver ants can find a wide application in orange organic farming where pesticide usage is prohibited. Similarly, weaver ants can effectively be applicable in small-scale orange farming where pesticide application is unaffordable. As the number of weaver ants per nest often differ, further studies are recommended to determine the actual number of weaver ants required to reduce fruit fly and disease-inflicted decays in orange orchards.

Acknowledgement

The authors are thankful to the Commission of Science and Technology (COSTECH) for financing this study. Similarly, the authors are thankful to Dr. Gration Rwegasira for a critical review of this paper.

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