Relative Attraction of Color Traps and Plant Extracts to the False Chinch Bug *Nysius raphanus* and Its Parasitoid, *Phasia occidentis*, on Brassica Crops in Colorado

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The false chinch bug (FCB), *Nysius raphanus* (Howard) (Hemiptera: Lygaeidae), is one of the most significant pests on Brassicaceae plants. Different colored traps and cups with plant extracts were tested to study attraction to FCB and its tachinid parasitoid, *Phasia occidentis* (Walker) (Diptera: Tachinidae). The yellow trap was the most attractive color to FCB, and the blue trap was the second. The blue trap was also the most attractive color to the tachinid parasitoid of FCB. Both species also showed attraction to crude extracts of canola and mustard oilseed.

KEY WORDS: False chinch bug; *Nysius raphanus*; *Phasia* (=*Phorantha*) *occidentis*; colored traps; colored cups; plant extracts; canola oil; mustard oil; Brassicaceae crops.

INTRODUCTION

The false chinch bug (FCB), *Nysius raphanus* (Howard) (Hemiptera: Lygaeidae), originally described from Kansas by Howard (12), is one of the most serious pests among North American species of *Nysius* (2,24). It is multivoltine (6) and overwinters in the adult stage under protective debris or rubbish (3,6,9,24). The false chinch bug is a general feeder with preference for plants in the Chenopodiaceae and Brassicaceae (10,12-15,23-25,30, and N. Demirel (2003) Ph.D. dissertation, Colorado State Univ., Ft. Collins, CO, USA). FCB commonly produces large aggregations on plants and the heavily attacked plants may wilt seriously and often fail to recover (13,15-16,23).

In studies involving the western black flea (WBF) beetle *Phyllotreta pusilla* (Horn), M.A. Al-Doghairi (2000, Ph.D. dissertation, Colorado State Univ., Ft. Collins, CO, USA) incidentally noted FCB attraction to yellow-colored traps. Furthermore, yellow traps baited with allyl isothiocyanate caught significantly more FCB than yellow cup traps baited with water (as control). Allyl isothiocyanate, used in this preliminary study, is among the secondary compounds common to Brassicaceae (1,11).

Such secondary compounds are also sometimes utilized in host finding by parasitoids of phytophagous insects (4,21,26-29). The most common parasitoid associated with FCB is the tachinid *Phasia* (= *Phorantha*) *occidentis* (Walker) (5,17). It was commonly recovered incidentally on traps during studies by Al-Doghairi (2000), but no efforts had been made to trap it specifically.

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The purpose of this study was to identify the trap components (color, attractants) that could be used for optimal FCB capture. Concurrently, observations were made on attraction of the FCB's primary tachinid parasitoid.

MATERIALS AND METHODS

All trials were conducted during summer 2000 at three different locations in the vicinity of Ft. Collins, Colorado. At the Cargill Oilseed Research Center (CORC) and Colorado State University Horticultural Field Research Center (HFRC) sites canola was the predominant crop surrounding the trap study. The third site was within an organically managed Napa cabbage field at Grant Family Farms (GFF) in Waverly, Colorado.

Color traps Three trap trials were conducted at CORC. The first trap trial (no. I) was conducted from 5 to 12 July and consisted of six color-traps as treatments: yellow, blue, neon yellow, neon green, neon pink and orange (Table 1). The second trap trial was repeated at two intervals, the first running from 16 to 21 July (trial no. II), and the second from 18 to 23 July (trial no. III). Each trap trial comprised eight different color traps as treatments: yellow, blue, neon green, neon yellow, neon orange, neon pink, white and silver (Table 1).

Two additional trap trials were conducted during the same season at HFRC. The first trial (no. IV) was conducted from 7 to 14 July and consisted of eight color-traps as treatments: yellow, blue, neon yellow, neon green, neon pink, orange, white and silver (Table 2). The second trial (no. V) was conducted from 14 to 21 July and also consisted of eight color-traps as treatments: yellow, orange, neon yellow, neon green, dull aluminum foil, shiny aluminum foil, white and silver (Table 2). The last trial (no. VI) was conducted from 1 to 7 August at GFF. It comprised six color-traps as treatments: yellow, blue, neon green, neon yellow, neon orange and neon pink (Table 2).

A trap consisted of a colored 13×8 cm index card covered, on each side, with a transparent sheet stapled to the card. Each of the colored sticky traps was placed on wood stake crosses whose horizontal bar was 60 cm above the ground. The two outer surfaces of each trap were coated with a thin layer of Tanglefoot® (The Tanglefoot Co., Grand Rapids, MI, USA). The trap-stakes were spaced 6 m apart within the respective canola or Napa cabbage fields. Upon collection at each evaluation trial date, each sticky color trap was encased in clear plastic wrap and transferred to the laboratory for counts of the captured FCB and its parasitoids. The experimental design was a completely randomized block with four replications. All data were analyzed by analysis of variance (ANOVA) using the SAS software and means were separated using the Least Significant Difference (LSD) Multiple Comparison Tests (22).

Colored cups Three different trials were conducted concurrently from 1 to 7 August at the GFF site. Basic 266 ml yellow and blue plastic drinking cups (Solo Cup Co., Highland Park, IL, USA) were used as the traps in this study. The first trial treatments were canola oil (1 ml/cup), mustard oil (1 ml/cup), crushed freeze-dried canola pods extract (1 ml/cup), ground mustard seed (1 mg/cup) (Frontier Natural Products, Fort Collins, CO, USA) and plain water (10 ml/cup) in the yellow-colored cups (Table 3). An extract of crushed canola seed pods (1 ml) was prepared by crushing fresh pods and then concentrating the juice by freeze-drying.

The second trial treatments were mustard and canola oil mixture (0.5 ml + 0.5 ml/cup),

canola oil (1 ml/cup), mustard oil (1 ml/cup), ground mustard seed (1 mg/cup) (Frontier Natural Products) and plain water (10 ml/cup) in the blue-colored cups (Table 3). In the third trial, treatments consisted of canola oil (1 ml/cup) and mustard oil (1 ml/cup) in the yellow- and blue-colored cups (Table 3). Each of the test treatments was poured into the base of the cup and the inner rim of the cup was coated with Tanglefoot® (The Tanglefoot Co., Grand Rapids, MI, USA).

The yellow and blue cups were placed 9 cm apart along the horizontal bar of a 38×38 cm wooden stake cross. Stakes supporting the cups were spaced 11 m apart. The experimental design was a completely randomized block with four replications. All data were analyzed as described above, by ANOVA with means separated using the LSD Multiple Comparison Tests (22).

RESULTS AND DISCUSSION

Color traps and cups In all the three trials at CORC, the highest FCB numbers were found on yellow sticky traps (F=11.988, df=5, 18, P=0.0001; F=16.828, df=7, 24, P=0.0001; F=17.63, df=7, 24, P=0.0001, respectively) (Table 1). The same occurred at the HFRC site in Trials IV and V (F=2.195, df=7, 24, P=0.0491; F=1.904, df=7, 24, P=0.0113, respectively) (Table 2) and the GFF site in Trial VI (F=2.914, df=5, 18, P=0.042) (Table 2). A previous study had also indicated yellow as being attractive to FCB (Al-Doghairi, 2000). Our results also support these findings: yellow traps were more attractive than the other colors. The blue trap was less attractive than the yellow, but more attractive than the other colors tested at CORC (Table 1). At HFRC, the second highest capture was obtained with silver in Trial IV and with the shiny aluminum foil trap in Trial V (Table 2). These values were not significantly different from others tested. In addition, there were also no significant differences among treatments other than the yellow color in trial VI at GFF.

In the first trial at GFF, using yellow-colored cup traps, attraction also occurred with extracts of freeze-dried canola seed pods (F=0.721, df=4, 15, P=0.049) (Table 3). In the second trial at GFF, using blue-colored cups baited with a combination of mustard and canola oil, this combination caught higher numbers of FCB than traps baited with ground mustard seed (F=4.029, df=4, 15, P=0.021) (Table 3). In the last trial, canola and mustard oil baits in yellow-cup traps caught significantly more FCB than blue-cup traps baited with mustard oil (F=1.093, df=3, 12, P=0.0390). Pivnick *et al.* (20) reported that the northern false chinch bug, *Nysius niger* Baker, is attracted to mustard oils with a specific side-chain structure. The compound ethyl ICB (4-isothiocyanatobutyrate), placed in rubber septa attached to yellow boll weevil traps, was the most attractive. Yellow-cup traps baited with allyl isothiocyanate (AITC) caught significantly more false chinch bugs than yellow cups baited with water (control) (Al-Doghairi, 2000). Mustard oils and, particularly, isothiocyanate compounds, can be difficult to handle because of the potential injury they can cause upon contact or inhalation. The data from the present trials suggest that unrefined extracts of canola or mustard oilseed, as well as dried canola seed pod extracts, can also be used to increase effectively FCB capture with colored traps. Moreover, the yellow traps, and combining yellow traps with the plant extracts of canola and mustard oilseed, were important tools for monitoring population density and employing an IPM program for FCB on Brassicaceae plants.

The blue trap was significantly more attractive for *P. occidentis* than all other tested colors at the CORC site *(*F=13.435, df=5, 18, P=0.0001; F=4.751, df=7, 24, P=0.002;

F=7.284, df=7, 24, P=0.0001, respectively) (Table 1). The blue trap also caught the highest number of parasitoids compared with the other treatments in Trial IV (Table 2). The neon green trap caught the highest number of parasitoids in Trial VI (F=1.356, df=5, 18, P=0.0287). However, there was no significant difference among treatments in Trial V.

TABLE 1. Capture of the false chinch bug *Nysius raphanus* and its associated tachinid parasitoid, *Phasia occidentis*, on different colored sticky traps at Cargill Oilseed Research Center, Ft. Collins, Colorado

Trap color	Number of insects (means ± S.E.) per four traps[z]	
	N. raphanus	*P. occidentis*
	Trial I	
Yellow	316.3±64.9 a	0.3± 0.3 b
Blue	130.8 ±38.9 b	9.8±2.5 a
Neon Yellow	55.5 ±11.8bc	0.5±0.3 b
Neon Green	45.3 ±8.0c	0.3±0.3 b
Neon Pink	26.8 ±6.6c	0.3±0.3 b
Orange	39.3 ±14.0c	0.5±0.5 b
	Trial II	
Yellow	137.5± 22.7a	3.0±1.6 c
Blue	78.3±13.9 b	22.5±6.3 a
Neon Green	34.5±3.9 c	5.5±1.3 bc
Neon Yellow	28.5±8.1 c	5.8±2.2 bc
Neon Orange	22.3±4.4 c	10.3±1.9 b
Neon Pink	22.8±4.6 c	4.5±2.3 bc
White	18.0±0.8 c	5.0±1.3 bc
Silver	18.0±4.2c	7.3±2.6 bc
	Trial III	
Yellow	181.0±19.8 a	3.5±1.3 b
Blue	131.8±34.4 b	31.0±8.0 a
Neon Green	19.3±4.0 c	3.3±0.9 b
Neon Yellow	25.3±7.2 c	6.5±2.1 b
Neon Orange	26.3±5.0 c	7.8±2.5 b
Neon Pink	33.5±6.6 c	12.3±2.0 b
White	32.8± 5.5c	12.0±1.6 b
Silver	23.3± 6.5c	11.3±1.4 b

[z]Within columns, means followed by a common letter do not differ significantly (P<0.05) by LSD.

The use of canola oil baits with yellow-colored cups also increased capture of *P. occidentis* in Trial I at GFF (F=1.941, df=4, 15, P=0.0156) (Table 3). Mustard oil baits with blue-colored-cup traps caught the highest number of *P. occidentis* in Trial II at GFF (F=3.758, df=4, 15, P=0.0260). In addition, blue cups baited with canola oil caught the highest number of parasitoids compared with yellow cups in Trial III (F=1.269, df=3, 12, P=0.0329). Previous studies have reported tachinids captured on yellow-colored traps. During studies of the apple maggot, *Rhagoletis pomonella* (Walsh), yellow sticky panels caught a total of 378 tachinids, primarily *Archytas apicifer* (Walker) and *A. californiae* (Walker) (7). The use of sticky colored panels was also suggested by Burk (8) as a useful way of obtaining specimens of certain tachinids, specifically *Euphasiopteryx ochracea* (Bigot). Data from this study suggest that blue traps would be far superior to standard yellow traps when surveying tachinids.

Previous research by Pivnick (19) had established that some hymenopterous parasitoids associated with *Brassica*-feeding insects also showed attraction to mustard oil compounds.

The braconid parasitoid *Meteorus leviventris* Wesmael was caught in highest numbers on traps baited with AITC. Later studies by Murchie *et al.* (18) showed that traps baited with 2-phenylethyl isothiocyanate caught more males and females of *Platygaster subuliformis* than traps baited with AITC or unbaited traps. However, the data from the present study appear to be the first showing that secondary host plant compounds can increase captures of tachinids. The combination of canola oil and blue color seems to be particularly effective for *P. occidentis*. Furthermore, the blue traps, and blue traps in combination with plant extracts of oilseed canola and mustard, were important tools for monitoring the tachinid parasitoid *P. occidentis* in the Brassicaceae plants. For IPM purposes, yellow sticky traps with plant extracts can be used to capture the pest directly. Used in addition to blue traps, they can be employed for monitoring purposes for both the pest and its parasitoid to decide upon other control methods.

TABLE 2. Capture of the false chinch bug *Nysius raphanus* and its associated tachinid parasitoid, *Phasia occidentis*, on different colored sticky traps at the Horticultural Field Research Center (Trials IV and V) in Ft. Collins and at the Grant Family Farms (Trial VI) in Waverly, Colorado

Trap color	Number of insects (means ± S.E.) per four traps [z]	
	N. raphanus	*P. occidentis*
	Trial IV	
Yellow	8.0±3.0 a	0.3±0.3 ab
Blue	3.5±1.0 b	1.0±0.4 a
Neon Yellow	3.3±1.7 b	0.5±0.5 ab
Neon Green	2.0±0.6 b	0.5±0.3 ab
Neon Pink	3.0±0.7 b	0.5±0.3 ab
Orange	1.3±0.6 b	0.0±0.0 b
White	4.8±0.8 ab	0.0±0.0 b
Silver	5.3±1.3 ab	0.3±0.3 ab
	Trial V	
Yellow	37.0±16.0 a	1.5±0.6 a
Orange	9.0±4.7 b	2.0±0.7 a
Neon Yellow	8.8±2.6 b	1.0±0.7 a
Neon Green	11.0±3.2 b	1.3±1.3 a
Aluminum foil dull surface	18.3±7.0 b	0.3±0.3 a
Aluminum foil shiny surface	20.3±3.3 ab	0.5±0.3 a
White	11.0±2.0 b	0.5±0.5 a
Silver	10.0±5.5 b	1.3±0.9 a
	Trial VI	
Yellow	187.5±91.6 a	4.0±0.4 b
Blue	65.0±10.4 b	4.3±0.8 b
Neon Green	34.5±11.2 b	18.5±8.1 a
Neon Yellow	29.8±5.5 b	7.3±1.4 ab
Neon Orange	20.3±9.3 b	13.0±8.1 ab
Neon Pink	17.0±4.4 b	10.0±2.0 ab

[z] Within columns, means followed by a common letter do not differ significantly ($P<0.05$) by LSD.

In conclusion, the false chinch bug response to sticky yellow traps consistently resulted in highest captures. The blue trap was the second most attractive color to FCB and was highly attractive to its tachinid parasitoid *P. occidentis*. Both species also showed attraction to crude extracts of oilseed canola and mustard.

TABLE 3. Capture of the false chinch bug *Nysius raphanus* and its associated tachinid parasitoid, *Phasia occidentis*, in yellow- and blue-cup traps baited with different mustard and canola compounds at Grant Family Farms in Waverly, Colorado

Tested compound (amount) / trap	Cup Color	Number of insects (means ± S.E.) per four cups[z]	
		N. raphanus	*P. occidentis*
		Trial I	
Canola oil (1 ml)	Yellow	27.8±7.5 ab	2.3±0.9 a
Mustard oil (1 ml)	Yellow	28.0±3.9 ab	0.3±0.3 b
Crushed freeze-dried canola pods extract (1 ml)	Yellow	30.5±8.3 a	0.8±0.5 ab
Ground mustard seed (1 mg)	Yellow	24.5±6.8 ab	1.3±0.5 ab
Water (10 ml)	Yellow	17.0±1.3 b	1.0±0.4 ab
		Trial II	
Mustard oil + Canola oil (0.5 ml+ 0.5 ml)	Blue	49.5±3.8 a	1.8±0.5 bc
Canola oil (1 ml)	Blue	48.3±10.4 a	2.8±0.3 ab
Mustard oil (1 ml)	Blue	46.5±5.9 a	4.3±0.9 a
Ground mustard seed (1 mg)	Blue	20.5±4.3 b	1.0±0.7 c
Water (10 ml)	Blue	28.5±6.6 ab	2.0±0.7 bc
		Trial III	
Canola oil (1 ml)	Yellow	69.5±7.8 a	3.5±0.9 b
Mustard oil (1 ml)	Yellow	65.0±8.1 a	3.5±0.9 b
Canola oil (1 ml)	Blue	52.5±14.1 ab	7.0±1.9 a
Mustard oil (1 ml)	Blue	45.8±10.7 b	5.0±1.8 ab

[z]Within columns, means followed by a common letter do not differ significantly ($P<0.05$) by LSD.

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