UvA-DARE (Digital Academic Repository)

Seasonal variation in resistance of chrysanthemum cultivars to *Frankliniella occidentalis* (Thysanoptera: Thripidae)

de Kogel, W.J.; van der Hoek, M.; Dik, M.T.A.; Gebala, B.; van Dijken, F.R.; Mollema, C.

DOI

[10.1023/A:1003080308129](https://doi.org/10.1023/A:1003080308129)

Publication date

1997

Published in

Euphytica

[Link to publication](#)

Citation for published version (APA):

de Kogel, W. J., van der Hoek, M., Dik, M. T. A., Gebala, B., van Dijken, F. R., & Mollema, C. (1997). Seasonal variation in resistance of chrysanthemum cultivars to *Frankliniella occidentalis* (Thysanoptera: Thripidae). *Euphytica*, 97, 283-288.
<https://doi.org/10.1023/A:1003080308129>

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.

Seasonal variation in resistance of chrysanthemum cultivars to *Frankliniella occidentalis* (Thysanoptera: Thripidae)

Willem Jan de Kogel^{1,2}, Marieke van der Hoek¹, Marian T.A. Dik¹, Barbara Gebala¹,
Folchert R. van Dijken¹ & Chris Mollema¹

¹ DLO-Centre for Plant Breeding and Reproduction Research (CPRO-DLO), P.O. Box 16, 6700 AA Wageningen, The Netherlands; ² Institute for Systematics and Population Biology, University of Amsterdam, P.O. Box 94766, 1098 GT Amsterdam, The Netherlands

Received 4 February 1997; accepted 7 June 1997

Key words: chrysanthemum, *Frankliniella occidentalis*, host plant resistance, light intensity, seasonal variation, shading

Summary

Seasonal variation in the level of host plant resistance can have important consequences for the repeatability of tests to measure host plant resistance to insect pests. In the present study, the levels of resistance to *Frankliniella occidentalis* of a susceptible and a partially resistant cultivar of chrysanthemum, *Dendranthema grandiflora*, were determined throughout the year. Thrips damage, reproduction and adult female survival were determined on excised leaves in Petri dishes under uniform conditions. Strong seasonal fluctuations were observed in these three characteristics. On leaves from plants grown in winter, damage, reproduction, and survival were higher than on leaves from plants grown in summer.

Clear differences in resistance were observed between the susceptible and the partially resistant cultivar on leaves from plants grown in winter, while differences disappeared in summer. Damage on both cultivars and survival on the susceptible cultivar were negatively correlated with mean daily solar radiation during plant growth, suggesting that the level of resistance depends on light intensity during plant growth.

This was confirmed in an experiment carried out in summertime with shaded and unshaded plants. Leaves from control plants, grown under high light intensity had a higher level of resistance than leaves from shaded plants grown under reduced light intensity. There were clear differences in resistance between the cultivars under shaded conditions (low light intensity), but not under unshaded control conditions (high light intensity).

Introduction

Western flower thrips, *Frankliniella occidentalis* (Per-gande) (Thysanoptera: Thripidae), is a serious pest of many vegetable and ornamental crops including chrysanthemum, *Dendranthema grandiflora* Tzvelev (Robb, 1989). Efforts are made to develop resistant chrysanthemum cultivars in order to grow crops free from thrips damage and to reduce the use of chemical insecticides (Van Dijken et al., 1994; De Jager, 1995).

Reliable screening methods for host plant resistance are a prerequisite for the development of such cultivars. Parameters used to assess resistance to *F. occidentalis* in chrysanthemum include plant parame-

ters such as reduction in plant length and leaf area after infestation with thrips (Van Dijken et al., 1994), damaged leaf area after infestation with thrips (Van Dijken et al., 1994), and insect parameters like longevity, growth and survival of thrips larvae on leaves (De Jager et al., 1995), and survival and reproduction of adult thrips in flowers (Van Dijken et al., 1995; Brouwer et al., 1996).

Spatial and temporal variation in level of resistance of plants should be taken into account when performing bio-assays to test for host plant resistance. For example, differences in level of resistance to *F. occidentalis* of cucumber leaves from different positions along the plant stem have been reported (De Kogel et al., 1997a,

b). During the development of a bio-assay to measure damage caused by thrips on leaves of chrysanthemum cultivars, it was observed that damage levels changed with the season (Van Dijken et al., unpublished results). Results of experiments performed in winter could not be repeated in summer. These results suggested that there was a seasonal effect on the level of resistance of some of the chrysanthemum cultivars.

Season has an effect on growth of chrysanthemums; relative growth rate, leaf initiation rate and stem length are higher in summer than in winter (Klapwijk, 1987). Leaf tissue concentrations of most elements decrease in chrysanthemum when growth rate increases by irradiance (Willits et al., 1990). In *Chrysanthemum balsamita* L. seasonal fluctuations in essential oil content and composition were recorded (Bestmann et al., 1987). The same authors showed that the essential oil had insecticidal properties against aphids.

Secondary plant compounds play a role in plant resistance to thrips. Such compounds are, for instance, aromatic amino acids. The concentration of aromatic amino acids in lettuce, tomato, pepper and cucumber is lower in thrips resistant cultivars (Mollema & Cole, 1995). The composition of phenols, sugars and amino acids in rice differs between thrips resistant and susceptible varieties (Thayumanavan et al., 1990). De Jager et al. (1995) showed that chemical characteristics of chrysanthemum are involved in resistance to *F. occidentalis*. Since the concentration of several plant compounds and other characteristics that are involved in plant defense against insects change with the season, it is of interest to study seasonal variation in host plant resistance, first, in order to develop reliable test methods, and secondly, to gain more insight in mechanisms of resistance.

The objective of the present study was to determine seasonal fluctuations in resistance levels of chrysanthemum cultivars with different levels of resistance to western flower thrips, and to determine which environmental factors are correlated with these fluctuations. For that purpose both plant and insect parameters were studied in a series of experiments performed over a period of one and a half year.

Material and methods

Plants and insects. Western flower thrips used in the experiments were obtained from a continuous mass-rearing on flowering plants of the susceptible chrysanthemum cultivar 'Sunny Cassa' (van Dijken et al.,

1994). Three weeks before each experiment, approximately 300 females were collected from the thrips mass-rearing and allowed to lay eggs for 2 days on single flowers of the cultivar 'Sunny Cassa'. To that end, flowers were put in a small bottle filled with water, and placed in a transparent plastic container (11 × 11 × 16 cm) with a ventilation hole covered with fine mesh gauze to prevent thrips from escaping. Some tissue paper and a small Petri dish ($\varnothing = 3.5$ cm) filled with water and covered with parafilm were added to provide a suitable climate for pupation. The container was closed with parafilm, and placed in a climate chamber ($T = 24^{\circ}\text{C} \pm 1.5^{\circ}\text{C}$, r.h. = 60%, 16L:8D h). Twice a week fresh flowers were added. After three weeks, adult females were collected from the flowers in the containers and used for experiments. In this way, approximately age-synchronized thrips were obtained under rearing conditions that were constant regardless of the season.

Two cultivars of chrysanthemum were used in this study; a susceptible cultivar 'Pink Pompon' and a partially resistant cultivar 'Lilac Byoux'. Three weeks old, rooted cuttings were potted, and grown in a greenhouse under natural light conditions, but, if necessary, with additional artificial light to create a minimal photoperiod of 14 hours (long-day conditions). Temperature was kept at 19°C , irrespective of the season.

Bio-assay. Four weeks after potting, 5th and 6th leaves (counted from the apex) from the chrysanthemum cultivars were harvested and placed on 1% agar (Oxoid, Agar Bacteriological (Agar No. 1)) in Petri dishes (1 leaf per dish). Twenty female thrips, shortly anaesthetized with CO_2 , were put in each Petri dish. A Petri dish lid with a condensation hole ($\varnothing = 1.6$ cm) covered with fine mesh gauze, was sealed on the dish with parafilm to prevent the thrips from escaping. Petri dishes were stored in the climate chamber. Since the synchronization of the thrips, and the bio-assay were performed in the climate chamber under conditions that were constant regardless of the season, any seasonal variation in resistance level of the plants must be due to the effects of season on the plants, and not on the thrips. Each experiment consisted of five replicates per cultivar.

After 5 days the number of surviving adults and the number of larvae per Petri dish were recorded. Damaged leaf area (silver damage in mm^2) was measured with an image-analyzer that consists of a video-camera, and Applesoft computer, and a high resolution screen (Mollema et al., 1992; van Dijken et al., 1994).

Experiments were conducted from January 1995 until July 1996. Linear Pearson correlation coefficients were calculated between the experimental parameters and the mean solar radiation during plant growth in the greenhouse. Mean solar radiation was calculated over the four weeks, two weeks, two days, and one day period preceding each experiment.

An additional experiment was performed in the summer of 1996 (July–August) to test the effect of shading on the level of chrysanthemum resistance. During 4 weeks, chrysanthemum plants of both cultivars were either grown under normal greenhouse conditions or under reduced light. For that purpose plants were grown under a cover of cheese cloth that reduced light with 70%. Eight plants per cultivar per treatment were used for a bio-assay. Data on damage, number of larvae and adult survival were each analyzed with a two-way ANOVA with main treatment factors cultivar and shading. Data on damage were log transformed, and data on adult survival were square root transformed prior to ANOVA to make the variances independent of the means (Sokal & Rohlf, 1981).

Results

Strong seasonal variation was observed in the level of resistance to *Frankliniella occidentalis* of the two chrysanthemum cultivars (Figure 1). On cultivar 'Lilac Byoux', damage levels were low compared to 'Pink Pompon'. Damage on 'Lilac Byoux' was slightly higher on leaves from plants grown in winter than in summer (Figure 1A). Cultivar 'Pink Pompon' showed larger fluctuations in damage levels. On this cultivar damage levels were very low and not different from cultivar 'Lilac Byoux' on leaves from plants grown in summer, whereas high levels of damage were observed on leaves from plants grown in winter (Figure 1A). Thus, in winter differences in level of resistance between cultivars were much larger than in summer.

In general, reproduction was higher on 'Pink Pompon' than on 'Lilac Byoux', but on leaves from plants grown in summer, differences between cultivars were less obvious (Figure 1B). Reproduction was higher on leaves from plants grown in winter than in summer. Survival of the adult females showed a dip in the summer (Figure 1C). On all experimental dates in 1995, survival was higher on 'Pink Pompon'. In 1996 differences were less obvious.

Negative correlation coefficients were found between the mean daily solar radiation (J/cm^2) dur-

Figure 1. Results of a bio-assay, performed under uniform conditions, with *Frankliniella occidentalis* females on leaves of two cultivars of chrysanthemum grown throughout the year (mean $\pm$ s.e.). A: silver damage on the leaf caused by thrips, B: reproduction of females and C: survival of females. □ = 'Pink Pompon', Δ = 'Lilac Byoux'.

ing plant growth in the greenhouse and the damage, reproduction and survival on the two cultivars as determined in the experiments performed under uniform conditions in the laboratory. These negative correlation coefficients were found between the experimental parameters and mean solar radiation regardless whether

Table 1. Correlation (r) between mean daily solar radiation (J/cm^2) during plant growth of two chrysanthemum cultivars in the greenhouse, and log-transformed values of thrips damage, thrips reproduction and thrips survival on leaves from these cultivars as determined in a bio-assay that was conducted under uniform conditions

	'Pink Pompon'			'Lilac Byoux'		
	r	P	n	r	P	n
Damage	-0.874	< 0.0001	20	-0.482	< 0.05	18
Reproduction	-0.433	0.056	20	-0.222	0.375	18
Survival	-0.678	< 0.001	20	-0.242	0.333	18

Figure 2. Correlation between log (thrips damage) as determined on leaves under uniform conditions, and mean daily solar radiation (J/cm^2) during plant growth on susceptible chrysanthemum cultivar 'Pink Pompon', $r = -0.874$, $P < 0.0001$, $n = 20$.

mean solar radiation was calculated over the full four week period the plants were in the greenhouse, or only the last two weeks, or two days, or one day preceding the experiments. Strongest correlations were found when the mean solar radiation over the four week period preceding experiments was used; only these are presented in Table 1. Significant negative correlations coefficients were found between radiation and damage on both cultivars, and radiation and survival on 'Pink Pompon'. The relation between damage and solar radiation on 'Pink Pompon' is presented in Figure 2.

Shading reduced plant length by circa 10 percent ('Pink Pompon': 38.1 (control) vs. 33.6 cm (shaded), 'Lilac Byoux': 33.8 (control) vs. 30.9 cm (shaded)). Plants grown under normal greenhouse conditions had leaves with a more dark color, than shaded plants. On leaves from plants grown under reduced light conditions, the levels of damage were higher (Table 2). ANOVA indicated significant effects of cultivar and shading (cultivar: $df = 1$, $MS = 13.104$, $P = 0.001$; shading: $df = 1$, $MS = 18.301$, $P < 0.001$; interaction: $df = 1$, $MS = 1.715$, $P = 0.205$; residual: $MS = 1.024$). On cultivar 'Pink Pompon' also the number of larvae

produced was higher on leaves of shaded plants, on cultivar 'Lilac Byoux' there was no difference between shading and control. Results of ANOVA showed significant effects of both treatment factors and interaction on thrips reproduction (cultivar: $df = 1$, $MS = 175.32$, $P = 0.022$; shading: $df = 1$, $MS = 222.11$, $P = 0.011$; interaction: $df = 1$, $MS = 334.91$, $P = 0.002$; residual: $MS = 30.58$). There was no effect of shading on adult survival (cultivar: $df = 1$, $MS = 9.93$, $P < 0.001$; shading: $df = 1$, $MS = 0.75$, $P = 0.178$; interaction: $df = 1$, $MS = 0.426$, $P = 0.310$; residual: $MS = 0.40$).

With respect to damage, as well as to reproduction, significant differences were observed between leaves from cultivars grown under shaded conditions, but not under natural light conditions. Adult survival was higher on cultivar 'Pink Pompon' than on 'Lilac Byoux' under both light regimes.

Discussion

Resistance levels to *Frankliniella occidentalis* are not constant within chrysanthemum cultivars. Seasonal fluctuations in levels of resistance were observed, especially in chrysanthemum cultivar 'Pink Pompon'. These fluctuations are not likely to be caused by differences in temperature in the greenhouse between seasons, since temperature was kept constant over all seasons. The level of resistance correlated very well with the mean solar radiation during the 4 week period of plant growth preceding experiments. This suggests that solar radiation is an important factor determining the level of resistance to thrips in chrysanthemum cultivars: in summer, at high light levels, plants are more resistant to thrips. An experiment in summer, in which light intensity was reduced with 70% for half of the number of plants by shading, confirmed this hypothesis. Plants grown in summer were more resistant to thrips than shaded plants grown in the same

Table 2. Effect of shading during plant growth of two chrysanthemum cultivars on silver damage (mm²), reproduction (number of larvae) and adult survival (maximal survival is 20) of *Frankliniella occidentalis* females on leaves from these cultivars as determined in a bio-assay under uniform conditions. Means (s.e.) in rows followed by the same letter are not significantly different ($P < 0.05$)

	'Pink Pompon'		'Lilac Byoux'	
	Control	Shade	Control	Shade
Damage	7.07 ^{b,c} (2.42)	32.85 ^a (8.19)	2.75 ^c (0.86)	8.45 ^b (2.16)
Reproduction	4.60 ^b (1.67)	15.10 ^a (2.29)	6.20 ^b (1.43)	5.13 ^b (1.55)
Survival	10.90 ^a (1.07)	10.70 ^a (1.50)	6.50 ^b (1.06)	4.13 ^b (0.67)

period. No differences in damage and number of larvae were observed between cultivars in summer (high light intensity), whereas there were clear differences in winter (low light intensity). Also, clear differences between cultivars were observed when plants were shaded in summer (low light intensity), whereas in the control plants (high light intensity), there was no difference between cultivars.

Seasonal fluctuations in levels of resistance should be taken into account when performing host plant resistance tests, especially when responses to changes in season are different among cultivars, because discrimination among cultivars is then dependent on the season. It is suggested that in summer, the selection of chrysanthemum plants that are resistant to thrips is facilitated by shading. Under reduced light intensity, differences in level of resistance between cultivars are larger than under high light intensity. Similar conclusions have recently been reported by Leibovich et al. (1996) for the selection of powdery mildew, *Sphaerotheca fuliginea* (Slecht. ex Fr.), resistance in squash (*Cucurbita pepo*).

In other insect-plant systems reduced levels of resistance to insects at reduced light intensity have been described also. Reduced light intensity decreased levels of resistance to *Ostrinia nubilalis* (Hubner) in maize (*Zea mays* L.) (Manuwoto & Scriber, 1985). *Stephanitis pyrioides* (Scott) in azalea (*Rhododendron mucronatum* L.) (Trumbule & Denno, 1995), and *Tetranychus urticae* (Koch) in strawberry (*Fragaria × ananassa* Duch.) (Patterson et al., 1994). Also, host plant resistance to fungal pathogens can be affected by light intensity. For example, *Festuca arundinacea* (Schreb.) plants showed greater susceptibility to *Rhizoctonia solani* under reduced light (Zarlengo et al., 1994). In other studies, however, no effect of light intensity was found on the level of host plant resistance to insects. França & Tingey (1994) for example, did not find an effect of reduced light intensity

on the performance of Colorado potato beetle, *Leptinotarsa decemlineata* (Say), on *Solanum* species. In their experiments, there was a difference of about 70% between the two light regimes. However, they did not observe differences in larval weight, developmental time, survival, adult weight or fecundity of the Colorado potato beetle between the two light regimes. In contrast to our experiments, the authors subjected both insects and plants to the different light regimes, whereas in our study only plants and not insects were subjected to different light regimes.

Differences in numbers of larvae between treatments, that were observed using our bio-assay, could be due to differences in number of larvae per female or to differences in number of surviving females. We counted larvae on day 5, which means that the eggs were laid on day 1 or 2, since the duration of the egg-stage is about 3 days. Presumably adult mortality is still low at that time. In cucumber, for instance, the effect of host plant resistance is observed only after 2 days after thrips transfer to the resistant plants. This is assumed to be a pre-host effect (Soria & Mollema, 1995). Hence, the number of larvae reflects the number of larvae/female/day. This is confirmed by the results of the shading experiment, where adult survival on 'Pink Pompon' was similar on shaded and control plants (10.7 and 10.9 adults surviving), but the number of larvae produced differed greatly (15.1 on shaded plants and 4.6 on control plants). This shows that the number of larvae/female is different and not the number of reproducing females.

Evidently, high light intensities induce resistance to thrips in chrysanthemum cultivars. However, it is unknown what kind of mechanisms are induced. Changes in morphology of the plants with changes in light intensity could explain differences in levels of resistance. For instance, the thickness of the cuticle could be different when plants are grown at different light regimes. Also, the concentration of several plant

constituents can change with changing light regimes. When these compounds are involved in host plant resistance this would explain the observed dynamics. For example, Bestmann et al. (1987) showed that the amount of essential oil in leaves of *Chrysanthemum balsamita* changed with the season. Highest concentrations were found in summer. They also showed that this essential oil has insecticidal properties against *Metopolophium dirhodum* aphids. Based on these two findings it can be predicted that this chrysanthemum species would show seasonal fluctuations in level of resistance, comparable to the findings of the present study.

Acknowledgements

We thank G.P. Terwoert for taking care of the chrysanthemum plants. Valuable comments by M.W. Sabelis and S.B.J. Menken were highly appreciated. This research is financially supported by the Netherlands Technology Foundation (STW), and is coordinated by the Life Sciences Foundation (SLW).

References

- Bestmann, H.J., B. Classen, U. Kobold, O. Vostrowsky & F. Klingauf, 1987. Pflanzliche Insektizide IV. Die Insektizide Wirkung des ätherischen Öls aus dem Balsamkraut, *Chrysanthemum balsamita* L. Anzeiger für Schädlingkunde, Pflanzenschutz und Umweltschutz 60: 31–34.
- Brouwer, I., B. Gebala & F.R. van Dijken, 1996. A new bioassay to test host plant resistance of chrysanthemum flowers to the western flower thrips. In: M.J. Sommeijer & P.J. Francke (Eds.), Proceedings of the Section Experimental and Applied Entomology of the Netherlands Entomological Society (N.E.V.), Amsterdam, Vol. 7, pp. 191–192.
- De Jager, C.M., 1995. Mechanisms of resistance to western flower thrips in chrysanthemum. PhD Dissertation, Leiden University. 132 pp.
- De Jager, C.M., R.P.T. Butôt, P.G.L. Klinkhamer & E. van der Meijden, 1995. Chemical characteristics of chrysanthemum cause resistance to *Frankliniella occidentalis* (Thysanoptera: Thripidae). J Econ Entomol 88: 1746–1753.
- De Kogel, W.J., A. Balkema-Boomstra, M. van der Hoek, S. Zijlstra & C. Mollema, 1997a. Resistance to western flower thrips in greenhouse cucumber: effect of leaf position and plant age on thrips reproduction. Euphytica 94: 63–67.
- De Kogel, W.J., M. van der Hoek & C. Mollema, 1997b. Oviposition preference of western flower thrips for cucumber leaves from different positions along the plant stem. Entomol Exp Appl 82: 283–288.
- França, F.H. & W.M. Tingey, 1994. Influence of light level on performance of the Colorado potato beetle on *Solanum tuberosum* L. and on resistance expression of *S. berthaultii* Hawkes. J Am Soc Horti Sci 119: 915–919.
- Klapwijk, D., 1987. Effect of season on growth and development of chrysanthemum in the vegetative phase. Acta Horti 197: 63–69.
- Leibovich, G., R. Cohen & H.S. Paris, 1996. Shading of plants facilitates selection for powdery mildew resistance in squash. Euphytica 90: 289–292.
- Manuwoto, S. & J.M. Scriber, 1985. Neonate larval survival of European corn borers, *Ostrinia nubilalis*, on high and low DIMBOA genotypes of maize: effects of light intensity and degree of insect inbreeding. Agric Ecosyst Environm 14: 221–236.
- Mollema, C., F.R. van Dijken, K. Reinink & R. Jansen, 1992. An automatic and accurate evaluation of thrips damage: image analysis, a new tool in breeding for resistance. In: Proceedings, Eight International Symposium on Insect-Plant Relationships, 9–13 March 1992, Wageningen, The Netherlands, pp. 261–262. Kluwer, Dordrecht.
- Mollema, C. & R.A. Cole, 1995. Low aromatic amino acid concentrations determine resistance to *Frankliniella occidentalis* in four vegetable crops. Entomol Exp Appl 78: 325–333.
- Patterson, C.G., D.D. Archbold, J.G. Rodriguez & T.R. Hamilton-Kemp, 1994. Daylength and resistance of strawberry foliage to the twospotted spider mite. HortSci 29: 1329–1331.
- Robb, K.L., 1989. Analysis of *Frankliniella occidentalis* (Pergande) as a pest of floricultural crops in California greenhouses PhD Dissertation, University of California, Riverside. 135 pp.
- Sokal, R.S. & F.J. Rohlf, 1981. Biometry, 2nd edition. W.H. Freeman & Co., New York.
- Soria, C. & C. Mollema, 1995. Life-history parameters of western flower thrips on susceptible and resistant cucumber genotypes. Entomol Exp Appl 74: 177–184.
- Thayumanavan, B., R. Velusamy & S. Sadasivam, 1990. Phenolic compounds, reducing sugars, and free amino acids in rice leaves of varieties resistant to rice thrips. Int Rice Res Newsl 11: 14–15.
- Trumble, B.B. & R.F. Denno, 1995. Light intensity, host-plant irrigation, and habitat-related mortality as determinants of the abundance of azalea lace bug (Heteroptera: Tingidae). Env Entomol 24: 898–908.
- Van Dijken, F.R., 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. J Econ Entomol 87: 1312–1317.
- Van Dijken, F.R., M. Dik & B. Gebala, 1995. Chrysanthemum ray flowers are an el dorado for the western flower thrips (*Frankliniella occidentalis*). In: M.J. Sommeijer & P.J. Francke (Eds.), Proceedings of the Section Experimental and Applied Entomology of the Netherlands Entomological Society (N.E.V.), Amsterdam, Vol. 6, pp. 173–179.
- Willits, D., M. Peet, M. Depa, J. Kuehny & P. Nelson, 1990. Modulation of nutrient uptake in chrysanthemum by irradiance, CO₂, season and developmental stage. Monogr Br Soc Plant Growth Regul 20: 59–65.
- Zarlengo, P.J., C.S. Rothrock & J.W. King, 1994. Influence of shading on the response of tall fescue cultivars to *Rhizoctonia solani* AG-1 IA. Plant Dis 78: 126–129.