Colonization of Cabbage by the Western Black Flea Beetle (*Phyllotreta pusilla*) as Affected by Mulch and Time of Day

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A 3-year study was conducted in Colorado (USA) to evaluate the response of the western black flea beetle (WBFB), *Phyllotreta pusilla* Horn (Coleoptera: Chrysomelidae), to different colored mulches and to determine if there were diurnal differences in the effect of mulch on their colonization on plants. The plants surrounded by aluminum mulch had the highest number of WBFB compared with the rest of the treatments in 1999 and 2000, but not in 2002; the black mulch had the lowest number of WBFB in 3 years of sampling. The highest number of WBFB were observed in the late day (4 p.m.) counting in 1999, whereas none of the treatments resulted in significant differences among early, mid, and late day counts in 2000 and in 2002.
KEY WORDS: Western black flea beetle; *Phyllotreta pusilla* Horn (Coleoptera: Chrysomelidae); colored mulches; cabbage; *Brassica oleracea* L.

INTRODUCTION

The western black flea beetle (WBFB), *Phyllotreta pusilla* Horn (Chrysomelidae: Coleoptera), is one of the most important pests on cruciferous plants in Colorado (Al-Doghairi, M.A. (2000) and N. Demirel (2003) Ph.D. dissertations, Colorado State Univ., Ft. Collins, CO, USA) including radish (*Raphanus* spp.), turnip (*Brassica rapa* L.) and cabbage (*B. oleracea* L.) (4,5). WBFB overwinters as adults under clods of earth, or under heaps of weeds, dead leaves, or other rubbish. There are apparently three generations annually in Colorado. Egg laying begins as early as mid-April and continues into early September (5). Important injury of cabbage is confined to young plants in seedbeds or to plants soon after they have been transplanted in the field (5).

The use of mulch is an important cultural method to conserve soil moisture, modify soil temperature and control weeds, and has effects on different crop pests (8,9). The color of the mulch can have different effects. The black mulches increase soil temperature (9,10), whereas white and aluminized mulches increase reflectance of light (9). In addition, increasing reflection of light sometimes repels pest species. Aluminum foil when used as mulch reflected up to 20.3% of the light, effectively repelling adult leafhoppers, whereas decreasing light reflection with black plastic, with only 5.3% light reflection, did not cause any repellent effects on the pest (2).

The aim of this study was to evaluate responses of WBFB to different colored mulches and also to determine if there was any diurnal difference in the effect of mulches on WBFB colonization of plants.

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MATERIALS AND METHODS

Trials were conducted over 3 years (1999, 2000, 2002) at the Colorado State University Horticulture Field Research Center in Ft. Collins, CO. Plots were established using transplanted cabbage ('Green Boy') planted at 38 cm within-row spacing. Transplant dates for the 3 years were 20 June 1999, 30 May 2000 and 27 June 2002. Individual plots consisted of four plants within a single row and plots were separated by two untreated plants. During 1999 and 2000, each cabbage plot was bordered on both sides by plots of cosmos plants; in 2002, each cabbage plot was bordered by plots of canola plants.

Mulch treatments consisted of placing a 30 cm (within-row)$\times$40 cm (inter-row) rectangle of different colored plastic or fabric around the base of the plant. Different color mulches were black landscape plastic mulch, white plastic mulch (spray painted with Rust-Oleum Gloss White 1992 [Rust-Oleum, Vernon Hills, IL, USA]), a woven aluminum mulch (Aluminet®), orange plastic mulch (spray painted with Rust Oleum Fluorescent Orange), yellow plastic mulch (spray painted with Rust-Oleum Yellow 7443), and used bare soil as a control. The experimental design was a randomized complete block with four replications and included six treatments.

Sampling was done by counting all flea beetles on the plants, and conducted daily at three different times: early (8 a.m. to 8:30 a.m.), mid (12 noon to 1 p.m.) and late day (4 p.m. to 4:30 p.m.), over four consecutive dates in 1999 and in 2002 and over three consecutive dates in 2000. Data were analyzed using two-way ANOVA (SAS Institute Inc.) and means were separated by Student-Newman-Keuls tests (SNK) (6).

RESULTS AND DISCUSSION

Effects of mulch color and time of day The largest number of flea beetles was present on cabbage plants surrounded by aluminum mulch (F=24.84; df=5, 282; P=0.0001) (Table 1) in 1999, on 29, 30 June, and 1 July sampling dates, at the 4 p.m. sampling time. In descending order, WBFB numbers on plants were: aluminum $>$ orange $>$ yellow = white $>$ bare soil $>$ black. There were some variations over time. The time of day significantly affected WBFB populations over different mulches in 1999 (F=34.86; df=2, 285; P=0.0001) (Table 2). All treatments, except for black mulches, showed significantly higher WBFB in late day counts (4 p.m.) compared with early morning counts in 1999 (Table 1) (F=24.84; df=5, 282; P=0.0001). This may have been due to the weather conditions. The lowest temperatures and the highest wind speeds were recorded in 1999 compared with those in 2000 and 2002. An average temperature of 20.8°C and an average wind speed of 6.3 mph were observed in 1999. The lower temperatures and lower light intensity may affect WBFB behavior on reflective aluminum mulch.

In 2000, again, the plots surrounded by aluminum mulch resulted in the highest WBFB numbers and with black mulch resulted in the lowest (F=28.15; df=5, 210; P=0.0001) (Table 1). There was no significant difference among the rest of the treatments during this evaluation period. In descending order, WBFB numbers on plants observed were: aluminum $>$ orange = yellow = white = bare soil $>$ black mulch. The time of day did not have a significant effect on WBFB populations on different mulches in 2000 (Table 2). There was no significant difference among the sampling times (8 a.m., 1 p.m. and 4 p.m.). During this evaluation period, the average temperature was 24.7°C and the average wind speed was 4.2 mph.

TABLE 1. Effect of mulch color on Western black flea beetle (*Phyllotreta pusilla*) populations on cabbage plants in Ft. Collins, Colorado

Mulch	Number of flea beetles (means ± S.E) per four plants[z,y]									Average of combined data[y]		
	1999[x]			2000[w]			2002[v]					
	8 a.m.	1 p.m.	4 p.m.	8 a.m.	1 p.m.	4 p.m.	8 a.m.	1 p.m.	4 p.m.	1999	2000	2002
Aluminum	12.4±1.3c	19.9±1.9b	26.9±2.7a	5.3±1.3a	8.0±1.6a	8.9±1.5a	13.8±2.1a	17.8±2.3a	16.1±2.6a	19.9±1.4a	10.0±0.6a	15.9±1.3c
Orange	12.3±1.1b	17.8±1.9a	21.3±2.2a	5.3±1.0a	5.6±1.5a	5.0±1.2a	26.3±2.8a	27.0±3.2a	24.9±2.9a	17.1±1.1b	5.7±0.5b	26.0±1.7a
Yellow	11.4±0.9b	13.6±1.7b	17.9±2.2a	4.5±0.8a	4.0±0.6a	3.6±0.7a	25.3±4.1a	23.3±3.9a	27.1±4.1a	14.3±1.0c	5.0±0.4b	25.2±2.3ab
White	9.6±1.2b	15.5±1.7a	18.1±1.4a	6.3±1.4a	4.8±1.0a	5.9±1.4a	27.9±3.1a	24.3±2.4a	27.1±1.7a	13.4±0.9cd	5.2±0.5b	26.4±1.7a
Black	5.6±0.8a	8.6±1.7a	7.6±1.0a	2.5±0.7a	2.6±0.7a	2.4±0.5a	13.5±1.5a	11.8±1.5a	14.7±1.8a	6.4±0.5e	2.6±0.3c	13.3±0.9c
Bare soil	6.9±1.0c	12.1±1.4b	16.4±2.6a	5.6±1.3a	5.5±0.9a	5.8±1.3a	17.0±1.7a	21.1±2.3a	20.3±2.0a	11.2±1.1d	5.5±0.5b	19.4±1.2b

[z] Within rows, means followed by a common letter do not differ significantly ($P< 0.05$) by SNK.
[y] Within columns, means followed by a common letter do not differ significantly ($P< 0.05$) by SNK.
[x] Sampling dates: 28 June, 29 June, 30 June and 1 July.
[w] Sampling dates: 6 June, 7 June and 8 June.
[v] Sampling dates: 28 June, 1 July, 3 July and 9 July.

TABLE 2. Effect of time of day on western black flea beetle (*Phyllotreta pusilla*) populations on cabbage plants in Ft. Collins, Colorado

	Number of flea beetles (means ± S.E) per four plants[z]		
Time of day	1999[y]	2000[x]	2002[w]
Early day (8 a.m.)	9.9±0.5c	5.3±0.4a	20.6±1.2a
Mid day (1 p.m.)	13.6±0.8b	5.7±0.4a	20.9±1.2a
Late day (4 p.m.)	17.7±1.0a	6.1±0.4a	21.7±1.2a

[z] Within columns, means followed by the same letter do not differ significantly ($P< 0.05$) by SNK.
[y] Sampling dates: 28 June, 29 June, 30 June and 1 July.
[x] Sampling dates: 6 June, 7 June and 8 June.
[w] Sampling dates: 28 June, 1 July, 3 July and 9 July.

Although aluminum mulches are most commonly documented to repel insects (1,2), they have been found attractive to some. For example, squash grown in aluminum mulch was slightly more attractive to the squash bug *Anasa tristis* (DeGeer) (Heteroptera: Coreidae) than squash plants grown with other mulches (3). However, two other chrysomelids, the banded cucumber beetle *Diabrotica balteata* LeConte and the spotted cucumber beetle *D. undecimpunctata howardi* Barber, appeared in the lowest numbers on the aluminum and aluminized plastic mulches. The highest population of *Diabrotica* spp. was observed on black mulches in cucumber and squash plants (7). In addition, adults of the chrysomelid *Leptinotarsa decemlineata* (Say), the Colorado potato beetle, had the highest populations on plants grown over black plastic mulches (8).

Several significant differences occurred during the 2002 trial (Table 1) and some also were different from previous seasons. In descending order, flea beetle numbers on the cabbage plants over different colored mulches were: orange = white > yellow, bare soil > aluminum = black (F=15.21; df=5, 282; P=0.0001). Unlike previous years, aluminum mulch treatment in this season resulted in much lower WBFB numbers relative to the other treatments. This may have been due to the weather conditions. The highest average temperature was 26.3°C and the lowest average wind speed was 4.1 mph. The higher temperatures and light intensity may have caused effects of the reflective aluminum mulch on WBFB behavior.

Conversely, the population density of flea beetles on the plants surrounded by white mulch was much higher than in the previous years. Plants surrounded by orange and yellow mulches continued to support higher numbers, about twice that of the bare soil control. However, time of day did not affect WBFB populations over different mulches in 2002 (Table 2). None of the treatments resulted in any significant difference among early, mid and late day counts. In a previous study it was reported that WBFB is active in greatest numbers during the middle of the day compared to earlier or later in the day, when the beetles usually stayed on lower levels of plant leaves or around the crown or on the ground (5). Such a relationship was observed in only one (1999) of the 3 years of this study.

In conclusion, different insect species may have different responses to colored mulches and time of day. In this study plants grown among aluminum mulches had the highest WBFB population densities in 1999 and in 2000, but not in 2002. Black mulches had the lowest number of flea beetles in all sampling years. The highest populations of WBFB were observed in late day counts in 1999. However, there were no significant differences among early, mid, and late day counts in 2000 or in 2002.

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