Laboratory Study on Effect of Color on Oviposition Rate of Wheat Midge, *Sitodiplosis mosellana* (Diptera: Cecidomyiidae)

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**ABSTRACT**

Studying the effect of host color on insect behavior can be useful for managing crop pests. Wheat spikes were exposed to wheat midge in the laboratory for oviposition (20±3°C, 70% R.H. and 16:8 h L:D). Different color folders were attached to corners of a 60-cm cubic cage. Then, 10 wheat spikes were placed in front of each folder and 40 midges were released inside each cage. In the four-choice test, wheat midges oviposited more on spikes with yellow (183±24) background followed by blue (161±11), green (139±8) and red (96±8). In the three-choice test, wheat midges oviposited more on the control (140±16) treatment followed by yellow (123±13), blue (114±10) and green (100±12). Wheat midges oviposited more on the black treatment (62 ± 7) than the control (92 ± 10) in a two-choice test. In the other two-choice test, wheat midges oviposited more on the control (179 ± 16) compared to red (84 ± 11). The results showed that the color contrast between wheat spikes and background was important for oviposition on wheat spikes. Red and black backgrounds were deterrent; however, yellow and blue backgrounds were not.

**Keywords:** wheat, midge, *Sitodiplosis mosellana*, visual, cues.

**INTRODUCTION**

Most insects can perceive visual cues such as color. The visual information obtained can help herbivorous insects during the pre-oviposition period, during which insects search for the host plant habitat and suitable host plants for feeding and/or oviposition (Thorsteinson 1960). Color is important mostly for diurnal insects and to some extent for crepuscular insects that are active at dawn and dusk. Sometimes the color of a plant indicates if the plant is in a suitable condition for the herbivore’s colonization (Dunn and Kempton 1976). The effect of color on behavior of cecidomyiids when approaching different objects and host plants has been studied (Wiseman *et al.* 1972; Sharma *et al.* 1990; Harris *et al.* 1993; Oakley and Smart 2002). The wheat midge, *Sitodiplosis mosellana* (Géhin) (Diptera: Cecidomyiidae), is a key pest of wheat, *Triticum aestivum* L. (Poaceae), in Europe and also in the northern Great Plains of Canada and USA (Wright and Doane 1987). Females start ovipositing at dusk, a short time before sunset until dark (Reeher 1945) on wheat spikes (Mukerji *et al.* 1988). Larvae feed on the surface of early-stage developing kernels (Ding and Lamb 1999), resulting in kernel shrivelling and reduction in quality and quantity of yield (Miller and Halton 1961). The effect of visual cues on the behavior of the wheat midge can be helpful in scrutinizing resistance in wheat lines. Understanding the interactions among the wheat

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plant cues and wheat midge can be helpful in managing and controlling this pest in the field such as making color traps. The objectives of this research were to explore the effect of background color as a visual cue on wheat midge egg density on spikes of spring wheat in the laboratory.

MATERIALS AND METHODS

Combinations of colors were used in four separate tests: 1) red, yellow, green and blue (5 replications); 2) yellow, green, blue and control (5 replications); 3) black vs. control (7 replications), and 4) red vs. control (5 replications) (20±3°C, 70% R.H. and 16:8 h L:D). A 60×60×5-cm block of Styrofoam was placed on a frame (60×60×65 cm), and was covered with black plastic film, and a 5-mm layer of soil to simulate the presence of soil in the field. Forty spikes of the susceptible wheat cultivar ‘Roblin’, *T. aestivum*, which were at the pre-anthesis stage but were out of the flag leaf were chosen (Zadoks growth stage 57-59: Zadoks *et al.* 1974), and the culms were cut off at 50 cm from the top of the spikes, and all leaves except the flag leaves were excised. Hereafter, the excised culm carrying the flag leaf and the spike will be called a spike. The spikes were placed in 12-cm-long plastic floral tubes. When 40 spikes were ready, 10 spikes were positioned vertically, touching each other, at each corner and at a distance of 4 cm from the edge of the meshed arena (Fig. 1). Color folders (37×31 cm) supplied by Grand & Toy® (Don Mills, Ontario, Canada), with the following factory codes, were used in the experiment: black# 99328, red #99331, yellow #99334, green #99326 and blue #99330. In order to control for position of the folders, the colors were rotated among different corners of the cage for each replication. The folders were attached to the cage corners. In all experiments, in each cage, 40 female and 40 male wheat midges were released (one female and one male midge per spike) at the center of the cage. Each replication was run for three nights. The spikes in front of each color folder were collected, labelled, and then dissected under a stereomicroscope (50x). The setup procedures and study of the oviposition were based on research of Lamb *et al.* (2000, 2001, 2002), Smith and Lamb (2001, 2004) and Smith *et al.* (2004 a, b, 2007). The number of eggs laid on each spike was recorded. The ‘control’ corner did not have any color folder; however, its background (which consisted of transparent plastic mesh and transparent plastic) was very pale beige. The spectral reflectance of the color folders were measured with a hyperspectral camera (PIKA II, Resonon Inc., Bozeman, MT, USA). Data were analyzed using procedures of SAS® (SAS Institute Inc. 2002). Each spike was considered as an experimental unit and the number of eggs per spike was analyzed. Data were square-root or log transformed to stabilize variance. A mixed model analysis of variance (PROC MIXED) was used to compare the egg numbers per spike for each treatment (*P*<0.05). Color was a fixed effect, and replication and spike were random effects. The Satterthwaite method (Satterthwaite 1946) was applied for determining the denominator degrees of freedom (d.f.). Comparisons among treatments were made using the Tukey-Kramer test where analysis of variance showed significant differences among means.

RESULTS

The spectral analysis showed that the relative reflectance differed among colors (Fig. 2). The red color folder had lower relative reflectance compared to other colors at a wavelength range of 500-560 nm; the yellow color folder had a higher reflectance value in that range. In Test 1, there was a significant difference among the treatments (MIXED ANOVA: $F_{3,192} =13.09$, *P*<0.0001). The highest egg densities were in the yellow (183±24)
treatment followed by blue (161±11), green (139±8) and red (96±8). The red treatment received significantly fewer eggs compared to the other treatments (Tukey-Kramer: P<0.0001); however, differences among other treatments were not significant based on results of the Tukey-Kramer test (0.2965<P<0.9334). In Test 2, there was a significant difference among the treatments (MIXED ANOVA: F3,191=5.51, P<0.0012). The highest egg density occurred in the control treatment (140±16) followed by yellow (123±13), blue (114±10) and green (100±12). Based on results of the Tukey-Kramer test, the green treatment had the lowest egg density compared with blue (P<0.0328) and control (P<0.0006) treatments, but was not significantly lower than the yellow treatment (P<0.0656). In Test 3, there was a significant difference between the two treatments (MIXED ANOVA: F1,123=6.27, P=0.0107); the black treatment received fewer eggs (62±7) than the control (92±10). In Test 3, there was a significant difference between the two treatments (MIXED ANOVA: F1,85=37.74, P<0.0001) and the red treatment received fewer eggs (84±11) than the control (179±16).

DISCUSSION

The goal of this research was to conduct a preliminary study on the effect of visual cues on host finding behaviour of wheat midge. The results could be useful in designing complicated research plans to investigate the host finding behaviour of wheat midge in detail. Studies on cecidomyiids showed that host finding and acceptance were influenced by visual cues, such as color (Harris and Rose 1990). Hessian flies laid more eggs on yellow, green and orange papers compared to blue and red papers (Harris and Rose 1990). Red and white were attractive to sorghum midge, Contarinia sorghicola Coq. (Diptera: Cecidomyiidae), while blue and black were the least attractive colors (Sharma et al. 1990). In our study, color of the background affected oviposition rate of wheat midges on spikes of ‘Roblin’ spring wheat. Red and black background suppressed wheat midge oviposition on spring wheat spikes, while yellow and blue were ineffective. Field studies in the United Kingdom showed that yellow traps were more attractive than blue traps to wheat midge (Oakley and Smart 2002). It is concluded that wheat midge, responds to background color which may be important in host finding behavior.

The low egg density on green, in the four-color and three-color tests, along with the high egg density on the control in the three-color test, indicated that the wheat midges detect the contrast between the host spike and the background color. The contrast among objects was important in Hessian fly (Harris et al. 1993) and apple maggot, Rhagoletis pomonella (Walsh) (Diptera: Tephritidae) (Owens and Prokopy 1986) when approaching host plants. The approaching behavior of Hessian fly was affected by the contrast between colors; with a black background, landing on white targets was more frequent than on black targets. Wheat midges may use the soil darkness and the contrast of spike greenness with sky to fly towards the top of the wheat plants to find suitable spikes for oviposition.

The practical use of the results of the visual cues experiment could be in studies of populations using color-traps (Oakley and Smart 2002). Based on this preliminary study, yellow color may be useful to be used in production of color traps for field use; however, more field research is needed to corroborate the results. We are not sure if the color of the cages used in the screening tests in the laboratory might affect screening results and egg density of wheat midge. However, different color mesh used for screening sorghum lines against sorghum midge affected screening results (Sharma et al. 1990). On the other side, screening results
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of wheat lines in the field and in the laboratory against wheat midge, showed that the set up procedure and cage condition (including the color of the mesh and the plastic) did not affect the oviposition behaviour of wheat midge (Lamb et al. 2000, 2001, 2002; Smith and Lamb 2001, 2004 and Smith et al. 2004 a, b, 2007). Changing the color of wheat tissue is not possible without changing fundamental physiological processes, so the results can not be applied from that point of view. In conclusion, wheat midge used visual cues in host finding and oviposition behaviours. The color contrast between wheat spikes and background had significant influence for egg allocation on the wheat spikes.

Figure 1. The schematic showing the setup procedure of the experiment for studying the effect of background color on oviposition rate of wheat midge, *Sitodiplosis mosellana* (Dip.: Cecidmyiidae).

Figure 2. The relative spectral reflectance of the color folders used to explore the effect of background color of wheat spikes on oviposition rate of *Sitodiplosis mosellana* in the laboratory. The relative reflectance was measured relative to a white object (Teflon) reflectance spectrum.
REFERENCES


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for the evolution of virulence. The Canadian Entomologist, 139: 133-140.


تصدر العملية على تأثير اللون على معدل وضع البيض من ذبابة القمح، 
(Diptera: Cecidomyiidae)

علي الحسيني قرالي

ملخص

يمكن دراسة تأثير اللون المضيف على سلوك الحشرات يكون من المفيد لإدارة أفات المحاصيل. تعرضت ستة نسابة القمح لذبابة القمح في المختبر لوضع البيض في درجة حرارة (20 ±3 °C) و 70% رطوبة، و بعد 10 ساعات من بعض القمح، ثم وضع 10 نسابة القمح أمام كل نمط وكفر من البراعيش. الدراسة أجريت على السماور مع الصفراء (183 ± 24) و الأحمر (139 ± 8) والأزرق (96 ± 8). على اختبار ثلاثة الدراسة أجريت أكثر على جهاز القمح (140 ± 16) العلاج بقليل الأبيض (123 ± 13) oviposited أكثر على العلاج السوداء (62 ± 10) والاخضر (14 ± 10) والأزرق (100 ± 12). البراعيش القمح oviposited أكثر على جهاز القمح (92 ± 10) في اختبار الاختيار الثانين. في اختبار الاختيار الثانين أخر، القمح أكثر على جهاز القمح (179 ± 16) مقارنة بحلبة (84 ± 11). وأظهرت النتائج أن التباين بين نسب القمح والخليفة مهم لوضع البيض على ستة نسابة القمح. نتائج الخلايا حمراء وسوداء الرادعة. ومع ذلك، كانت الخلايا الأزرق والأبيض لا.

الكلمات الدالة: القمح، ذبابة، Sitodiplosis mosellana، البصرية، العطية.

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