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Factors influencing glassiness in lettuce

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Abstract

In a series of glasshouse experiments, performed in winter during the years 1978-1982, the effects of various factors on the incidence of glassiness in lettuce were studied.

With lettuce crops grown in soil nightly outcoming radiation, compactness of the soil, cultivar and nitrogen supply were studied in relation to glassiness.

Two experiments with lettuce grown in Nutrient Film Technique (NFT) were performed to investigate the specific effect both of NO_3^- and of total salt concentration on glassiness.

From the factors studied in the lettuce crop grown in soil it appeared that compactness of the soil and nitrogen supply were correlated negatively with the amount of glassiness observed. A positive correlation was found between amount of glassiness and amount of nightly outcoming radiation. Clear differences in sensitivity for glassiness between cultivars could be observed, 'Mistra' and 'Rolinda' showing less tolerance and 'Renate' and 'Amanda Plus' a high tolerance to glassiness. Studies in NFT revealed that the observed positive effect of nitrogen supply on glassiness in soil is very likely to be a consequence of higher total salt concentration rather than a specific effect of NO_3^-. From the factors studied, high compactness of the soil, higher plant temperature, tolerant cultivars and higher total salt concentration proved to be effective tools in reducing glassiness under poor light conditions in glasshouses.

Introduction

Glassiness in lettuce is a physiological disorder in the Netherlands mostly occurring under poor natural light conditions from November till February in glasshouses. The symptoms are water-soaked spots mostly along the leaf edges and bounded by veins. If the spots subsist for a longer period the tissue may die and the lettuce becomes unsaleable. Glassiness is generally accepted to be a consequence of imbalance between water uptake and transpiration. High rates of water uptake combined with low transpiration levels may provoke symptoms mentioned above (van Esch & van Holsteijn, 1977). There are a great number of factors which exert influence on glassiness. Differences in sensitivity between cultivars have been noticed (van Esch & van Holsteijn, 1977). Strijbosch, Vonk & van de Vooren (1974) suggested a positive correlation between glassiness and amount of incoming radiation. Van Nierop (1972) suggested that higher setpoints for heating during the night may reduce or even prevent glassiness.

In an experiment the effect of both daily incoming and nightly outcoming radiation on incidence of glassiness was studied in order to verify the effect found earlier by Strijbosch et al. Van Oijen (1977) found that a low nitrogen level in the soil was conducive to the disorder and hence increased N dosages to suppress the disorder. Since nitrogen supply and total salt concentration are probably linked, three experiments were set up, one in soil and two in NFT. In the latter two experiments the specific effect of NO_3^- and the effect of total salt concentration were studied separately. Apart from this the effect of compactness of the soil and of cultivar on incidence of glassiness were studied in two subsequent experiments.

Material and methods

Radiation

The lettuce cultivar 'Mistra' was planted on 27 September in a heated glasshouse. From 3 October till 6 December daily recordings were done of incoming global radiation outside and outcoming radiation inside the glasshouse during the night. For incoming global radiation a solarimeter type Kipp M3 was used, while outcoming radiation was measured with a net-radiaton meter type Thies at a height of 110 cm above the crop at pipe-level. On the spot of the radiation meter the heating pipe was wrapped in aluminum film. Scores for glassiness were assessed during a period of 31 days, starting on 30 October.

Nitrogen and total salt concentration

In order to study the effect of nitrogen (NO_3^-) on the occurrence of glassiness three experiments were conducted, one in soil and two in NFT. In the soil experiment five dressings of ammonium nitrate were supplied, i.e. 0, 50, 100, 150 and 200 g m^{-2} glasshouse area in four replicates. During 43 days, starting on 10 October, daily recordings of glassiness were done. Cumulative scores of the disorder were computed against nitrogen level.

In the first NFT experiment four levels of nitrogen were maintained at a constant level, i.e. 1.5 mS cm^{-1}. Treatments were in four replicates. The composition of the nutrient solutions of the four treatments is given in Table 1. Cultivar 'Renate' was planted on 20 October in a heated glasshouse. During 42 days, starting on 8 December, scores for glassiness were determined. Cumulative scores of glassiness were calculated per treatment.

In the second NFT experiment four levels of electric conductivity (EC), i.e. 0.75, 1.5, 2.5 and 4.0 mS cm^{-1}, were maintained during the whole growing period. The

Table 1. Composition of four nutrition treatments as used in the first nutrition experiment in NFT.

Treatment	NO_3^- (mmol l^{-1})	SO_4^{-2} (mmol l^{-1})
1	13.5	0.38
2	12.38	0.94
3	11.25	1.50
4	8.63	2.82

All solutions contained: $H_2PO_4^-$, 1.5; NH_4^+, 0.75; K^+, 7.5; Ca^{+2}, 3.38; Mg^{+2}, 1.13 mmol l^{-1} and Fe, 52.5; Mn, 7.5; Zn, 4.5; B, 30; Cu, 0.75; Mo, 0.75 μmol l^{-1}.

composition of the nutrient solutions of the EC level of 0.75 is: NO_3^-, 7.13; $H_2PO_4^-$, 0.75; SO_4^{-2}, 0.38; NH_4^+, 0.38; K^+, 3.75; Ca^{+2}, 1.69; Mg^{+2}, 0.56 mmol l^{-1} and Fe, 26; Mn, 3.75; Zn, 2.25; B, 15; Cu, 0.38; Mo, 0.38 μmol l^{-1}. The composition of the solutions of the other three EC levels was adapted proportionally. Cultivar 'Renate' was planted on 24 October in a heated glasshouse. During 33 days, starting on 8 December, glassiness was recorded and cumulated per treatment.

Compactness of the soil

Two experiments were conducted in a heated glasshouse. In the first experiment two levels of soil compactness were maintained: rotary cultivated and soil pressed by a tractor. Cultivar 'Renate' was planted on 21 October in a heated glasshouse. Score for glassiness was assessed during a period of 35 days, starting at 23 December. In the second experiment four levels of soil compactness were maintained: rotary cultivated soil, trodden-down soil, soil pressed by a tractor and soil pressed by a vibrating tamper. Cultivar 'Renate' was planted on 12 October in a heated glasshouse. Soil compactness was measured with a penetrometer. In Table 2 average values for soil compactness are summarized. Glassiness was recorded and averaged per treatment.

Cultivars

Two experiments were conducted. In the first experiment cultivars 'Mistra' and 'Renate' were planted on 27 September in a heated glasshouse. Score for glassiness was assessed during a period of 31 days, starting at 30 October.

In the second experiment the lettuce cultivars 'Amanda Plus', 'Dalida', 'Deciso'

Table 2. The average compactness of the soil.

Treatment	Compactness of the soil in kg cm^{-2} at a depth of 0-50 cm	
	first experiment	second experiment
Rotary-cultivated soil	6.7	4.1
Trodden down soil		5.8
Tractor	9.7	8.0
Vibrating tamper		9.2

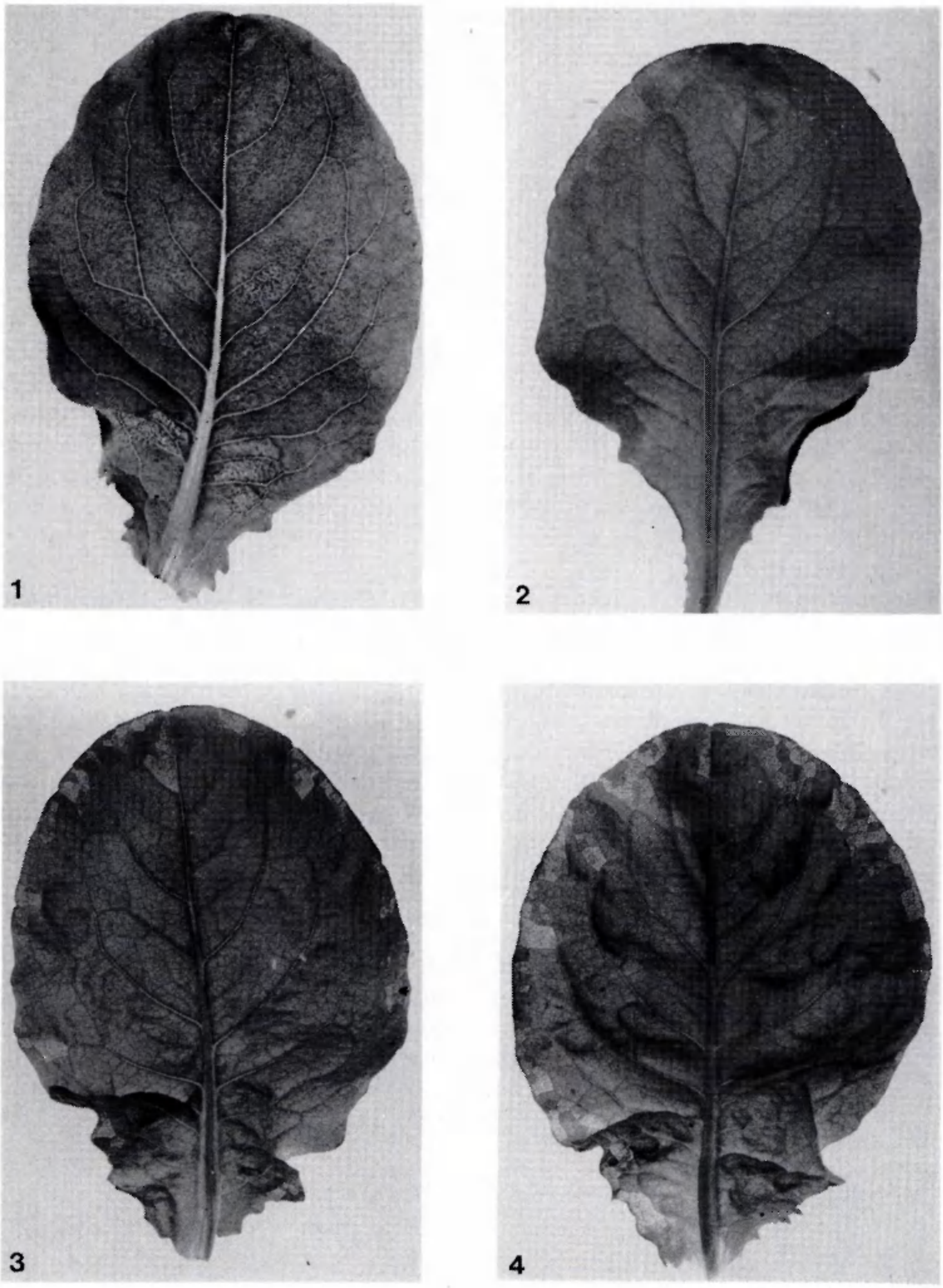

Fig. 1. Scale of glassiness used in the experiments. Score 0 (top left), 1 (top right), 2 (bottom left) and 3 (bottom right).

and 'Rolinda' were planted on 30 October in a heated glasshouse. During 54 days, starting on 1 November, glassiness was recorded.

Climate conditions and assessment of glassiness

In all experiments set-points for heating temperature were 6 °C at night and 12 °C by day. Ventilation took place at 7 °C and 14 °C respectively. Assessments of glassiness took place in the early morning hours each day. In all experiments glassiness was recorded of an average value per plant, i.e. mean score of individual leaves per plant, on each of 5 plants each at random per experimental plot to a scale of 0-3 (Fig. 1).

Results

Radiation

Global radiation did not show a significant positive relation with score for glassiness on the following day. Recordings of nightly outcoming radiation were plotted against score for glassiness of the morning after; a significant positive relation could be observed as shown in Fig. 2. This means that directly after nights with a high level of outcoming radiation an increase in glassiness in the morning was observed.

Nutrition

Supplying extra nitrogen to the plants as a base dressing in the soil or in NFT during the whole growing period did not give similar results. From Fig. 3 it is clear that when more ammonium nitrate was added as a base dressing to the soil, occurrence

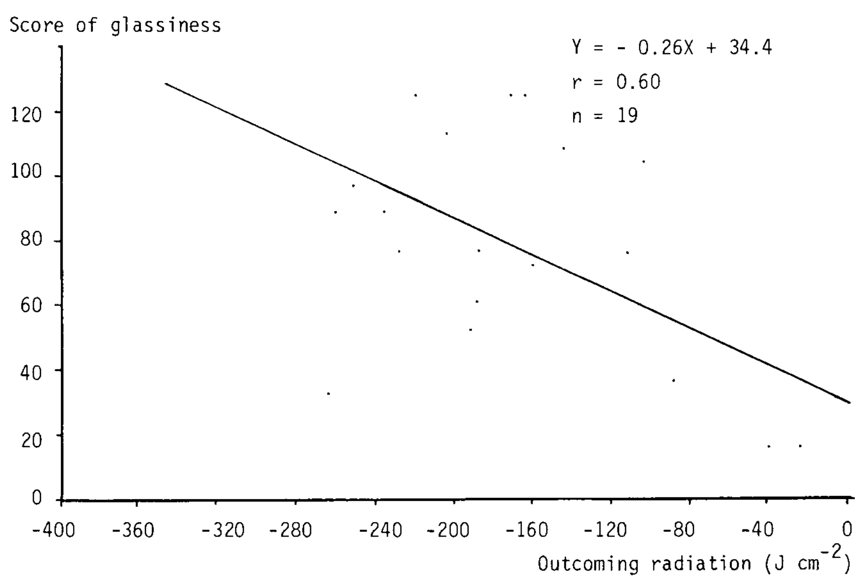

Fig. 2. Relation between intensity of nightly outcoming radiation and incidence of glassiness.

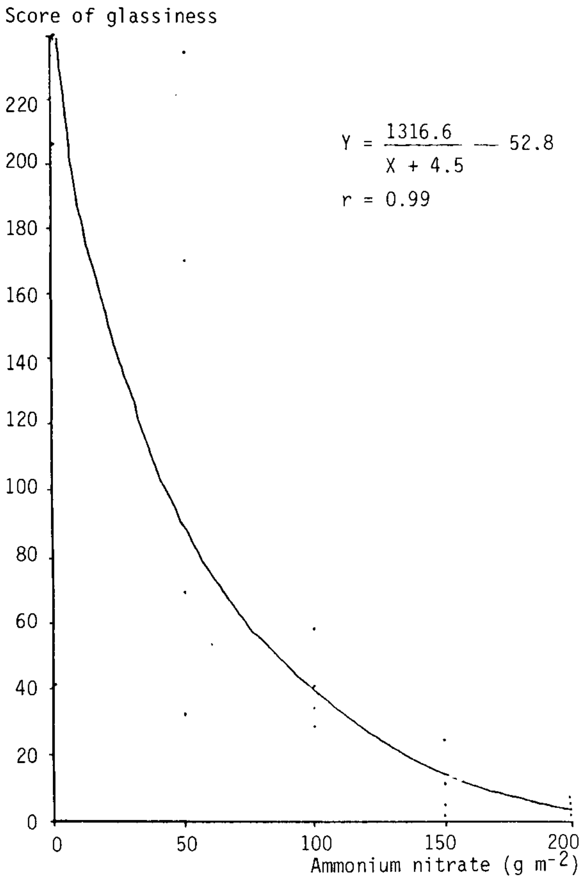

Fig. 3. Relation between dosage of ammonium nitrate as base dressing in the soil and score of glassiness.

Table 3. Cumulative score of glassiness at four nitrogen levels in the first NFT experiment.

Nitrogen level in mmol l^{-1}	Cumulative score of glassiness
13.5	211
12.38	252
11.25	232
8.63	271

Tukey's yardstick (1 %):77.

of glassiness decreased. Adding more nitrogen at a constant EC level in the first NFT experiment did not reduce incidence of glassiness significantly as shown in Table 3. A higher EC level during the growing period in the second NFT experiment reduced incidence of glassiness as shown in Table 4. From Table 4 it becomes

Table 4. Cumulative score of glassiness with four EC levels in the second NFT experiment.

EC level in mS cm^{-1}	Cumulative score of glassiness
0.75	34.0
1.5	40.4
2.5	25.3
4.0	2.6

Tukey's yardstick (1 %):8.9.

clear that the EC level is an important factor in controlling glassiness. As will be seen the EC level and the incidence of glassiness are correlated negatively. In neither of the experiments mentioned above significant differences in average head weight between treatments was found.

Compactness of the soil

In both experiments a higher level of compactness of the soil reduced glassiness. Differences in level of glassiness between rotary-cultivated soil and soil pressed by a tractor were 1.4 and 2.2 respectively. The relation between compactness of the soil and glassiness in the second experiment is given in Fig. 4. From that figure it is clear that the incidence of glassiness decreases with greater compactness of the soil. In both experiments no significant relation between compactness of the soil and mean head weight was found.

Cultivars

In the two experiments a distinct difference in sensitivity to glassiness between the cultivars could be noticed. In the first experiment cultivar 'Mistra' showed signi-

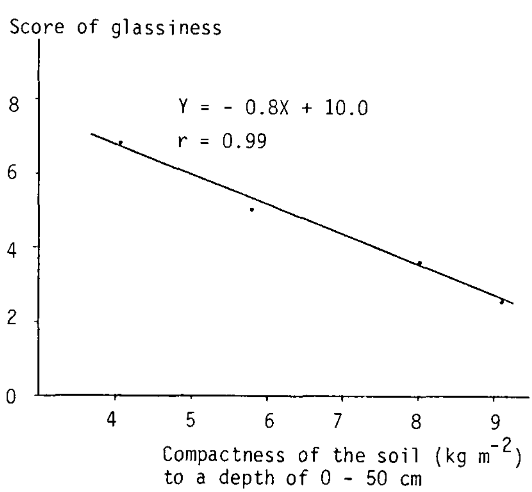

Fig. 4. Relation between compactness of the soil and score of glassiness.

ficantly more glassiness than cultivar 'Renate'. Cumulative scores were 112 and 76 respectively. In the second experiment cultivar 'Dalida' showed significantly more glassiness than the cultivars 'Rolinda', 'Deciso' and 'Amanda Plus'. Cumulative scores were 167, 98, 88 and 77 respectively.

Discussion and conclusion

From the radiation experiment it appears that glassiness increases according to amount of radiation at night. This is probably a consequence of lower plant temperature combined with higher humidity under influence of outcoming radiation. At reduced plant temperature and increased humidity, transpiration may be too low in relation to water uptake. Therefore, in order to prevent a low plant temperature an increased ambient night temperature is needed. In contrast to Strijbosch et al. (1974), in our experiment no significant relation between score for glassiness and incoming radiation on the preceding day could be found. A day of high incoming radiation was not always followed by a night of high outcoming radiation. In our experiment both radiations were measured whereas in the experiment of Strijbosch et al. no recordings of the outcoming radiation were done. It is quite possible that during the experiment of Strijbosch et al. the limited number of days of high incoming radiation in which glassiness was assessed were followed by nights of high outcoming radiation.

From the nutrition experiment it appears that glassiness decreases when extra nitrogen is supplied as a base dressing to the soil. The same results were found in an experiment of van Oyen (1977). In our experiments, in spite of the addition of more nitrogen at a constant EC level in NFT during the growing period, no reduction of glassiness could be observed. Results of the second nutrition experiment in NFT reveal that glassiness decreases at EC levels higher than 1.5 mS cm^{-1}. Therefore the discrepancy in results between the soil and NFT experiments may be explained by the fact that nitrogen and EC level are probably linked in the soil experiment, causing - like in the NFT experiment - a direct EC effect on the incidence of glassiness. A low EC of the nutrient solution on one hand may lead to a relatively low nutrient status of the leaves, leading to a lower shoot/root ratio (Brouwer, 1962), and on the other hand may change the balance of transpiration and water uptake. Consequently a high EC of the nutrient solution may reduce water uptake and hence root pressure. It is quite possible that compactness of the soil has similar consequences.

Differences in sensitivity to glassiness between cultivars as observed in our experiments reveal that also genetic background is an important factor. Breeding for resistant cultivars therefore also seems to be an effective method of lowering risks of glassiness. Results of our experiments indicate that, when use has to be made of cultivars sensitive to glassiness, maintaining a higher EC level in combination with pressed soil and a higher ambient temperature at night may reduce the incidence of glassiness to acceptable levels.

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