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Attraction of larvae of the armyworm *Spodoptera litura* (Lepidoptera: Noctuidae) to coloured surfaces

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Abstract. Attraction of first instar larvae of *Spodoptera litura* to different colours was studied to determine those that could be used as effective visual attractants for trapping the larvae during dispersal. The larvae were presented with cones of coloured paper. Each cone was placed in the center of a 15-cm Petri dish around the edge of which the larvae were released. Percentage of larvae arriving at the cone was recorded at 5-min intervals over a 15-min period. Differences in the percentages reflected differences in larval attraction to the different colours. The larvae were highly attracted to Foliage Green, Green Bice and Cadmium Yellow. The larvae arrived at the Scarlet Red, Ultramarine Blue, Gray, Orange, White and Black cones in percentages that were almost equal, but lower than at the Foliage Green, Green Bice and Cadmium Yellow cones. Arrival of larvae at the coloured cones increased with time, but their relative preference for different colours remained the same. This study shows that green and yellow can be used as visual attractants in *Spodoptera litura* larval traps.

INTRODUCTION

Our knowledge of the attraction or repulsion of lepidopterous larvae by various colours is restricted to a few reports. Götz (1936) reports that young and starved larvae of the nymphalid butterflies *Vanessa io* (L.), *V. urticae* (L.), *Araschnia levanoporsa* (L.) and the pierids *Pieris brassicae* (L.), *Gonopteryx rhamni* (L.) were attracted by green, yellow, orange and red colours, and were repelled by blue colour. Their attraction to green declines whereas that to dark colours, like brown or black, increases when the larvae complete their feeding and are ready to pupate. Hundertmark (1937) reports that *Lymantria dispar* (L.) larvae are attracted to blue and repulsed by yellow. Role of colours in the attraction and feeding of *Spodoptera littoralis* (Boisduval) larvae was studied by Meisner & Ascher (1973). Larvae of the citrus butterfly, *Papilio demoleus* L., show a strong attraction to yellow, followed by green and red, and are repelled by blue (Saxena & Goyal, 1978). Saxena & Onyango (1987) report that the larvae of the stem borer *Chilo partellus* (Swinhoe) show a high level of attraction to certain shades of green followed by yellow. These authors further report that yellow and green coloured sticky cylinders could be placed between rows of host plants to trap the early instar larvae of this species, which balloon off and disperse from the plants on which the eggs were laid.

The fact that larvae of some lepidopterous insects are attracted by certain colours suggests the possibility of developing more appropriately coloured traps for use in management programs. This would be suitable for trapping those larvae that move from plant to plant. One such pest is the armyworms, including various species of the genus *Spodoptera* Guenée. Larvae of these species feed on plants on which the eggs were laid and then move to other plants. The extent of movement depends on the type of plant on which they have been feeding and that available in the vicinity. If attractively coloured traps could be placed in suitable places in infested fields, dispersing larvae might be attracted and trapped before they reach other plants. Thus trapping the larvae would reduce the population of the pest in the field and contribute to overall pest management.

In the above context, we have tried to develop tactics for using coloured traps to reduce populations of larvae of the cotton armyworm, *Spodoptera litura* (F.), which is a serious pest of cotton and many other crops in India and neighbouring regions. For this purpose, we tested the response of the larvae to different colours and identified the most attractive colour. In the future we shall test different designs (sizes, shapes, etc.) of traps, inter-trap distances and the effect of various field conditions, particularly plant growth, stage, spacing and cropping pattern, on trapping success. This information will be used to determine the most attractive colour, effective design, location and inter-trap distances relative to cropping conditions, for trapping larvae.

MATERIAL AND METHODS

This study was done in a laboratory of the Department of Zoology at the University of Delhi, India. The coloured papers used in our tests were purchased from Camlin India Pvt. Ltd and are listed in Table 1. The reflectance spectra of these papers are given in Fig. 1. Each of these papers was tested in the form of a cone that was fixed inside a clear, transparent, mylar sheet cone (5 cm base dia., 5 cm ht.). The colour of the paper was visible through the mylar sheet.

For each test, a cone of the desired colour was placed in the centre of a glass Petri dish (15 cm dia., 1.5 cm deep). The dish was uniformly illuminated (1200–1500 lux) from above by a 40 W daylight fluorescent tube at a distance of 1.25 m, and kept at a temperature of 26–28°C and relative humidity of 50–60%. Ten neonate first instar larvae of *Spodoptera litura* (F.) were taken from a culture reared on castor leaves and released around the periphery of the bottom of the Petri dish. They were observed for 15 min. When a larva arrived at the cone, it was removed with a fine brush. The number of larvae that reached a cone within 5-, 10- and 15-minute intervals was recorded and the percentages calculated.

Each treatment was replicated five times. The percentages of larvae reaching the cones were subjected to ANOVA followed by Duncan's Multiple Range Test for separating the means at $P = 0.05$.

TABLE 1. Orientation of neonate *Spodoptera litura* larvae to different coloured paper cones, each offered alone for 15 min.

Paper colour and code No.[a]	% larvae arriving at the cone (mean ± s.e.) within		
	5 min	10 min	15 min
White	22.0 ± 6.6 ab	36.0 ± 6.7 ab	42.0 ± 3.7 ab
Black	24.0 ± 5.0 ab	38.0 ± 4.8 ab	48.0 ± 7.3 ab
Ultra-marine blue (UB-318)	30.0 ± 6.3 ab	38.0 ± 3.7 ab	50.0 ± 6.3 ab
Foliage green (FG-328)	64.0 ± 11.6 c	80.0 ± 5.4 c	88.0 ± 4.8 c
Green bice (GB-329)	62.0 ± 10.6 c	76.0 ± 8.1 c	86.0 ± 6.0 c
Cadmium yellow (CY-307)	60.0 ± 7.0 c	68.0 ± 6.6 c	80.0 ± 3.1 c
Orange (OR-311)	44.0 ± 8.7 bc	54.0 ± 5.0 bc	64.0 ± 5.0 bc
Scarlet red (SR-309)	26.0 ± 6.7 ab	38.0 ± 7.3 ab	52.0 ± 8.6 bc
Grey (GR-300)	22.0 ± 8.6 ab	38.0 ± 10.1 ab	44.0 ± 2.2 ab
Clear mylar sheet cone	16.0 ± 5.0 a	26.0 ± 5.0 a	32.0 ± 3.7 a

Means followed by the same letter in a column are not significantly different (P = 0.05; DMRT).
[a]All the papers except white and black were those of Camlin India Pvt. Ltd.

RESULTS

Percentages of larvae arriving at Foliage Green (FG), Green Bice (GB) and Cadmium Yellow (CY) cones in the first 5 min (Table 1) were significantly greater (60–64%) than those arriving at the other coloured cones. The only exception was the Orange (OR) cone (44%), which attracted numerically but not significantly fewer larvae than the above three colours. The remaining colours attracted 16 to 30% of the larvae and did not differ significantly from one another.

By the end of the 10th min, 80% of the larvae reached the Foliage Green cone, whereas the percentages that reached the Green Bice and Cadmium Yellow cones were lower (76 and 68, respectively), but not significantly so. Again, arrival at the Orange cone (54%) lagged behind that at the Foliage Green cone, but not significantly so. By the 15th min, 80% or more of the larvae reached the Foliage Green, Green Bice and Cadmium Yellow cones (not significantly different). Percentages of larvae arriving at the Orange and Scarlet Red cones were numerically but not significantly lower (64 and 52%, respectively). The remaining cones attracted fewer larvae and the percentages (32–50) are significantly lower than those for green (FG and GB) and yellow (CY) cones.

DISCUSSION

First as well as later instar larvae of *Spodoptera litura* sometimes disperse from infested to other plants. Trapping such larvae on their way to other plants could be an effective component of any management program for this armyworm. Trapping would be predictably more useful if it is directed against the first rather than later instars. The efficacy of the traps would depend on their attractiveness, which is determined by the attractive stimuli incorporated in the traps.

The present work shows that certain colours serve as visual attractants for first instar *S. litura* larvae. The larvae that arrived at Foliage Green, Green Bice, Cadmium Yellow and Orange coloured cones in significantly or numerically greater percentages than at other coloured cones could be due to differences in one or both of the following characteristics: (a) brightness (i.e. intensity) of the light reflected from cones and/or (b) hues (i.e. spectral wavelengths) of the reflected light. The intensity of light reflected from a white surface is higher, and that reflected

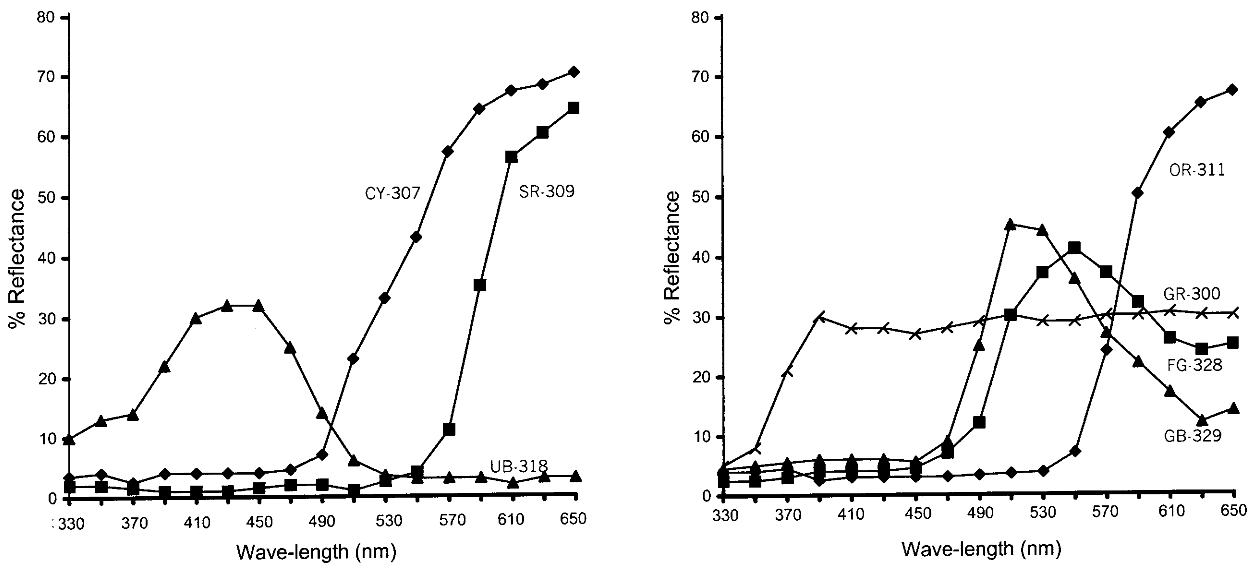

Fig. 1. Spectral reflectance curves of the coloured papers (Camlin India Pvt. Ltd.) measured using a Zeiss spectrophotometer and MgO as the standard (100%). The code numbers given next to the reflectance curves refer to coloured papers listed in Table 1.

from a black or gray surface is lower, than from a yellow or green surface. For example, Prokopy (1972) showed this for the apple maggot fly, *Rhagoletis pomonella* (Walsh). In spite of this larvae of *S. litura* arrived at the yellow and green coloured cones in greater percentages than at the white, black or gray cones. We believe this is due to larval attraction to the hues (i.e. spectral wavelengths) rather than the brightness of the green and yellow cones.

That lepidopterous larvae can distinguish between spectral wavelengths, using their visual organs termed stemmata, was electrophysiologically demonstrated in the larvae of *Bombyx mori* (Ishikawa, 1969; Ichikawa & Tateda, 1982, Kitabatake et al., 1983), *Papilio xuthus* (Ichikawa & Tateda, 1980, 1982), *Pieris rapae crucivora*, *Mamestra brassicae* (Ichikawa & Tateda, 1982) and *Trabala vishnou* (Lin et al., 2002). These studies reveal that there are three categories of photoreceptors in the stemmata, each sensitive to one of three spectral regions: ultraviolet, blue or green. However, behavioural tests revealed that larvae of *Bombyx mori* respond phototactically to only short (UV-blue) and long wave (green-red) lengths (Kitabatake et al., 1983; Shimuzu, 1981).

The responses of *S. litura* larvae to green-yellow described here are similar to those of other lepidopterous larvae and insects of other groups, reported by several authors and included in the reviews of Mazokhin-Porshnyakov (1969), Prokopy (1983), Menzel & Backhaus (1991), Gilbert (1994), Briscoe & Chittka (2001). As there are very few reports on the behavioural responses of lepidopterous larvae to colours, and the tints or spectral wavelengths of the colours tested were not specified in these reports, it is not possible to compare their responses to broad regions of the visible spectrum. There are differences among species in the relative attractiveness of green and yellow. For example, *S. litura* larvae are almost equally attracted to green and yellow, whereas *Chilo partellus* larvae show a greater attraction to green than yellow (Saxena & Onyango, 1987) when tested using the same brand of coloured papers. On the other hand, larvae of the citrus butterfly, *Papilio demoleus*, are more attracted to yellow than green (Saxena & Goyal, 1978). Furthermore, the attraction of *S. litura* larvae to orange, observed in this work, is also reported for the larvae of nymphalid and pierid butterflies by Götz (1936). *S. litura* larvae were not attracted to blue and thus differ from the larvae of the lepidopteran, *Lymantria monacha*, which are strongly attracted to blue and repulsed by yellow (Hundertmark, 1937).

This work provides a basis for further studies to test the shapes and sizes of green and yellow coloured traps, and the distances over which they are effective, and deciding the number, locations and timing for placing such traps in fields for the management of *S. litura* larvae.

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