UvA-DARE (Digital Academic Repository)

Variation in performance of western flower thrips populations on susceptible and partially resistant cucumber

de Kogel, W.J.; van der Hoek, M.; Mollema, C.

Publication date
1997

Published in
Entomologia Experimentalis et Applicata

[Link to publication](#)

Citation for published version (APA):

de Kogel, W. J., van der Hoek, M., & Mollema, C. (1997). Variation in performance of western flower thrips populations on susceptible and partially resistant cucumber. *Entomologia Experimentalis et Applicata*, 83, 73-80.

General rights

It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

Disclaimer/Complaints regulations

If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: <https://uba.uva.nl/en/contact>, or a letter to: Library of the University of Amsterdam, Secretariat, Singel 425, 1012 WP Amsterdam, The Netherlands. You will be contacted as soon as possible.

Variation in performance of western flower thrips populations on susceptible and partially resistant cucumber

Willem Jan de Kogel^{1,2}, Marieke van der Hoek¹ & Chris Mollema¹

¹DLO-Centre for Plant Breeding and Reproduction Research (CPRO-DLO), Dept. of Vegetable and Fruit Crops, P.O. Box 16, 6700 AA Wageningen, The Netherlands; ²Institute for Systematics and Population Biology, University of Amsterdam, P.O. Box 94766, 1090 GT Amsterdam, The Netherlands

Accepted: December 3, 1996

Key words: *Frankliniella occidentalis*, *Cucumis sativus*, biotype, host plant resistance, life history, population growth rate

Abstract

Biotypic variation is of major concern in breeding for host plant resistance to insects. The existence or development of aggressive biotypes can lead to a rapid break-down of host plant resistance. Therefore the study of biotypic variation should be included in breeding programs for resistance to insects. In the present study we measured the reproduction of randomly collected females of ten different populations of the insect herbivore *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae) on one susceptible and two resistant cucumber (*Cucumis sativus* L.) accessions. Significant differences between thrips populations were observed on all three cucumber accessions. None of the populations had a significantly higher reproduction than the Dutch reference population NL1. For three populations, the Dutch population NL1, a population from New Zealand (NZ), and an Italian population (IT), partial life history parameters, such as reproduction rate, developmental time and survival were determined and the relative rate of increase r_r was calculated. On all three cucumber accessions the r_r -value of population NZ was lower than of populations NL1 and IT. It is concluded that there is biotypic variation in *F. occidentalis* with regard to performance on cucumber plants with different levels of resistance. Reproduction is a good criterion for differentiating biotypes of *F. occidentalis* on cucumber.

Introduction

Western flower thrips, *Frankliniella occidentalis* (Pergande), was a local pest in western USA until 1980 (Brødsgaard, 1991). Since the early 1980s it has spread worldwide and become a major pest. In the Netherlands it has become the most important pest in many ornamental and vegetable crops in greenhouses (Mantel & van de Vrie, 1988). Chemical and biological control are used to control this pest. Chemical control is difficult because *F. occidentalis* has become resistant to many insecticides (Robb, 1989; Immaraju et al., 1992; Brødsgaard, 1994). Furthermore, the use of insecticides to control *F. occidentalis* limits biological control methods against other pests. Introduction of resistant cultivars could help to manage these problems.

Variation in host plant resistance to *F. occidentalis* has been described in cotton (Trichilo & Leigh, 1988), chrysanthemum (Robb, 1989; de Jager et al., 1993; van Dijken et al., 1994), rose (Gaum et al., 1994), pepper (Fery & Schalk, 1991), tomato (Kumar et al., 1995), and cucumber (Mollema et al., 1995; Soria & Mollema, 1995). Cucumber accessions (i.e., a sample of a local plant population as conserved in gene bank collections) have been selected with partial resistance to *F. occidentalis* using a population of *F. occidentalis* (NL1) that was collected in the Netherlands on cucumber (Soria & Mollema, 1995). After infestation with thrips, these plants showed reduced levels of damage compared to a susceptible control. Life history parameters of *F. occidentalis* differed between susceptible and partially resistant plants; reproduction was reduced, mortality was higher and the developmental

period was longer on some of the resistant accessions (Soria & Mollema, 1995).

Insects may adapt to the host plant resistance involved. Populations of the same pest species that differ in performance on different plant species or varieties are commonly referred to as biotypes (Claridge & den Hollander, 1983; Diehl & Bush, 1984; Saxena & Barrion, 1987; Menken & Raijmann, 1996). The units that are identified as 'biotypes' may be different clones, groups of clones, different populations, or simply phenotypically similar groups composed of an unknown number of different genotypes (Via, 1989). Biotypic variation is of major concern when developing host plant resistance to insects. Failure to recognize the existence of biotypes may lead to severe infestation of formerly resistant cultivars (Smith et al., 1994). For example in a study on resistance to the cabbage aphid *Brevicoryne brassicae* (L.) of Brussels sprouts it was found that only one out of seven sprout clones that were highly resistant to aphids from one location was also resistant to aphids from several other locations (Dunn & Kempton, 1972). Saxena & Barrion (1987) have listed 36 insect species with known biotypes. Well known examples are the Hessian fly, the brown planthopper, and several aphid species.

In the Thripidae two cases of biotypic variation with regard to performance on different host plant genotypes have been described. Zawirska (1976) mentions two biological types of *Thrips tabaci* (Lind.); the 'tabaci type' (continuous arrhenotoky, oligophagous) and the 'communis type' (continuous thelytoky, polyphagous). Karban (1989) describes differences between populations of the wingless thrips *Apterothrips septicornis* (Trybom). This species lives on the rosette-forming plant *Erigeron glaucus* (Ker.). By testing three populations of thrips from three plant clones he showed that population growth of thrips was higher on cuttings of their native host plant clone than on cuttings of the other two clones, indicating that thrips were adapted to their own host plant clone. In *F. occidentalis* there are no data available on biotypic variation with regard to differential performance on host plants.

Here we report on differences in performance among populations of *F. occidentalis*, collected from different crops and of different geographic origin, on a susceptible and two partially resistant cucumber accessions. Partial life history parameters of three of these thrips populations were determined on the three cucumber accessions, and the relative rate of increase r_r was calculated. The relative importance of the indi-

vidual life history parameters for screening for biotypic variation is discussed.

Material and methods

Plant material and insects. Three cucumber accessions were used: a susceptible inbred line 'G6' and two accessions, 9104 and 9140 (CPRO-DLO numbers) that were previously selected for low levels of damage after infestation with *F. occidentalis* (Mollema et al., 1995). Plants were grown in a greenhouse at 20–30 °C.

Thrips population NL1cu was collected in 1988 on cucumber in Wageningen, the Netherlands, and since then maintained on flowering cucumber plants, variety 'Autumn Green'. Population NL2ch was collected from chrysanthemum in a greenhouse in the Netherlands in 1991 and reared since then on flowering chrysanthemum, cultivar 'Sunny Cassa' (van Dijken et al., 1994). In 1993–1994 populations of *F. occidentalis* were collected from different crops in a number of countries worldwide. Populations were reared in 0.5 liter glass jars on bean pods (*Phaseolus vulgaris* cv. Prelude) and provided with additional bee-collected pollen in a climate chamber ($T=25$ °C, L16:D8, r.h.=60–70%). To avoid contamination with thrips from other origins, bean pods were washed in water and incubated for 4 days in the climate chamber. After 4 days any larvae that had hatched from eggs in the bean pods were removed before the bean pods were used in the rearings. The origin of the populations is summarized in Table 1. Samples (200 individuals) of population NL1cu and NL2ch were used to start a rearing on bean pods in the same way (NL1be and NL2be). All bean reared populations were reared on beans for at least 2 months before testing. Thrips were collected with an aspirator, shortly anaesthetized with CO₂, and manipulated with a fine brush.

Reproduction test with randomly collected females. Reproduction of thrips was determined in the climate chamber ($T=25$ °C, L16:D8, r.h.=60–70%). Plants of G6, 9104, and 9140 were used 4.5 weeks after sowing (de Kogel et al., 1996). Leaf discs (dia.=8 cm) were taken from basal leaves and put in petri dishes on moist tissue paper. Randomly collected female thrips from a single population, were put on the leaf discs (10 females/disc, 4 leaf discs/accession). After 2 days of adaptation, thrips were transferred to fresh leaf discs (10 females/disc, 4 leaf discs/accession) where they were allowed to oviposit for 24 h. After 4 days the

Table 1. Origin of populations of *F. occidentalis* used in the experiments

Code	Country	Collected from	Reared on
NL1cu	Netherlands	Cucumber	Cucumber
NL1be	Netherlands	Cucumber	Bean
NL2ch	Netherlands	Chrysanthemum	Chrysanthemum
NL2be	Netherlands	Chrysanthemum	Bean
GE	Germany	Gerbera	Bean
FR	France	Bean	Bean
IT	Italy	Bean	Bean
SP	Spain	Cotton	Bean
HU	Hungary	Bean	Bean
SWI	Switzerland	Bean	Bean
SWE	Sweden	Brassica	Bean
NZ	New Zealand	Egg-plant	Bean

numbers of hatched larvae were recorded. Numbers of larvae are much easier to determine than numbers of hatched larvae. De Kogel et al. (1997) showed that numbers of larvae and numbers of eggs are strongly correlated, therefore, reproduction was expressed as number of larvae/female/day. In each separate experiment, reproduction of thrips from two or three populations was determined. Population NL1cu was used in every experiment as a reference. Experiments were performed during March–June 1994. Data were analyzed by a two-way ANOVA with as main treatment factors thrips population and cucumber accession. Means were separated based on LSD ($\alpha=0.05$).

Life history parameters of age-cohorts of females from three populations. To obtain females of the same age, thrips age-cohorts were made on leaf discs of susceptible cucumber G6. Randomly collected females were allowed to oviposit for one day on leaf discs after which they were carefully removed. After 4 days, hatched larvae were transferred to fresh leaf discs. Thrips were transferred every 4 days to a fresh leaf disc until adult emergence. Directly after adult emergence, the thrips (females and males) were put on leaf discs of G6, 9104 and 9140 where they were allowed to mate. These females of the same age were used in experiments.

In experiment I, reproduction of populations NL1cu and NZ was determined on day 4, 5, and 6 after adult emergence. To this end, 40 3-day old female thrips were put on small leaf discs (dia.=1.2 cm, 1 female/disc) of the three accessions in wells of a tissue culture plate according to Soria & Mollema (1995). Thrips were transferred to a fresh leaf disc every day.

Four days after removal of the females, the numbers of larvae per leaf disc were counted. Adult survival over this period was recorded. In experiment II, populations NL1cu and IT were tested. The procedure was the same except that reproduction was determined on day 3, 4, 5, and 6 after adult emergence. For each experiment data on reproduction were analyzed by a two-way ANOVA on square root transformed data, with main treatment factors accession and population.

Van Rijn et al. (1995) found a decrease after day 4 of ovipositional rate, adult survival and net reproduction rate for *F. occidentalis* on cucumber leaf discs. The percentage of reproducing females in our experiments also decreased after day 4 (data not shown). Linear regression, on the percentage of reproducing females of age 4, 5, and 6, was used to make an estimate of the intersection with the age (x) axis, and hence the oviposition period (i.e., the number of days that females reproduce after emergence) (Romanov et al., 1991).

In another experiment, preadult survival and developmental time of population NL1cu, NZ, and IT were determined on G6, 9104 and 9140. For each population, 36 newly hatched larvae per accession were collected from leaf discs of the same accession. Larvae were isolated individually on small leaf discs (dia.=2.1 cm, 1 larvae/disc). Larvae were observed twice a day and survival and developmental time until adult emergence were recorded. Leaf discs were replaced twice a week. Data on developmental period and preadult survival were analyzed with the Kruskal-Wallis test and means separated by Dunn's Multiple Comparisons Test.

Relative rate of increase. Differences in values for life history components cause differences in the population growth rate r_m (Caswell & Hastings, 1980). Based on the (partial) life history components mentioned above, life tables were constructed. Because we did not determine reproduction and adult survival over the total life span of the thrips, we assumed that oviposition rate and adult survival per day were constant during the oviposition period estimated as described above. Based on these life tables we calculated the population growth rate according to Carey (1993). We use the term relative rate of increase, r_r , to indicate that we did not determine the true r_m . The relative rate of increase is used to illustrate the relative differences among the populations.

There was a difference in overall level of reproduction of NL1 between experiment I and experiment

Table 2. Mean reproduction (number of larvae/adult/day) of randomly collected females of different populations of *F. occidentalis* on susceptible cucumber G6 and partially resistant cucumber 9104 and 9140. Values followed by the same letter (a–f in columns, x–z in rows) are not significantly different ($P < 0.05$), n =number of replicates

Thrips population	G6 mean	G6 s.e.	9104 mean	9104 s.e.	9140 mean	9140 s.e.	n
NL1cu	2.62 ^{d,x}	0.14	0.58 ^{e,z}	0.07	1.46 ^{c,y}	0.13	36
NL1be	4.09 ^{ab,x}	0.30	0.91 ^{abc,z}	0.25	2.65 ^{ab,y}	0.46	8
NL2ch	1.51 ^{e,x}	0.19	0.80 ^{bc,y}	0.20	0.74 ^{d,y}	0.13	16
NL2be	3.44 ^{bc,x}	0.31	1.68 ^{a,z}	0.36	2.58 ^{ab,y}	0.15	8
GE	2.95 ^{cd,x}	0.50	1.01 ^{abc,y}	0.28	3.39 ^{a,x}	0.25	4
FR	2.62 ^{d,x}	0.48	0.73 ^{abc,y}	0.24	2.80 ^{ab,x}	0.26	4
IT	3.23 ^{bcd,x}	0.68	0.54 ^{bc,y}	0.11	3.33 ^{a,x}	0.31	4
SP	2.48 ^{cd,x}	0.44	0.33 ^{c,y}	0.08	2.01 ^{bc,x}	0.29	4
HU	4.75 ^{a,x}	0.54	0.56 ^{bc,z}	0.15	3.47 ^{a,y}	0.41	4
SWI	3.60 ^{abc,x}	0.17	0.90 ^{abc,y}	0.23	2.87 ^{ab,x}	0.73	4
SWE	3.21 ^{cd,x}	0.50	1.62 ^{a,y}	0.39	2.76 ^{ab,x}	0.23	8
NZ	3.02 ^{cd,x}	0.31	1.44 ^{ab,y}	0.27	1.57 ^{c,y}	0.24	8

II. For calculating oviposition rate of the populations NL1 and IT, mean reproduction of day 4, 5, and 6 in experiment II was used. For population NZ mean reproduction of day 4, 5, and 6 from experiment I was corrected for the relative difference in NL1 reproduction between experiment I and II by multiplying with 2.11. According to data reported previously (Trichilo & Leigh, 1988; Higgins & Meyers, 1992; van Rijn et al., 1995), the sex ratio for stable populations of *F. occidentalis* is quite uniform, and was here assumed to be 0.67 (fraction females). Based on data of van Rijn et al. (1995) on life history of *F. occidentalis* on cucumber cv. Corona, the pre-oviposition period was assumed to be 2 days. To the developmental period from L1 to adult 3 days were added, which is the duration of the egg-stage of NL1cu on cucumber at 25 °C (Soria & Mollema, 1995).

Results

Reproduction test with randomly collected females.

In general, reproduction of the thrips was reduced on 9104 and sometimes on 9140 when compared to G6 (Table 2). ANOVA indicated significant effects of thrips populations, cucumber accessions and a significant interaction (Table 3). Rearing of populations NL1cu and NL2ch on bean resulted in a higher reproduction on all three cucumber accessions compared to the level of reproduction when thrips were taken from

their original host plants, (Table 2). Reproduction relative to G6 (G6=100) was similar for population NL1, regardless of the plant species (cucumber or bean) on which the thrips were reared (NL1cu: 9104=22, 9140=56; NL1be: 9104=22, 9140=65). This also holds for population NL2, except for accession 9140 where differences in reproduction relative to G6 are somewhat larger (NL2ch: 9104=53, 9140=49; NL2be: 9104=49, 9140=75). Comparison of populations that had been reared on beans (all populations except NL1cu and NL2ch) revealed significant differences among populations on all three accessions. Reproduction on G6 ranged from 2.48 to 4.75, on 9104 from 0.33 to 1.68, and on 9140 from 1.57 to 3.47. Compared to population NL1be, reproduction on G6 was significantly lower in populations GE, FR, SP, SWE and NZ. On 9104 none of the populations differed significantly from NL1be. On 9140 only population NZ had a significantly lower reproduction than population NL1be.

Life history components of age-cohorts of females from three populations.

Life history components of age-cohorts of females from populations NL1, NZ and IT were determined (Table 4). In Figures 1 and 2, mean reproduction on successive days after adult emergence is shown. ANOVA on total reproduction (pooled over all days) revealed a significant difference between populations NL1 and NZ ($df=1$, $F=36.73$, $P<0.001$), and no difference between populations NL1 and IT ($df=1$, $F=0.25$, $P=0.618$). There was a significant effect of

Figure 1. Mean reproduction and s.e. (number of larvae/female/day) of *F. occidentalis* from populations NL1 and NZ on three cucumber accessions (G6, 9104, and 9140) on day 4, 5 and 6 after adult emergence.

Figure 2. Mean reproduction and s.e. (number of larvae/female/day) of *F. occidentalis* from populations NL1 and IT on three cucumber accessions (G6, 9104, and 9140) on day 3, 4, 5 and 6 after adult emergence.

accession in both experiments ($P < 0.001$). Adult survival did not differ among populations and accessions (Table 4). Preadult survival was not different between populations, but was significantly reduced on 9104 and 9140 when compared to G6 in all populations except for population NZ on accession 9140 ($P < 0.01$). Developmental time was not different between populations. Developmental time was prolonged on 9104 and 9140 compared to G6 ($P < 0.001$, pooled data from three populations). The estimated oviposition period was reduced on 9104 and 9140 compared to G6 and was somewhat lower in population NZ compared to NL1 and IT.

Relative rate of increase r_r . Populations NL1 and IT had very similar relative rates of increase (Figure 3).

Table 3. Results of ANOVA on reproduction of randomly collected females from different populations of *F. occidentalis* on susceptible and partially resistant cucumber accessions

Source of variation	df	MS	F	P
Thrips population	11	9.543	15.42	<0.001
Cucumber accession	2	104.758	169.32	<0.001
Interaction	22	2.486	4.02	<0.001
Error	287	0.619		
Total	322			

interaction = thrips population $\times$ cucumber accession.

Table 4. Life history parameters, (mean (s.e.)), of three populations of *F. occidentalis* on three cucumber accessions. OR=oviposition rate (number of eggs/female/day, mean of day 4, 5, and 6 after emergence), AS=adult survival from day 4–6, PS=preadult survival, DP=developmental period from L1 to adult (days), OP=oviposition period (days)

Parameter	Accession	Thrips population		
		NL1	NZ	IT
OR	G6	3.88(0.28)	1.96(0.19)	3.09(0.25)
	9104	0.78(0.21)	0.65(0.14)	0.70(0.13)
	9140	1.87(0.18)	0.36(0.08)	1.53(0.17)
AS	G6	0.89(0.08)	0.95(0.03)	0.92(0.08)
	9104	0.75(0.13)	0.79(0.06)	0.90(0.07)
	9140	0.83(0.09)	0.88(0.05)	0.83(0.09)
PS	G6	0.64(0.08)	0.81(0.07)	0.75(0.07)
	9104	0.17(0.06)	0.04(0.04)	0.14(0.06)
	9140	0.17(0.06)	0.50(0.08)	0.25(0.07)
DP	G6	10.6(0.2)	10.5(0.2)	10.4(0.2)
	9104	12.7(0.3)	12.7(-)	13.1(0.5)
	9140	14.3(1.0)	12.8(0.5)	13.2(0.6)
OP	G6	16	10	15
	9104	8	7	9
	9140	11	6	8

The r_r was strongly reduced on 9104 and 9140 when compared to G6 in all populations. Population NZ had a slightly lower r_r on G6 and a much lower r_r on 9104 and 9140 when compared to the other two populations.

Discussion

Biotypes of insect pests may overcome the protective properties of resistant cultivars. For that reason the

Figure 3. Relative rate of increase (r_r) of *F. occidentalis* populations NL1, NZ and IT on three cucumber accessions (G6, 9104, and 9140).

study of insect biotypes should be included in breeding programs for resistance to insects in crop plants. This can lead to a better understanding of mechanisms of host plant resistance (Saxena & Barrion, 1987). Several methods are used to identify insect biotypes (Smith et al., 1994). Most methods use a set of cultivars with different levels of resistance, and measure either the cultivars' reaction to insect attack or the life history traits of the insect (e.g., survival, growth, reproduction). Differences in life history traits between insect populations result in different population growth rates, which is the most important criterion for differentiating insect biotypes (Kerns et al., 1989).

In the present study we show that there is biotypic variation between populations of *F. occidentalis*. In reproduction tests with randomly collected females, significant differences between populations were observed. Some of the populations reproduced significantly less than the Dutch population NL1be on the susceptible cucumber G6. On the resistant accession 9104 none of the populations was significantly different from NL1be. On resistant accession 9140 only the New Zealand population (NZ) was significantly different from population NL1be (Table 2).

F. occidentalis has been present in Europe since the early 1980's. In New Zealand, however, *F. occidentalis* was first collected in 1934 (Mound & Walker, 1982) and has apparently been present for decades. It was probably introduced from the USA at the end of the 19th century (N. Martin, pers. comm.). This population is generally referred to as the New Zealand lupine strain (Martin & Workman, 1994); it is believed to be restricted to lupine plants and has never been a pest in greenhouses. The NZ population used in our study is

a greenhouse-collected population which is probably a recent introduction (Martin & Workman, 1994). At present it is not known whether the lupine strain and the greenhouse population interbreed.

In a reproduction test with age-cohorts of females on cucumber, population NZ had again a significantly lower reproduction when compared to population NL1. The Italian population (IT) did not differ significantly from NL1 in experiments with randomly collected females nor in experiments with age-cohorts of females. Both types of experiments give clearly comparable results and can be used in screening tests for biotypic variation.

The relative rate of increase of population NZ is low when compared to populations NL1 and IT (especially on 9104 and 9140). The r_r for population NL1 on the susceptible cucumber G6 is 0.13 day^{-1} . Values of r_m of *F. occidentalis* at 25°C as reported in literature are: 0.17 day^{-1} on susceptible cucumber cv. Corona (van Rijn et al., 1995), 0.157 day^{-1} on a susceptible cotton variety (Trichilo & Leigh, 1988), 0.14 day^{-1} on bean (Brødsgaard, 1991; Gerin et al., 1994), 0.171 day^{-1} on chrysanthemum (Robb, 1989), 0.127 day^{-1} on petunia (Wijkamp, 1995) and 0.02 day^{-1} on peanut (Lowry et al., 1992). In the present study negative values for r_r were found on the most resistant cucumber accessions, especially for population NZ. This is mainly due to the very low preadult survival. Gaum et al. (1994) determined r_m of *F. occidentalis* on discs of petals from rose cultivars with different levels of resistance. On the most resistant cultivar they also found a negative r_m -value ($r_m = -0.438$ at 30°C). The true r_m is probably even lower, since the reported r_m was calculated in a wrong way, as pointed out by van Rijn et al. (1995).

Values for life history parameters such as adult survival, preadult survival, developmental period, and reproduction, on which the calculation of r_r of population NL1 was based, were comparable to data published by Soria & Mollema (1995). In both studies, adult survival was slightly higher on G6 than on 9104 and 9140, but not significantly different. Preadult survival was significantly reduced on 9104 and 9140 compared to G6 in both studies. Developmental period was prolonged on 9140 compared to G6 with about 4 days; in the present study developmental period was also longer on 9104 than on G6; this was not found by Soria & Mollema (1995). Reproduction of age-cohorts of females was lower on 9104 and 9140 than on G6 in both studies.

Most dramatic differences in life history parameters between populations NL1, NZ, and IT occur in

reproduction rate and preadult survival (Table 4). Studies on population growth models of colonizing species (high r_m) showed that of several life history factors, differences in developmental period had the greatest impact on population growth (Lewontin, 1965). When r_m is lower, changes in fecundity have greater impact on r_m (Caswell & Hastings, 1980). On the partially resistant cucumber accessions r_r is low, and therefore reproduction seems a good parameter for differentiating biotypes of *F. occidentalis* on these accessions. Populations should all be reared on the same host plant before they are tested, because the host plant they are reared on before an experiment is performed can have a great effect on the level of reproduction. Rearing populations NL1cu (cucumber) and NL2ch (chrysanthemum) on beans and bee-collected pollen results in higher reproduction (see Table 2). Bean pods and bee-collected pollen seems to be a very good food source for *F. occidentalis* compared to cucumber and chrysanthemum.

The present study shows that there are differences in performance of populations of *F. occidentalis* of different origin. On one susceptible and two resistant cucumber accessions significant differences among populations were observed. However, none of the populations was more aggressive than the reference population NL1 that was collected in the Netherlands. Population NL1 seems therefore suitable as a test population in breeding programs for host plant resistance to western flower thrips in cucumber.

Acknowledgements

We thank M. W. Sabelis, S. B. J. Menken, and G. Vierbergen for valuable discussion and L.C.P. Keizer for statistical assistance. We are most grateful to all the researchers who sent us samples of western flower thrips. This research is financially supported by the Netherlands Technology Foundation (STW), and is coordinated by the Life Sciences Foundation (SLW).

References

- Brødsgaard, H. F., 1991. Bionomics of thrips (Thysanoptera: Thripidae) in relation to their control in Danish glasshouse crops. Ph. D. Dissertation, University of Copenhagen, 113 pp.
- Brødsgaard, H. F., 1994. Insecticide resistance in European and African populations of western flower thrips (Thysanoptera: Thripidae) tested in a new residue-on-glass test. *Journal of Economic Entomology* 87: 1141–1146.
- Carey, J. R., 1993. *Applied Demography for Biologists with Special Emphasis on Insects*. Oxford University Press, New York, 206 pp.
- Caswell, H. & A. Hastings, 1980. Fecundity, developmental time, and population growth rate: an analytical solution. *Theoretical Population Biology* 17: 71–79.
- Claridge, M. F. & J. den Hollander, 1983. The biotype concept and its application to insect pests of agriculture. *Crop Protection* 2: 85–95.
- Diehl, S. R. & G. L. Bush, 1984. An evolutionary and applied perspective of insect biotypes. *Annual Review of Entomology* 29: 471–504.
- Dijken, F. R. van, M. T. A. Dik, B. Gebala, J. de Jong & C. Mollema, 1994. Western flower thrips (Thysanoptera: Thripidae) effects on chrysanthemum cultivars: plant growth and leaf scarring in nonflowering plants. *Journal of Economic Entomology* 87: 1312–1317.
- Dunn, J. A. & D. P. H. Kempton, 1972. Resistance to attack by *Brevicoryne brassicae* among plant of Brussels sprouts. *Annals of Applied Biology* 72: 1–11.
- Fery, R. L. & J. M. Schalk, 1991. Resistance in pepper (*Capsicum annum* L.) to western flower thrips [*Frankliniella occidentalis* (Pergande)]. *HortScience* 26: 1073–1074.
- Gaum, W. G., J. H. Giliomee & K. L. Pringle, 1994. Resistance of some rose cultivars to the western flower thrips, *Frankliniella occidentalis* (Thysanoptera: Thripidae). *Bulletin of Entomological Research* 84: 487–492.
- Gerin, C., Th. Hance & G. Van Impe, 1994. Demographical parameters of *Frankliniella occidentalis* (Pergande) (Thysanoptera, Thripidae). *Journal of Applied Entomology* 118: 370–377.
- Higgins, C. J. & J. H. Meyers, 1992. Sex ratio patterns and population dynamics of western flower thrips (Thysanoptera: Thripidae). *Environmental Entomology* 21: 322–330.
- Immaraju, J. A., T. D. Paine, J. A. Bethke, K. L. Robb & J. P. Newman, 1992. Western flower thrips (Thysanoptera: Thripidae) resistance to insecticides in coastal Californian greenhouses. *Journal of Economic Entomology* 85: 9–14.
- Jager, C. M. de, R. P. T. Butot, T. J. de Jong, P. G. L. Klinkhamer & E. van der Meijden, 1993. Population growth and survival of western flower thrips *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae) on different chrysanthemum cultivars. Two methods for measuring resistance. *Journal of Applied Entomology* 115: 519–525.
- Karban, R., 1989. Fine-scale adaptation of herbivorous thrips to individual host plants. *Nature* 340: 60–61.
- Kerns, D. L., G. J. Puterka & D. C. Peters, 1989. Intrinsic rate of increase for greenbug (Homoptera: Aphididae) biotypes E, F, G, and H on small grain and sorghum varieties. *Environmental Entomology* 18: 1074–1078.
- Kogel, W. J. de, A. Balkema-Boonstra, M. van der Hoek & C. Mollema, 1996. Resistance to western flower thrips in greenhouse cucumber: effect of leaf position and plant age on thrips reproduction. *Euphytica*: in press.
- Kogel, W. J. de, M. van der Hoek & C. Mollema, 1997. Oviposition preference of western flower thrips for cucumber leaves from different positions along the plant stem. *Entomologia Experimentalis et Applicata*: in press.
- Kumar, N. K. K., D. E. Ullman & J. J. Cho, 1995. Resistance among *Lycopersicon* species to *Frankliniella occidentalis* (Thysanoptera: Thripidae). *Journal of Economic Entomology* 88: 1057–1065.
- Lewontin, R. C., 1965. Selection for colonizing ability. In: H. G. Baker & G. L. Stebbins (eds) *The Genetics of Colonizing Species*. New York, Academic Press, pp. 77–94.

- Lowry, V. K. J. W., J. R. Smith & F. L. Mitchell, 1992. Life-fertility tables for *F. fusca* (Hinds) and *F. occidentalis* (Pergande) (Thysanoptera: Thripidae) on peanut. *Annals of the Entomological Society of America* 85: 744–754.
- Mantel, W. P. & M. van de Vrie, 1988. De Californische trips, *Frankliniella occidentalis*, een nieuwe schadelijke tripssoort in de tuinbouw onder glas in Nederland. *Entomologische Berichten*, Amsterdam 48: 140–144.
- Martin, N. A. & P. J. Workman, 1994. Confirmation of a pesticide-resistant strain of western flower thrips in New Zealand. *Proceedings of the 47th New Zealand Plant Protection Conference*. pp. 144–148.
- Menken, S. B. J. & L. E. L. Raijmann, 1996. Biochemical systematics: principles and perspectives for pest management. In: W. O. C. Symondson & J. E. Liddell (eds), *The Ecology of Agricultural Pests*, Chapman & Hall, London, pp. 7–29.
- Mollema, C., G. Steenhuis & H. Inggamer, 1995. Genotypic effects of cucumber responses to infestation by western flower thrips. In: B. L. Parker, M. Skinner & T. Lewis (eds), *Thrips Biology and Management*, Plenum Press, New York, pp. 397–401.
- Mound, L. A. & A. K. Walker, 1982. *Fauna of New Zealand*, Number 1, Terebrantia (Insecta: Thysanoptera). 113 pp.
- Rijn, P. C. J. van, C. Mollema & M. M. Steenhuis-Broers, 1995. Comparative life history studies of *Frankliniella occidentalis* and *Thrips tabaci* (Thysanoptera: Thripidae) on cucumber. *Bulletin of Entomological Research* 85: 285–297.
- Robb, K. L., 1989. Analysis of *Frankliniella occidentalis* (Pergande) as a pest of floricultural crops in California greenhouses. Ph. D. dissertation, University of California, Riverside. 135 pp.
- Romanov, L. R., O. M. B. de Ponti & C. Mollema, 1991. Resistance in tomato to the greenhouse whitefly: analysis of population dynamics. *Entomologia Experimentalis et Applicata* 60: 247–259.
- Saxena, R. C. & A. A. Barrion, 1987. Biotypes of insect pests of agricultural crops. *Insect Science and its Application* 8: 453–458.
- Smith, C. M., Z. R. Khan & M. D. Pathak, 1994. *Techniques for Evaluating Insect Resistance in Crop Plants*. CRC Press, Florida, 320 pp.
- Soria, C. & C. Mollema, 1995. Life-history parameters of western flower thrips on susceptible and resistant cucumber genotypes. *Entomologia Experimentalis et Applicata* 74: 177–184.
- Trichilo, P. J. & T. F. Leigh, 1988. Influence of resource quality on the reproductive fitness of flower thrips (Thysanoptera: Thripidae). *Annals of the Entomological Society of America* 81: 64–70.
- Via, S., 1989. Field estimation of variation in host plant use between local populations of pea aphids from two crops. *Ecological Entomology* 14: 357–364.
- Wijkamp, I., 1995. Virus-vector relationships in the transmission of tospoviruses. Ph. D. Dissertation, Wageningen Agricultural University, Wageningen, 143 pp.
- Zawirska, I., 1976. Untersuchungen über zwei biologische Typen von *Thrips tabaci* Lind. (Thysanoptera, Thripidae) in der VR Polen. *Archiv für Phytopathologie und Pflanzenschutz*, 12: 411–422.