WESTERN FLOWER THRIPS: REACTIONS TO ODOURS AND COLOURS

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Summary

The response of western flower thrips to odours and colours and combinations were tested in an Y-tube olfactometer, in a windtunnel and in a small greenhouse. In the Y-tube female thrips were attracted to p-anisaldehyde, honey and pollen but not to sugar, chrysanthemum flowers and buds. In the windtunnel female thrips were more attracted to yellow than to blue sticky plates. Addition of p-anisaldehyde did not increase the catch of sticky plates. Thrips were much more attracted to yellow chrysanthemum flowers than to buds. When the flowers and buds were covered from sight, however, open buds attracted more thrips than flowers. In greenhouse experiments no positive effects on the numbers of thrips caught by sticky traps was found by the addition of honey, pollen or p-anisaldehyde. The conclusions are that thrips are attracted to certain odours when walking but in flight their landing response seems to be dominated by a response to colour.

INTRODUCTION

Western flower thrips, *Frankliniella occidentalis* (Pergande), is a serious pest on many ornamental and vegetable crops (Lewis, 1997). Odours and colours that influence their behaviour could be used to improve biological and chemical control strategies, for instance in 'attract and infect' systems, a variation on the theme of 'lure and kill',(Jones & Langley, 1998). The major problem in the control of western flower thrips (WFT) is their habit to live deep inside flowers where they are very difficult to reach by control agents. Our 'attract and infect' strategy aims at attracting and infecting a sufficient number of thrips with pathogens to start of an epizootic that spreads through the population. This paper deals with the attraction of thrips to various odours and colours and combinations of both stimulants to find the most suitable attractants.

Western flower thrips are attracted to coloured sticky traps, in particular to yellow and blue colours (Lewis, 1997). Several attempts have been made to improve trapping efficiency using plant odours (Brødsgaard, 1990; Teulon & Ramakers, 1990; Frey et al., 1994). Many of the volatiles tested are flower odours such as p-anisaldehyde, geraniol, eugenol, myrcene, benzaldehyde and salicylaldehyde (Terry, 1997). Behavioural responses of thrips to volatiles in laboratory assays have been reported using different methods: the Petterson four-arms olfactometer (Pow et al., 1998), a V-shaped olfactometer (Gerin, 1994), an Y-tube olfactometer (Holtmann, 1963), and flight chamber olfactometers (Frey et al., 1994; Hollister et al., 1995; Teulon et al., 1999). Due to the use of different methods and specific problems of greenhouse and field studies, reports on attractiveness of volatiles are often not comparable and sometimes contradictory. Some authors reported major improvements of trap catches using odours. Others using the same odours found no effect at all. We therefore decided to redo some of the tests and add new ones in order to sort out the behavioural responses of WFT to odours and colours and combinations of both stimulants.

MATERIAL AND METHODS

Insects

A rearing of *Frankliniella occidentalis* was maintained on potted, flowering chrysanthemum plants, *Dendranthema grandiflora* Tzelev, of the susceptible cultivar 'Sunny Cassa' in a greenhouse at 25° C and 70 % RH, 16:8/L:D. Adult females were collected from the rearing with an aspirator and starved overnight, only provided with water, in Perspex ring cages (Murai, 1990) at 25° C , 16:8/L:D. These insects were used for experiments on the following day.

Y-tube experiments

A glass Y-tube olfactometer (internal diameter of 0.5 cm; length of arms is 5 cm) placed in black box in a dark room at 22° C in an inclining position with a halogen lamp attached to the ceiling was used. The end tubes of the Y were connected to 4-ml glass-vials to which samples could be added. The airflow was first purified by passage through charcoal pellets. Air was sucked at the base of the Y-tube by means of a membrane pump. The method is described in more detail by De Kogel et al. (1999).
To test the effect of plant odours 1 µl of the volatile component diluted in paraffin oil (Uvasol, Merck) and 1 µl pure paraffin oil at the control side was applied on a 1 cm^2 piece of filter paper. This was done 30 min before the first thrips was released, in order to allow the odour to reach a constant release rate. Preliminary assays showed that paraffin oil was not attractive to thrips. Alternatively 0.1 g honey, 0.01g Chrysanthemum pollen, 2 ml satisfied sugar solution, a chrysanthemum flower (CV Yellow Dreamtime), a closed and a half open bud were put in the vials to test the reactions of the thrips.

Individual female thrips were released one at a time within the first cm of the base tube of the olfactometer using a small size aspirator. Activated by the odour-loaded airflow and additionally motivated by the light, thrips started walking upwards the tube. Incidentally a thrips made no choice between both arms within 3 minutes; this was scored as a no-choice. Experiments consisted of 25 thrips. After each five thrips, the entire set-up was turned 180° to avoid any positional effects. Between experiments, all parts of the set-up were cleaned with acetone. Data were analysed with a two-sided binomial test.

Wind tunnel experiments

The wind tunnel is described in great detail by Griepink (1996). The flight area measures 3 x 1.3 x 0.8 m. Wind speed, temperature, humidity and light intensity can be set. The air is filtered with active charcoal and blown from the side through a perforated metal plate giving a horizontal laminar flow through the length of the tunnel. In our test 60-100 female WFT were collected from the rearing and pre-conditioned overnight as described above. In the morning at 8.00-9.00 O'clock the Perspex container with the thrips was put 40 cm from the downwind end of the tunnel at a height of 30 cm and opened. The yellow and blue sticky plates (20x10 cm, Brinkman BV 's Gravenzande NL) were hung from the ceiling of the tunnel at 40 cm from the upwind end with the centre being at 40 cm from the bottom. Flowers and buds were offered in little glass flasks with water placed on the bottom of the windtunnel also at 40 cm from the upwind end. The thrips therefore had to cover 2.2 meters to reach their goal. After 24 hours the final assessment was made, every two hours during daytime a visual count of numbers on the plates was made. Numbers of thrips that were caught on the sticky plates were counted. Flowers and buds were dipped and taken apart in alcohol and the numbers of thrips were assessed under a stereo binocular microscope. Flowers and buds were sometimes covered with a 10 cm high brown paper hood with holes that allowed air to pass through but blocked sight. The conditions in the windtunnel were kept at 25° C and 60 % RH. No wind or very low wind speeds of 0.17 m/sec were used. The tunnel was lighted for 18 hours a day by 10 Philips high frequency TLD 50W/84HF fluorescent lamps giving an estimated illumination of about 1200 lux.

Greenhouse experiments

The greenhouse was 3,4 x 6 m and provided with four tables (2 on each side) of 2,4 x 0,9 m. On each table a group of 25 (5 rows of 5) yellow chrysanthemums (20 cm high potted chrysanthemums CV 'Yellow Dreamtime', each with 50-60 flowers of 2 cm diameter each) was placed. The greenhouse was kept at 25° C and 70 % RH and a 16:8/L:D regime. Each group of plants was provided twice with 100 WFT to build up a population. The experiments were done a month after starting the population when large numbers of thrips were found in the plants throughout all four plots.

In the experiments small yellow or blue sticky plates (5 x 10 cm) were attached to a cane stick of 50 cm and put 15 cm above the flowers at each of the four sides of each plot. Just below each sticky plate a 1,5 ml eppendorf vial provided with an attractant was attached to the cane stick. Four different attractants were tested. The control (A) consisted of 10 µl of pure paraffin oil on a small piece of filter paper only. Treatment B contained 10 µl pure paraffin oil and 10 µl honey. Treatment C contained 5 mg of pollen (*Pinus spp.*) and paraffin oil. Treatment D contained 10 µl of 1% p-anisaldehyde in paraffin oil. Each of the four plots was provided with each of the four treatments and in each plot the relative positions of the four treatments were different to compensate for possible one-sided effects of attraction by sunlight or air currents in the greenhouse. The numbers of thrips on the plates and in the vials were counted after 48 hours.

RESULTS

Y-tube experiments

Table 1 shows the results of the Y-tube experiments with female western flower thrips. It is clear that p-anisaldehyde is an attractive odour. Honey and chrysanthemum pollen are also attractive, sugar gives a neutral response. Surprisingly thrips responded not positively to the odours of chrysanthemum flowers and buds.

Table 1*. Responses of female western flower thrips to odour sources offered in one arm of an Y-tube olfactometer.*

Treatment	Number of choices	Positive choices	Conclusion
10% p-anisaldehyde	94	64.9 % *	Attractive
0.1 g honey	75	70.7 % *	Attractive
0.01 g chrysanthemum pollen	74	68.9 % *	Attractive
2 ml saturated sugar	71	52.1 %	Neutral
1 chrysanthemum flower	63	38.1 %	Neutral
1 chrysanthemum bud open	70	58.3 %	Neutral
1 chrysanthemum bud closed	73	46.6 %	Neutral

*: $p<0.05$, two sided binominal test

Wind tunnel experiments

Table 2 shows the results of a series of wind tunnel experiments. It is clear that in this situation the female trips preferred yellow traps above blue ones. Addition of p-anisaldehyde did not increase the catch of the plate to which the odour was added. Transparent plates with or without odour did not catch any thrips. When flowers and buds are offered most thrips are found on the flowers and some on open buds, none on very young closed buds. When however the flowers and buds are covered with a cylinder that allows airflow but blocks the sight, the catch on flowers is much reduced but the catch rate on open buds remains the same.

Table 2. *Percentages of female western flower thrips caught in or on coloured sticky plates or chrysanthemum flowers or buds placed in a windtunnel.*

Object 1	% caught	Object 2	% caught	Object 3	% caught	No. released
Blue plate	11.6 %	Yellow plate	60 %	-	-	60
Yellow plate + p-anisaldehyde	22.8 %	Yellow plate	25.7 %			70
Blue plate + p-anisaldehyde	18.3 %	Blue plate	16.6%	-	-	60
Transparent plate + p-anisaldehyde	0	Transparent plate	0	-	-	100
5 chrysanthemum buds closed	0	5 chrysanthemum buds open	4 %	5 chrysanthemum flowers	29.3 %	300
5 closed buds under a cover	0.6 %	5 open buds under a cover	6.6. %	5 flowers under a cover	4.3 %	300

Greenhouse experiments

Table 3 shows the results of two greenhouse experiments. The results are variable and it is not clear that any of the attractants increase the numbers on the sticky plates in a consistent way. The plant odour p-anisaldehyde showed higher catch rates in the first experiment but not in the second.

Table 3. *Catch of western flower thrips on small sticky plates provided with vials with different attractants in a greenhouse experiment with yellow chrysanthemums.*

Date	colour	Attractant	No thrips caught/4 plates	% relative to the untreated control
16-08-99	Yellow	none	142	100 %
	Plates	Honey	75	53 %
	48 h	Pollen	169	119 %
		p-anisaldehyde	266	187 %
18-08-99	Blue	none	809	100 %
	Plates	Honey	370	46 %
	48 h	Pollen	565	70 %
		p-anisaldehyde	809	100 %

DISCUSSION

The Y-tube experiments showed that female trips are able to smell and positively respond to p-anisaldehyde, to honey and to chrysanthemum pollen. This is in agreement with earlier findings and reviewed by Kirk (1985). The thrips did not respond to the smell of sugar whereas sugar is sometimes being used as an additive to chemical pesticides with the claim that it improves efficacy by luring thrips out of flowers. The reactions to chrysanthemum flowers and buds were negative or neutral, when more flowers were offered the thrips even significantly chose to avoid those (data not shown). The reaction to opening buds was less negative and even turned slightly positive when one bud was offered. This corresponds well with the findings in the windtunnel and observations in the greenhouse that suggest that the odour of opening buds is attractive to thrips.

The windtunnel experiments showed that yellow plates were more attractive than blue ones. The literature is full of contradictory statements which plates are the best. It seems that the local situation and other stimuli determine which type of plate attracts most thrips. The addition of p-anisaldehyde or geraniol (data not shown) does not increase the catch on the plates, on transparent plates with odour nothing was caught. Similar findings were made by Teulon et al. (1999). They suggest that these odours induce a landing or arrestment response rather than attract flying thrips. The experiments with chrysanthemum flowers and buds showed that visual clues play the major role. Many landed on the wide-open yellow flowers and few on the buds. The experiments with the perforated hoods showed that when the flower cannot be seen but only smelled, the attractiveness is considerably reduced and the open bud even becomes more attractive. These experiments do suggest strongly that odour does play some role in attracting flying thrips but that colour is the dominant factor. The greenhouse trials showed variable results but no clear consistent increase of trap catch by adding attractant volatiles. Frey et al. (1994) improved trap catches in the laboratory by adding geraniol, but under greenhouse conditions geraniol did not improve trap catches reliably. *Thrips flavus* Schrank, a flower-inhabiting thrips species (Kirk, 1985) and cereal thrips species (Holtmann, 1963) have were shown to respond positively to geraniol. Teulon & Ramakers (1990) and recently Teulon et al. (1999) did sometimes find a 2-3-fold increase in trap catches by adding p-anisaldehyde. The differences may be explained by the larger amounts of attractants they used and the much larger greenhouses and distance between the traps used in their experiments. Overall we conclude that colour seems to be the dominant attractant for flying western flower thrips. Attractive odours are being perceived by both flying and walking thrips and probably do play a role in the behaviour of thrips. Simply adding these attractants to traps, however, leads to variable and sometimes contradictory results because our understanding of thrips behaviour is still insufficient.

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