Weathering Rate of Rubber Septa–Impregnated Male Sex Pheromone of Sweetpotato Weevil, *Cylas formicarius elegantulus* (Coleoptera: Brentidae), in East Hawaii

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Abstract. In recent years, sweetpotato, *Ipomoea batatas* (L.) Lamarck, production in Hawaii has been increasing, reaching 243 harvested ha, with a total production of 3.76 million kg in 2009. Sweetpotato production in Hawaii is hindered by three major quarantine pests, for which only one, the sweetpotato weevil, *Cylas formicarius elegantulus* (Summers) (Coleoptera: Brentidae), has an identified sex pheromone, (Z)-3-dodecen-1-ol (E)-2-butenoate, that has been deployed in traps for monitoring and suppression of field populations. The longevity of a commercial source of this sex attractant was tested under field conditions on the Hamakua Coast on the island of Hawaii. Based on a linear regression developed from weevil catch results versus weeks of aging, catch dropped to 50% of the catch of unweathered lure at 13.2 weeks, at a lower elevation site, and at 9.0 weeks, at a higher elevation, windier site. Based on these results, lures in traps should be replaced every 9 weeks to maintain at least 50% of maximum trap catch. Further research is needed to integrate pheromone-baited traps for sweetpotato weevil into a pest management system for sweetpotato pests in Hawaii. Suppression of sweetpotato weevil populations may be enhanced by increasing pheromone concentration in traps.

Key words: *Ipomoea batatas,* detection, monitoring, mass trapping

Introduction

Sweetpotato, *Ipomoea batatas* (L.) Lamarck (Convolvulaceae), is a plant primarily grown for its edible storage root. It originated in either Central or South America and has since spread to many parts of the world and is currently grown in over 100 countries, with production greatest in China. Sweetpotato cultivation in Hawaii pre-dates contact with America and Europe (Huaccho and Hijmans 2000), although the date of arrival is unknown. Hawaiians were already cultivating it when Captain Cook first reached the Islands in 1778 (Staples and Herbst 2005). In recent years, sweetpotato production in Hawaii has been increasing (Figure 1), reaching 243 harvested ha, with a total production of 3.76 million kg in 2009 (NASS 2010, 2005, 2003, 2001, 1999, 1997).

Sweetpotato production in Hawaii is hindered by three major quarantine pests: the sweetpotato weevil, *Cylas formicarius elegantulus* (Summers) (Coleoptera: Brentidae), the West Indian sweetpotato weevil, *Euscepes postfasciatus* (Fairmaire) (Coleoptera: Curculionidae), and the sweetpotato vine borer, *Omphisa anastomosalis* (Guenee) (Lepidoptera: Crambidae) (Follett 2006). Of these pests, the sweetpotato weevil has the widest geographic range worldwide as it occurs in all parts of the tropics, as well as in many subtropical and temperate zones, where sweetpotatoes are grown (Heath et al. 1986). It is the only one of the three pests for which a sex pheromone, (Z)-3-dodecen-1-ol (E)-2-butenoate, has

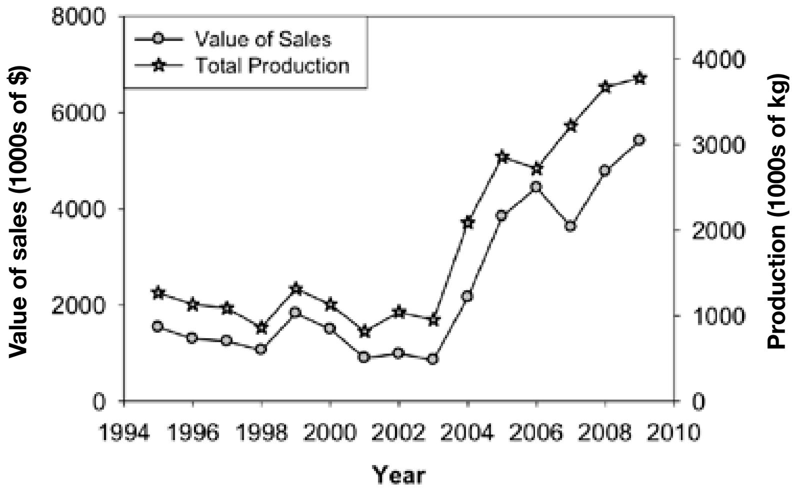

Figure 1. Production (in 1000s of kg) and value of sales (in 1000s of $) of sweetpotatoes in Hawaii from 1995 to 2009.

been identified (Heath et al. 1986) and deployed for monitoring and suppression of field populations (Jansson et al. 1991). As a preliminary step in the development of improved integrated pest management (IPM) methods for sweetpotato pests in Hawaii, the longevity of a commercial sex pheromone attractant for sweetpotato weevil was tested under field conditions on the island of Hawaii.

Materials and Methods

Attractant. Rubber septa, each loaded with 12 micrograms of (Z)-3-dodecen-1-ol (E)-2-butenoate (Suterra, LLC [lot no. 129008190]), were obtained from Great Lakes IPM, Inc. (Vestaburg, MI).

Sites. Weathering trials were conducted at two different sites on the Hamakua Coast of the island of Hawaii. Site 1 was located on Indian Tree Road in the Onomea Bay Ranch Subdivision, mauka of the Hawaii Belt Road, approximately 0.3 miles north of the 8 mile marker, Mokuohiki, near Papaikou, South Hilo, Hawaii (Universal Transverse Mercator (UTM) grid (USGS 2001): Easting 0279807, Northing 2191411 m, Zone 05 Q) and was at 128 m elevation. Site 2 was located near Pepeekeo on Kaupakuea Homestead Road (UTM Easting 0275462, Northing 2194217 m, Zone 05 Q) and was at 427 m elevation. A weather station was set up at each site to collect data on rainfall, temperature, relative humidity, and wind speed over the course of the 20-week weathering period and one week assessment period.

Bioassay. Sweetpotato weevil rubber septa were set out in 5 separate sweetpotato weevil lure traps, one septum per trap (Great Lakes IPM, Inc.) in a randomized complete block design (RCB), every two weeks for 18 weeks (for a total of 50 traps) at recently planted sweetpotato fields starting on June 9, 2009 (at Site 1) and March 23, 2010 (at Site 2). An RCB design was used to factor out the possibility of weathering rate bias if

Table 1. Average (± SEM) temperature, percentage relative humidity, wind speed, and weekly rain at sites used for sweetpotato weevil male lure weathering trials. Data are presented separately for the 20-week weathering period and for the 1-week assessment period at each of two sites.

Site	Date	Temp (°C)	% Relative humidity	Wind speed (m/s)	Weekly rain (mm)
Site 1					
Weathering	9 June–27 Oct, '09	23.5 ± 0.02	85.7 ± 0.06	1.06 ± 0.01	59.6 ± 0.004
Assessment	27 Oct–3 Nov, '09	24.0 ± 0.08	83.3 ± 0.26	0.86 ± 0.03	13.2 ± 0.006
Site 2					
Weathering	23 Mar–10 Aug, '10	19.7 ± 0.18	86.4 ± 0.45	2.33 ± 0.01	47.3 ± 0.003
Assessment	10–17 Aug, '10	20.6 ± 0.07	85.2 ± 0.29	1.96 ± 0.04	19.0 ± 0.009

area microclimatic differences were present. The RCB design consisted of 5 separate sections of sweetpotato rows. Within each section (block) there was one trap of each weathering age (10 traps), with traps spaced 2.0 m apart within the block and with position in each block randomly assigned. Blocks were placed in every other row of sweetpotatoes. Each trap held 300 ml soapy water (1.6 ml dishwashing liquid [e.g., Palmolive dishwashing liquid] in 300 ml water) as the killing agent for captured weevils. All traps were serviced weekly (at Site 1) or every two weeks (at Site 2) to remove any trapped weevils (to minimize decay of trapped weevils) and to maintain levels of soapy water. Weevil counts were made in some traps to monitor overall field population levels, but those counts did not contribute to an understanding of weevil response to aged pheromone-impregnated septa and are not reported here. On 27 Oct., 2009 (Site 1) and on 10 Aug., 2010 (Site 2) [week 20], all of the traps were spread out in either an 8 m x 8 m grid (Site 1) or a 10 m x 10 m grid (Site 2) in a new RCB design in the remaining portion of the field (see Figure 2). An additional 5 traps were incorporated in the RCB design to serve as the "0 week" unweathered control. All traps were serviced one week after field placement to assess weevil catch relative to aging of the pheromone-impregnated septa.

Statistical Analyses. Regression analysis was done on $\log_{10}$ transformed trap catch data and lure aging time. Untransformed data was plotted for figures to enhance clarity.

Results

Weekly rainfall, average temperature, percentage relative humidity, and wind speed for each site are presented in Table 1.

Site 1. The regression of $\log_{10}$ transformed mean weevil catch against weeks of aging was significant (F = 25.181; df = 1,9; p = 0.0007), with r^2 = 0.74. The untransformed data and best fit regression line are presented in Figure 3. Based on the best fit regression line, weevil catch dropped to 50% of the initial weevil catch at 13.2 weeks.

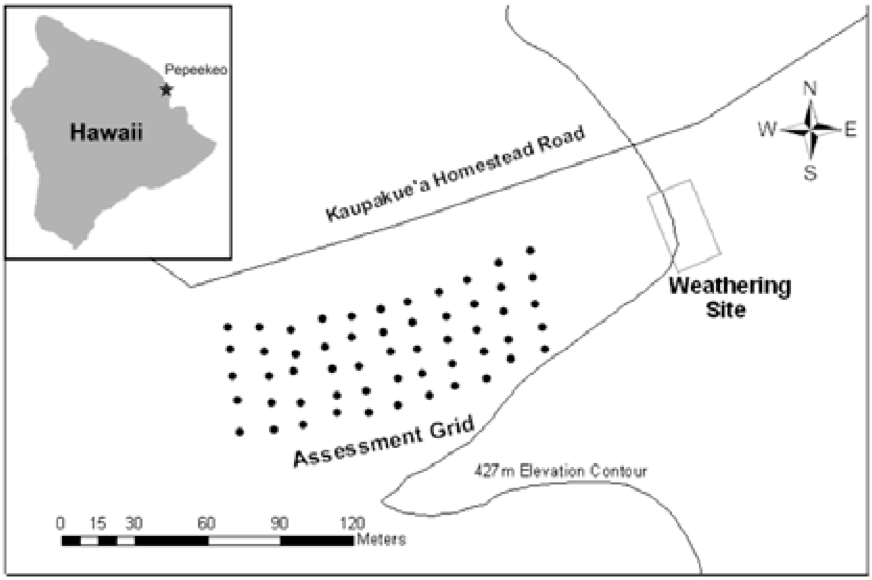

Figure 2. Site map for sweetpotato weevil male lure weathering trial no. 2, located near Pepeekeo, Hawaii, showing relative positions of the weathering site to the assessment site. A similar set-up was used with weathering trial no. 1.

Site 2. The regression of $\log_{10}$ transformed mean weevil catch against weeks of aging was significant ($F = 445.95$; df = 1,9; $p < 0.0001$), with $r^2 = 0.98$. The untransformed data and best fit regression line are presented in Figure 4. Based on the best fit regression line, weevil catch dropped to 50% of the initial weevil catch at 9.0 weeks.

Discussion

Weathering at both sites included much of the warmer summer weather which produce higher lure volatilization rates than in cooler seasons. Of the two weathering sites, the faster weathering occurred at the windier site (Site 2), even though that site was at a higher elevation and had a lower average temperature. At this site, it took 9 weeks for weevil trap catch to drop off to 50% of the initial trap catch. Therefore to maintain at least 50% of maximum trap catch, fresh lures should be provided at least every 9 weeks. This replacement rate could be extended over the cooler winter months, or at production sites that are cooler or less windy, but no data were collected to document how much slower weathering would occur in these alternative production conditions.

It is common practice among sweetpotato growers in East Hawaii to harvest the high quality roots and leave the damaged, undersized, or misshapen cull roots in the field. To prevent build-up of pest populations, fields are typically not re-planted again to sweetpotato for three years. While sufficient land is available to permit this type of rotation, build-up of populations of sweetpotato weevil and other sweetpotato pests is limited. However, if sweetpotato production continues to increase, there may be pressure to shorten fallow or rotation periods between successive sweetpotato crops, and effective pest control methods

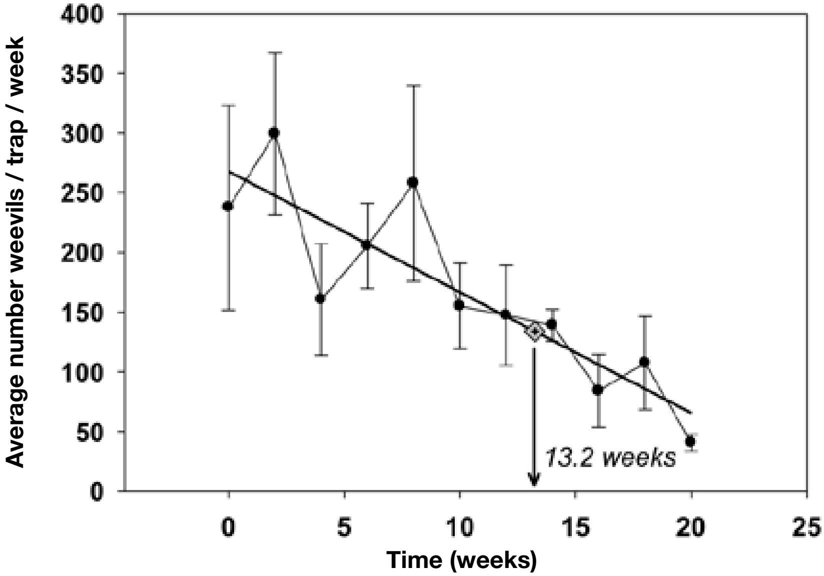

Figure 3. Catch of male sweetpotato weevil lure over time in weathering trial no. 1 in Papaikou, South Hilo, Hawaii, showing 13.2 weeks as the age at which the regressed catch value was 50% of the initial value.

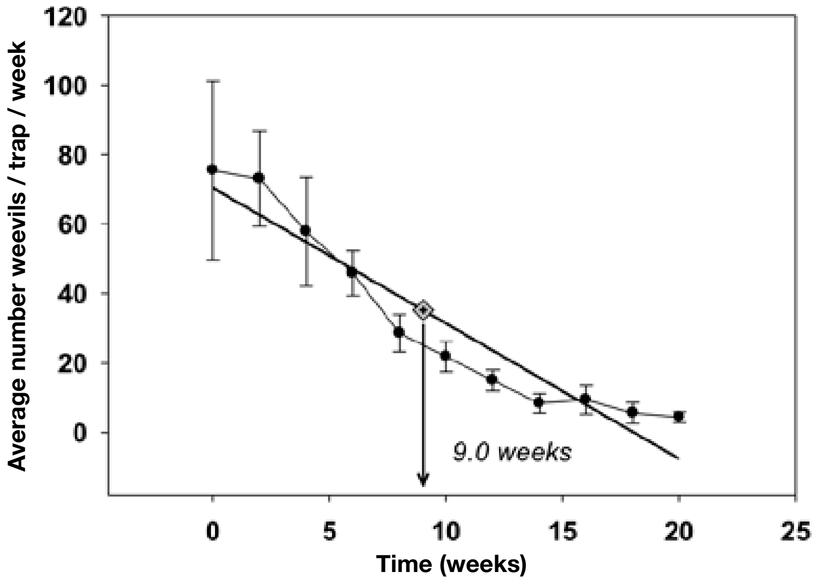

Figure 4. Catch of male sweetpotato weevil lure over time in weathering trial no. 2 in Pepeekeo, South Hilo, Hawaii, showing 9.0 weeks as the age at which the regressed catch value was 50% of the initial value.

will be needed. Even with field rotation, sweetpotato weevils are found infesting sweetpotato roots after sorting and grading for commercial sale (Follett et al. 2007). Culled sweetpotatoes left in the field after harvest can develop high infestation rates. Follett et al. (2007) reported 279 sweetpotato weevils/kg from cull roots collected at an abandoned field, and male lure traps captured in excess of 1000 sweetpotato weevils per trap per day in one particularly heavily infested sweetpotato field in East Hawaii (McQuate, unpublished data).

In addition to use as a monitoring tool, traps baited with (Z)-3-dodecen-1-ol (E)-2-butenoate have potential for population suppression through mass trapping. It has been proposed that the pheromone dosage per trap should be 100 μg to 1.0 mg for successful mass trapping (Jansson et al. 1991). Pillai et al. (1993) reported that an IPM program in India, using mass trapping (1.0 mg lure per trap and one trap /100m^2) for sweetpotato weevil, reduced weevil damage in sweetpotato roots from 33% to 9.7% (1st season) and from 39% to 9.5% (2nd season). Similarly, Hwang (2000) reported that 1.0 mg pheromone-baited traps for sweetpotato weevil, deployed at a density of 4 traps per 0.1 ha, reduced damage to roots 57 – 65%. Further research is needed to test the benefit of mass trapping and increased lure loading rates on sweetpotato root production in East Hawaii. Mass trapping of sweetpotato weevils could be integrated with other control methods, such as insecticide treatment of cuttings (for new plantings) and crop rotation to effectively manage the pest complex in sweetpotato.

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