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Effects of temperature, vapour pressure deficit and radiation on infectivity of conidia of *Botrytis cinerea* and on susceptibility of gerbera petals

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Abstract. The effect of vapour pressure deficit, temperature and radiation on the postharvest susceptibility of gerbera flowers to *B. cinerea*, on the water relations of gerbera flowers and on the lesion formation after conidial infection of *B. cinerea* was studied. The temperature range in which *B. cinerea* could germinate and grow *in vitro* is 5–30 °C. In climate chamber experiments flowers had more lesions of *B. cinerea* at temperatures of 20 and 25 °C than at 10 and 15 °C. At 15, 20 and 25 °C the infectivity of *B. cinerea* conidia was negatively affected during a storage-period of 7 days. At a vapour pressure deficit (VPD) of 200 Pa significantly more conidia of *B. cinerea* were infective than at 800 Pa. At a VPD of 800 Pa the susceptibility of gerbera flowers for *B. cinerea* was not significantly different than at 200 Pa. High radiation levels in glasshouses in spring and summer negatively influenced the infectivity of conidia of *B. cinerea* on the flower surface, but did not affect the susceptibility of gerbera flowers for *B. cinerea*. In spring and early summer conidia lost their infectivity at high radiation levels, high temperatures and high levels of VPD. In summer gerbera flowers could be more susceptible to *B. cinerea* because of high temperatures in glasshouses, but the negative effect of radiation on the conidia of *B. cinerea* seemed to overrule the temperature effect. Thus, the numbers of lesions in spring and summer can be low compared with the numbers in other seasons, although the numbers of *B. cinerea* colonies on spore traps can be high. The effect of temperature on the susceptibility of gerbera flowers can probably be explained by changes of water status in the petals. At higher temperatures the number of lesions and the turgor (= water potential – osmotic potential) in the petals increased. Temperatures < 10 °C during lesion formation (RH > 95% and VPD < 50 Pa) had a temporary negative effect on the number of lesions. After 3 days of incubation the numbers of lesions were about equal (≥ 30 lesions/cm^2) from 5 to 20 °C. At 30 °C no lesion formation was observed even after 3 days.

Introduction

The fungus *Botrytis cinerea* Pers. ex Pers., the imperfect stage of *Sclerotinia fuckeliana* [Ellis and Waller, 1984], causes damage to a wide variety of plants. Infection takes place through wounds, via decaying or dead plant tissue, and by direct penetration of the undamaged host [Verhoeff, 1980]. *B. cinerea* causes damage to ornamentals such as gerbera, rose, chrysanthemum and potted plants among which saintpaulia [De Jong, 1985, 1986]. Conidia play an important role in dispersal of *B. cinerea* in

glasshouses. Necrotic lesions ('spotting') on flower buds and petals are caused by early infections. Salinas et al. [1989] showed that these symptoms are encouraged by a relative humidity (RH) above 93% which only occurs during postharvest conditions. Below 93% RH no lesion formation was observed. They also found that germination of conidia and lesion formation occurred between 4 and 25 °C; at 30 °C, germination and lesion formation did not occur. Between 18 and 25 °C many lesions became visible within 1 day after inoculation; at 4 °C it took 2 to 3 days before lesions could be seen. They did not test the effect of low RH's (≤ 90%), which are more common in glasshouses than high RH's, and the effect of temperatures at low RH's on infection of *B. cinerea* conidia on gerbera flowers.

The dispersal of conidia of *B. cinerea* in a gerbera crop growing under glass and the effects of environmental factors in the glasshouse on dispersal and infection of gerbera flowers during the postharvest period were studied [Kerssies, 1993]. The best linear regression model showed that susceptibility of gerbera flowers to lesion formation during the postharvest period was affected by their variables during development of the gerbera flowers ($R_2 = 0.81$; $P \leq 0.05$): RH in the glasshouse (positively correlated), global radiation outside the glasshouse (negatively correlated) and age of the crop (positively correlated). Marois et al. [1988] showed that in California (USA) the susceptibility of rose flowers to *Botrytis* blight was affected by RH and temperature during development of the flowers. In the fall, when RH was lower and temperature was higher, the rose flowers were less susceptible than in winter.

The aim of the present study was to investigate the effect of glasshouse levels of vapour pressure deficit (VPD), temperature and radiation on the susceptibility of gerbera flowers to *B. cinerea* during the postharvest period, on the water relations of gerbera flowers during the postharvest period and on the infectivity of conidia of *B. cinerea*.

Materials and methods

Germination and growth rate

The effect of temperature on germination of conidia and on growth of mycelium of *B. cinerea in vitro* was determined at six different temperatures: 5, 10, 15, 20, 25 and 30 °C. All plates were grown under fluorescent light (Pope, FTD 36W/30, 8 $\mu molm^{-2}s^{-1}$). For the effect of temperature on germination of conidia (Experiment 1) 10 potato dextrose agar (PDA) plates per temperature were inoculated with 100–125 freshly harvested conidia per plate, obtained from a 7-day old *B. cinerea* culture. Two days after inoculation the germination percentage was determined as number of colonies on PDA. For the effect of temperature on mycelial growth (Experiment 2), 5 potato dextrose agar plates per temperature were infested

at the centre by means of a mycelial plug, obtained from a 3-day old *B. cinerea* culture. Three days after inoculation the radial growth of *B. cinerea* mycelium was measured in cm^2. The experiments were repeated twice. Non-linear regression analysis was applied for the percentage germinated conidia and for the mycelial growth, with temperature as the independent variable.

Flowers, inoculation and incubation
Gerbera flowers (cv. 'Terrafame') were grown on rockwool in a glasshouse of 100 m^2. For all experiments isolate Bc-16 of *B. cinerea* was used, obtained from an infected gerbera flower (from Salinas). Cultures were grown on potato dextrose agar under fluorescent light (Pope, FTD 36W/30, 8 $\mu molm^{-2}s^{-1}$) for 7 to 9 days at 20 °C [Salinas et al., 1989]. Conidia were freshly harvested in sterilized, distilled water and adjusted to a density of 1×10^4 conidia per ml. Flowers were inoculated with 1 ml conidial suspension in a Potter [1952] spray tower, resulting in approximately 90 conidia/cm^2 petal and 30 lesions/cm^2 petal, and air dried for 10 min before placing them in a climate chamber of in a plastic box (RH > 95%, VPD < 50 Pa). For each combination of temperature, VPD and day four flowers were used. After one or more days (maximum of 7 days) in the climate chamber (= storage period; during this period no lesions occurred) the upper 10 petals of each flower were placed on wet paper in plastic boxes (RH > 95%, VPD < 50 Pa) and incubated at 20 °C under fluorescent light (Pope, FTD 36W/30, 8 $\mu molm^{-2}s^{-1}$). After 1 day incubation at RH > 95% (VPD < 50 Pa), *B. cinerea* lesions were counted under a microscope (10 × magnification, Salinas et al. [1989]). Resulting numbers of lesions per cm^2 on gerbera petals were subjected to analysis of variance (ANOVA).

Temperature, vapour pressure deficit and lesion formation
The effects of temperature and VPD on flowers and on conidia of *B cinerea* was observed, both expressed as numbers of lesions after incubation at RH > 95% (VPD < 50 Pa). Young (just open) gerbera flowers were inoculated before or seven days after placing them in a climate chamber (= storage period). The stems of the flowers were placed in plastic tubes each containing 32 ml distilled water.

In Experiment 3 the effect of temperature on lesion formation was studied. The flowers were kept in a climate chamber for seven days (= storage period) at four different temperatures: 10, 15, 20 or 25 °C and a VPD of 400 Pa. Experiment 3 was repeated at least three times.

In Experiment 4 the effect of VPD at different temperatures on lesion formation was studied. The flowers were kept in a climate chamber for seven days (= storage period) at two different VPD's: 200 or 800 Pa and at three different temperatures: 15, 20 or 25 °C. Experiment 4 was repeated at least twice.

Seven days after placing the flowers in a climate chamber the upper ten

petals of each flower were incubated at RH > 95% (VPD < 50 Pa) and 20 °C, for Experiments 3 and 4. From each flower the water potential (in kPa) of three other petals was measured by using a pressure chamber [Meeteren, 1980a]. Fifteen other petals were placed at –20 °C. After thawing, the petals were squeezed for sap extraction. The osmotic potential (in kPa) of the sap was measured by cryoscopy using a Gonotec Osmomat 030 osmometer [Meeteren, 1980a]. The turgor (in kPa) was calculated with the formula: turgor = water potential – osmotic potential (neglecting the matrix potential). Values of water potential, osmotic potential and turgor in the petals were subjected to analysis of variance (ANOVA).

In Experiment 5 the effect of temperature and time on lesion formation was studied, from day 0 to day 7, at 15 or 25 °C and a VPD of 400 Pa. Every day the numbers of lesions on the flowers after incubation at RH > 95% (VPD < 50 Pa) and 20 °C, the water potential and the osmotic potential were determined. The experiments were repeated at least twice. Non-linear regression analysis was applied for the mean numbers of lesions and for the turgor in petals with the storage period as the independent variable, except for the turgor in petals at 15 °C to which no regression could be applied.

In Experiment 6 the effect of temperature on lesion formation during incubation at RH > 95% (VPD < 50 Pa) was studied. After inoculation, the upper 10 petals of each flower were placed on wet paper in plastic boxes and incubated at 5, 10, 15, 20, 25 or 30 °C in the dark. After 1 and 3 days, *B. cinerea* lesions were counted under a microscope (10× magnification). The experiments were repeated once.

Radiation in the glasshouse and lesion formation

For radiation experiments a part of the crop in a glasshouse of 100 m^2 was grown under a double screen of white cheesecloth. The total global incoming radiation (Watt/m^2) inside and outside the screen was recorded with a tube solarimeter (type TSL, spectrum: 300–2500 nm). The screen reduced the total global incoming radiation by approximately 35%.

In Experiment 7 the influence of radiation on the infectivity of *B. cinerea* conidia was studied. Young (just open) gerbera flowers outside the screen were harvested and inoculated. After inoculation the stems of the flowers were put in tubes containing 32 ml distilled water and placed in the glasshouse, inside or outside the screen (5 flowers per treatment). After four days the upper 10 petals of each flower were incubated at RH > 95% (VPD < 50 Pa) and 20 °C. After 1 day, lesions were counted. The experiment was repeated 14 times under different radiation intensities, from March until December 1992.

In Experiment 8 the influence of radiation on the susceptibility of gerbera flowers to infection by *B. cinerea* was studied. Flowers were harvested inside and outside the screen (6 flowers per treatment), inoculated and incubated at RH > 95% (VPD < 50 Pa) and 20 °C. After 1 day, lesions

were counted. The experiment was repeated 19 times under different radiation intensities, from March until December 1992.

Results

Germination and growth rate

The fitted percentage of germinated conidia (Experiment 1) and the fitted mycelial growth (Experiment 2) of *B. cinerea* showed an optimum between 20–25 °C (Fig. 1). The partial regression coefficients of the two non-linear regression equations were tested pairwise and were not significantly different at $P \leq 0.05$.

Temperature and lesion formation

Experiment 3. When flowers grown at 20 °C were placed in a climate chamber for 7 days, higher temperatures were significantly more favourable for lesion formation (Table 1). This was observed for flowers inoculated before and after the 7-days storage period. At 20 and 25 °C the numbers of lesions were high, > 13 lesions/cm^2 compared to those at 10 and 15 °C ($\leq$ 8.4 lesions/cm^2). At temperatures of 15, 20 and 25 °C the numbers of lesions increased significantly when flowers were inoculated after the 7-days storage period (Table 1). No significant interaction was found between temperature and storage period. From 10 to 25 °C the water potential

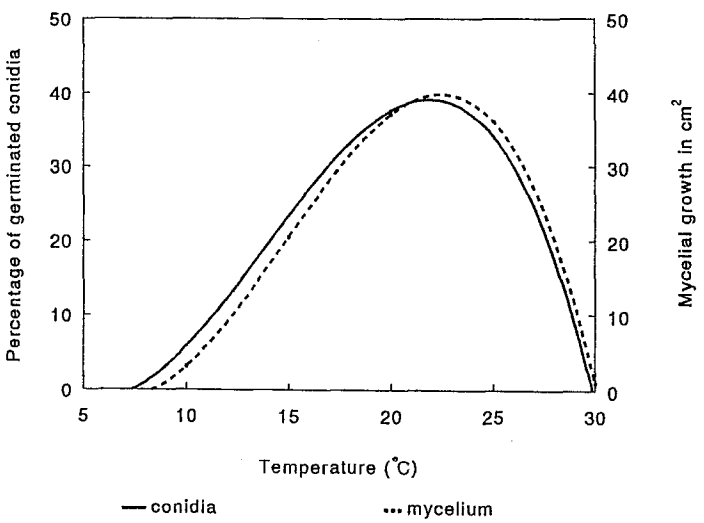

Fig. 1. Experiment 1, Fitted values of percentage germinated conidia (= Y_1) of *B. cinerea, in vitro*, at different temperatures (= X); Experiment 2, Fitted values of radial mycelial growth in cm^2 (= Y_2) of *B. cinerea, in vitro*, at different temperatures (= X); $Y_1 = 18.3\ (\pm\ 11.3) - 7.3\ (\pm\ 2.6)*X + 0.80\ (\pm\ 0.17)*X^2 - 0.019\ (\pm\ 0.003)*X^3$; $R^2 = 0.84$, $P \leq 0.05$. $Y_2 = 33.1\ (\pm\ 8.1) - 10.7\ (\pm\ 1.8)*X + 0.99\ (\pm\ 0.12)*X^2 - 0.022\ (\pm\ 0.002)*X^3$; $R^2 = 0.95$, $P \leq 0.05$.

Table 1. Experiment 3. Temperature and lesion formation on gerbera petals
With storage of conidia = flowers inoculated with conidia of *B. cinerea* before the 7-days storage period
Without storage of conidia = flowers inoculated with conidia of *B. cinerea* after the 7-days storage period

Temperature	Mean numbers of lesions/cm^2	
	With storage	Without storage
10 °C	5.2 a[1] A[2]	5.6 a A
15 °C	6.2 a A	8.4 a B
20 °C	13.1 b A	19.0 b B
25 °C	16.0 b A	21.6 b B

[1] Significant differences within columns.
[2] Significant differences within rows.
Means followed by a common letter are not significantly different ($P \leq 0.05$).

increased, the osmotic potential decreased and the turgor increased in the petals, after the 7 day storage period (Fig. 2).

VPD and lesion formation
Experiment 4. When flowers were inoculated and stored in a climate chamber for 7 days at different temperatures, a VPD of 200 Pa was signifi-

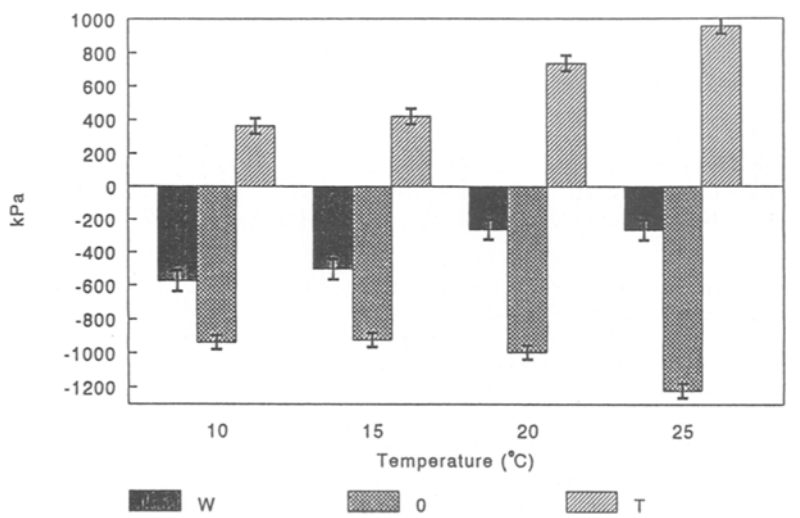

Fig. 2. Experiment 3. Water potential (W), Osmotic potential (O) and Turgor (T) in gerbera petals (VPD = 400 Pa) at different temperatures, after the 7-day storage period in a climate chamber.

cantly more favourable to lesion formation than a VPD of 800 Pa at 15 or 20 °C, but not at 25 °C (Table 2). When flowers were inoculated after the 7-days storage period no significant differences were observed in the numbers of lesions between the two VPD-levels, at any temperature (Table 2). Significantly more lesions were formed on flowers inoculated after the 7-days storage period than before in two cases: at both VPD levels at 25 °C and at a VPD of 800 Pa at 15 and 20 °C. After the 7-days storage period the water potential, the osmotic potential and the turgor in the petals were not significantly different at any VPD-level or temperature (Table 3). In Experiment 4 no significant interactions were found between VPD and temperature.

Table 2. Experiment 4. VDP and lesion formation on gerbera petals, at different temperatures
With storage of conidia = flowers inoculated with conidia of *B. cinerea* before the 7-days storage period
Without storage of conidia = flowers inoculated with conidia of *B. cinerea* after the 7-days storage period

Temperature	VPD (Pa)	RH (%)	Mean numbers of lesions/cm^2	
			With storage	Without storage
15 °C	800	53	5.5 a[1] A[2]	8.1 a B
	200	88	7.5 b A	8.4 a A
20 °C	800	65	10.7 a A	18.6 a B
	200	91	14.3 b[1] A	19.2 a A
25 °C	800	75	17.0 a A	22.3 a B
	200	94	16.0 a A	20.5 a B

[1] Significant differences between the two VPD-levels at the same temperature.
[2] Significant differences between inoculation times at the same temperature and VDP.
Means followed by a common letter are not significantly different ($P \leq 0.05$).

Table 3. Experiment 4. Waterpotential (W), Osmotic potential (O) and Turgor (T) in gerbera petals, at different VPD's and temperatures, after the 7-days storage period

Temperature	VPD (Pa)	RH (%)	W (kPa)	O (kPa)	T (kPa)
15 °C	800	53	–625 a	–994 a	370 a
	200	88	–518 a	–955 ab	438 a
20 °C	800	65	–314 b	–1197 abc	878 b
	200	91	–245 b	–1111 abc	867 b
25 °C	800	75	–425 ab	–1312 bc	887 b
	200	94	–260 b	–1161 c	902 b

Means in each column followed by a common letter are not significantly different ($P \leq 0.05$).

Temperature, storage time and lesion formation
Experiment 5. Storage from one to seven days at different temperatures and a VPD of 400 Pa influenced subsequent lesion formation (Fig. 3). The first 4 days the numbers of lesions decreased at 15 and 25 °C, after 4 days the numbers increased at 25 °C but remained stable at 15 °C. The partial regression coefficients of the two non-linear regression models at 15 °C and 25 °C for the mean numbers of lesions on the petals are significantly different at $P \leq 0.05$.

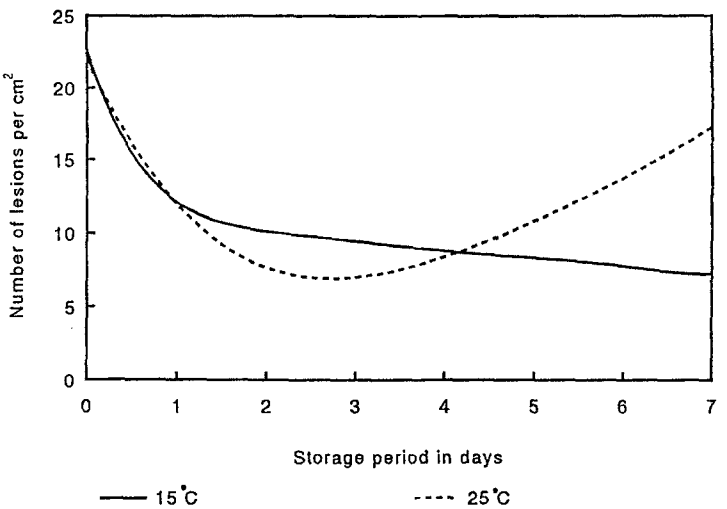

Fig. 3. Experiment 5. Fitted values of mean numbers of lesions (= *Y*) on gerbera petals after different storage periods (days = *X*) at 15 °C (Y = 11.0 (± 2.0) + 11.7 (± 2.5)*0.14 (± 0.18) exp$X$ – 0.5 (± 0.4)*X; R^2 = 0.80, $P \leq 0.05$), 25 °C (Y = –10.4 (± 12.4) + 32.5 (± 12.1)*0.57 (± 0.15) exp$X$ + 3.9 (± 1.7)*X; R^2 = 0.71, $P \leq 0.05$).

The water potential of the petals decreased at 15 °C from –317 kPa at day 1 to –515 kPa at day 7. At 25 °C the water potential decreased slightly during the first 3 days, but after 3 days it increased from –428 kPa to –265 kPa. The osmotic potential was fairly stable at 15 °C but at 25 °C it decreased from –421 kPa at day 1 to –610 at day 7. The turgor was fairly stable during the first 3 days, but at 25 °C it increased after 3 days. At 15 °C the turgor decreased slightly (Fig. 4).

Temperature and lesion formation during incubation at RH > 95%
Experiment 6. Temperatures ≤ 10 °C during lesion formation (RH > 95%) had a negative effect on the numbers of lesions after 1 day but not after 3 days (Fig. 5). After 1 day of incubation the numbers of lesions were high (> 23 lesions/cm^2) between 10 to 20 °C. At 5 °C and ≥ 25 °C the numbers of lesions were low (< 13 lesions/cm^2). After 3 days of incubation the numbers of lesions were about equally high (≥ 30 lesions/cm^2) from 5 to 20 °C. At 30 °C no lesion formation was observed even after 3 days.

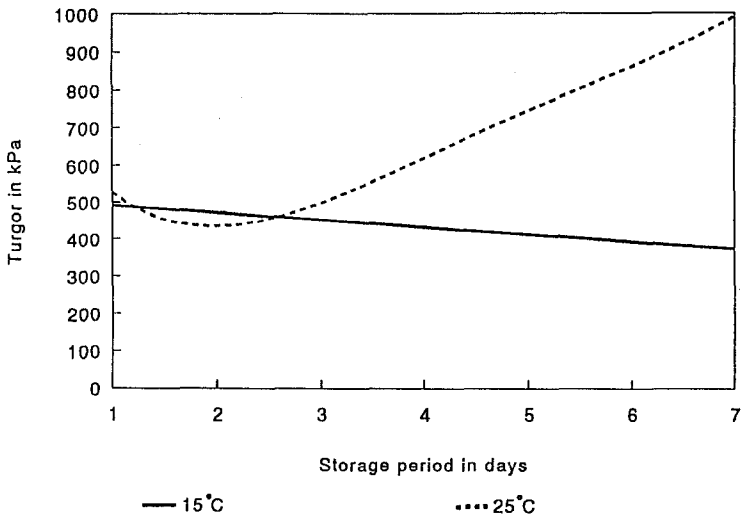

Fig. 4. Experiment 5. Mean values of the turgor in gerbera petals after different days of storage at 15 °C and fitted values of the turgor (= T) in gerbera petals after different storage periods (days = X) at 25 °C (T = 114 (± 93) + 1264 (± 1018)*0.23 (± 0.23) exp$X$ – 125 (± 16)*X; R^2 = 0.88, P ≥ 0.05).

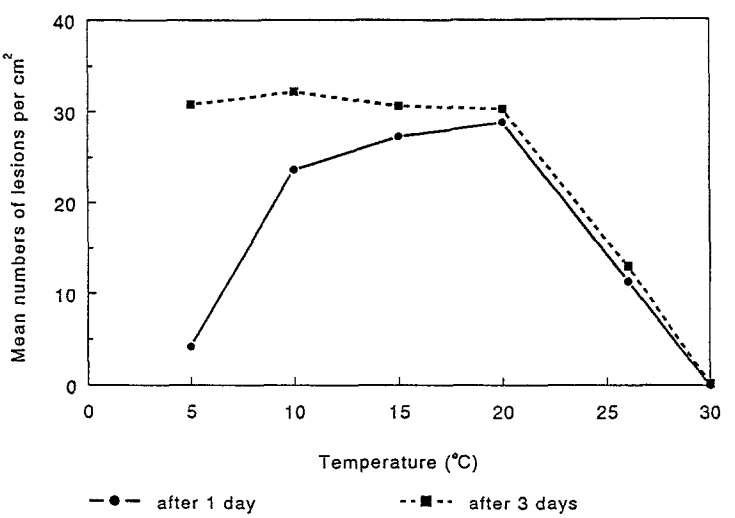

Fig. 5. Experiment 6. Mean numbers of *B. cinerea* lesions per cm^2 on gerbera petals at different temperatures during incubation at RH > 95% (VPD < 50 Pa).

Radiation in the glasshouse and lesion formation

Experiment 7. In spring and summer, when radiation levels in the glasshouse were high, the numbers of lesions after incubation at RH > 95% and 20 °C were significantly lower on plants tested outside the screen

(> 900 Watt/m^2) than inside the screen (< 670 Watt/m^2). In autumn and winter when the radiation levels inside and outside the screen were low (< 300 Watt/m^2) no significant differences were observed between the numbers of lesions on inoculated flowers tested inside and outside the screen (Table 4).

Experiment 8. In spring and summer and in autumn and winter no significant differences were observed between numbers of lesions on flowers, after inoculation and incubation, grown inside or outside the screen (Table 5).

Table 4. Experiment 7. Means numbers of lesions per cm^2 on gerbera petals, after inoculation with conidia of *B. cinerea*, exposure to global radiation for 4 days and subsequent incubation at 20 °C (RH > 95%)

Season	Global radiation (Watt/m^2)	Mean numbers of lesions/cm^2
Spring and summer	948 (outside screen)	9 a
	666 (inside screen)	18 b
Autumn and winter	216 (outside screen)	17 b
	147 (inside screen)	18 b

Means in each column followed by a common letter are not significantly different ($P \leq 0.05$)

Table 5. Experiment 8. Mean numbers of lesions per cm^2 on gerbera petals, after exposure to global radiation inside or outside the screen for 5 to 11 days, inoculation with conidia of *B. cinerea* (approximately 90 conidia/cm^2) and incubation at 20 °C (RH > 95%)

Season	Global radiation (Watt/m^2)	Mean numbers of lesions/cm^2
Spring and summer	854 (outside screen)	22 a
	603 (inside screen)	23 a
Autumn and winter	305 (outside screen)	23 a
	208 (inside screen)	20 a

Means followed by a common letter are not significantly different ($P \leq 0.05$)

Discussion

The experiments

Experiments 1 and 2 showed that the temperature range in which *B. cinerea* can germinate and grow *in vitro* is 5–30 °C. A similar *in vitro* result was obtained by Ramsey and Lorbeer [1986] and by Shiraishi et al. [1970], who found ranges of 3 to 33 °C and 5 to 32 °C for conidial germination and of 5 to 30 °C and 5 to 35 °C for mycelial growth of *B. cinerea*, respectively. In heated glasshouses the temperature fluctuates between

17 °C in winter and 30 °C in summer. *B cinerea* is therefore able to germinate and grow in Dutch glasshouses during most of the year. After harvest, in cooling chambers and during transportation, when the temperature is between 5 and 20 °C, *B. cinerea* is able to germinate and grow.

Experiment 3 showed that at temperatures ≥ 20 °C flowers have more lesions of *B. cinerea*. At these temperatures flowers senesce faster or they secrete more nutrients, salts or sugars which favour the infectivity of conidia of *B. cinerea* [Blakeman, 1980], or they evaporate more (= higher RH) which also favours the infectivity of *B. cinerea* conidia. At temperatures ≥ 15 °C the infectivity of *B. cinerea* conidia was negatively affected during storage. Conidia on the flower surface probably dry and lose their infectivity faster at higher temperatures, which is in agreement with Coley-Smith [1980]. She stated that temperature has a direct effect on the longevity of conidia, high temperatures being more inimical to survival than low. Salinas et al. [1989] found that dry, ungerminated conidia of *B. cinerea* on gerbera flowers can remain infective, but their viability decreases as they become older.

The optimum temperature for spore germination and mycelium growth of *B. cinerea in vitro* was between 20–25 °C. The optimum temperature *in vivo* is between 18–20 °C (Kerssies, personal observation). The temperature extremes *in vitro* and *in vivo* are the same, but the optima are different. Shoemaker and Lorbeer [1971] found for *B. squamosa* also a higher optimum temperature for growth in culture than for germination of conidia on onion leaves.

Experiment 4 showed that at a VPD of 800 Pa flowers have fewer lesions of *B. cinerea* than at 200 Pa. VPD has no significant effect on the susceptibility of gerbera flowers for *B. cinerea* (Table 2), but at a VPD of 800 Pa conidia of *B. cinerea* dry quicker and lose their infectivity faster than at 200 Pa, as found by Blakeman [1980] and Berg and Lentz [1968]. The fluid secreted by the flower, containing nutrients, salts and sugars, dries faster at high VPD levels, so that *B. cinerea* conidia cannot use these nutrients for germination. Winspear et al. [1970] showed that reducing the relative humidity in glasshouses from 90% to 75% resulted in a decrease of the incidence of *B. cinerea* on tomato plants.

Experiments 7 and 8 showed that high radiation levels in glasshouses negatively influenced the infectivity of conidia of *B. cinerea* on the flower surface, but had no effect on the susceptibility of gerbera flowers for *B. cinerea*. Hennebert and Giles [1958] found a negative effect on conidia by direct sunlight.

Susceptibility of gerbera flowers

The results of the present study show that the linear regression equation calculated with data obtained from glasshouse experiments [Kerssies, 1993] is based on causal relations. Linear regression accounted for 80% of the variation in the number of lesions on gerbera flowers in glasshouses in

terms of relative humidity (positively correlated), global radiation outside the glasshouse (negatively correlated) and age of the crop (positively correlated; not studied in the present paper). The present study shows that the seasonal effect on the numbers of lesions on gerbera petals, observed in glasshouse experiments [Kerssies, 1993], cannot be explained exclusively by a change in the physiology of the flowers. Only temperature had a significant effect on the susceptibility of gerbera flowers (Table 1). In spring and early summer conidia lose their infectivity at high radiation levels, high temperatures and high VPD levels. Therefore, the numbers of lesions can be low compared with the numbers in other seasons, although the numbers of trapped spores are high. Ultraviolet radiation cannot be a factor, because UV radiation could not be detected within glasshouses (Steinbuch, personal observation). In summer, gerbera flowers are more sensitive to *B. cinerea* because of high temperatures in glasshouses, but the negative effect of radiation on the conidia of *B. cinerea* seems to overrule the temperature effect on the flowers.

The effect of temperature on the susceptibility of gerbera flowers can be explained by the change of water relations in the petals. At higher temperatures the numbers of lesions and the turgor in the petals increase. A higher turgor can cause leakage of nutrients, sugars and salts to the flower surface [Meeteren, 1980b]. Leakage has a positive effect on germination of *B. cinerea* conidia on the flower surface [Salinas et al., 1989; Blakeman, 1980]. This positive effect was corroborated by the relation between the number of lesions at 25 °C increasing over time and the increasing turgor of the petals (Experiment 5, Fig. 3–4). Coley-Smith [1980] stated that ageing conidia of *B. fabae* contained reserves adequate for germination but insufficient to bring about infection. Infectivity could be restored to old spores by supplementing their reserves with an external source of nutrients.

The effect of temperature on the susceptibility of gerbera flowers can also be explained by a mechanism described by Schnathorst [1959]. He showed that a physico-chemical resistance mechanism is involved in the resistance to *Erisyphe cichoracearum* in lettuce. He stated that a difference in osmotic value was one of these mechanisms, because the osmotic value of resistant lettuce plants was more negative than of susceptible plants. He suggested that the role of the osmotic value of host cells in regulating the growth of powdery mildew on lettuce plants might be closely linked with carbohydrate metabolism, and that a pathogen cannot succeed if the suction pressure of a host cell contents is higher than that of the parasite. VPD had no significant effect on the water relations in gerbera petals and had no significant effect on the susceptibility of gerbera flowers for *B. cinerea* either. The relation between susceptibility of gerbera petals for *B. cinerea* and their water status (water potential, osmotic potential and turgor) of gerbera petals needs more research.

Lesion formation

The effect of temperature on lesion formation during incubation at RH > 95% (Experiment 6) was as found by Salinas et al. [1989]. The result shows that *B. cinerea* can cause big losses of cutflowers during the postharvest period, because this fungus can infect within a wide range of temperatures, as long as the RH > 95%.

Conidia of *B. cinerea* survive glasshouse conditions and cause lesions during the postharvest period when the RH > 95% (VPD < 50 Pa). Gerbera flowers are sensitive for *B. cinerea* conidia during all seasons, under most glasshouse conditions. Therefore it is necessary to decrease the numbers of *B. cinerea* conidia in the glasshouse by keeping the RH as low as possible, especially in autumn and winter and by keeping the radiation as high as possible (clean glass, avoidance of shade), especially in autumn and winter, when the radiation is low in the Netherlands at 52° NL.

The present study shows that flowers with a higher turgor are probably more sensitive to *B. cinerea*. During flower formation the turgor in glasshouse-flowers can be decreased by altering the nutrient solution. During the postharvest period the turgor in flowers can be decreased by lowering the amount of salts or sugars in the storage water. The temperature during storage has to be as low as possible (< 10 °C), because at low temperatures the flowers had fewer lesions of *B. cinerea*.

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