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CHRONIC DISCOLORATION OF LEAF TIPS OF GLADIOLUS AND ITS RELATION TO THE HYDROGEN FLUORIDE CONTENT OF THE AIR AND THE FLUORINE CONTENT OF THE LEAVES[1]

Chronisch optredende verkleuring van bladtoppen bij gladiolen en het fluorwaterstofgehalte van lucht en fluorgehalte van blad

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The gladiolus variety 'Snow Princess', which is very susceptible to HF, was used in field experiments to investigate the correlation between traces of HF occurring in the atmosphere and a gradually developing leaf tip injury such as occurs in some gladiolus varieties. The average HF-pollution in the atmosphere could be estimated by using filter papers soaked in lime water. The plants growing in atmospheres polluted with HF showed a gradual increase of leaf tip burn. Leaf tips 15 cm in length were analysed for their fluorine content. A positive correlation was found between the average concentration of HF in the atmosphere, the length of leaf tip burn and the fluorine content of the leaf tips.

INTRODUCTION

During the growth of some varieties of tulips and gladiolus in the field it has been observed, at several places in the Netherlands, that a gradual increase in leaf tip injury occurred. The varieties showing this phenomenon were the same as those which were known to be very sensitive to hydrogen fluoride gas.

Very low HF-concentrations applied in fumigation chambers to gladiolus with an exposure time of several days to several weeks have been shown to cause a gradually increasing leaf tip injury (THOMAS & HENDRICKS, 1956; STERN, 1962).

It is possible that HF in low concentrations, if frequently supplied to plants by a wind coming from a source of HF, could cause in the field accumulation of fluorine in the leaves, resulting in a gradual increase in leaf tip damage.

In the Netherlands an extensive investigation was made by BARKMAN (1958) concerning the area of distribution of cryptogamic epiphytes (lichens, mosses, algae). According to the epiphytic vegetation the least polluted areas in the Netherlands are the North-Veluwe woods, the Wadden isles and the western part of Goeree, Schouwen and Walcheren. It was found on the other hand that in certain regions hardly any epiphytes occurred, especially north-east of industrial areas, north-east of cities and along the main roads. Directly around these areas was a second area where the most sensitive epiphytes (particularly some lichens) were still absent. BARKMAN concluded that the disappearance of the epiphytes in these areas is most probably caused mainly by atmospheric pollution.

The purpose of the present investigation was to determine whether there is, in fact, a relation between the occurrence of a constant very low HF air pollu-

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tion, the development of a gradually increasing leaf tip damage and the fluorine content of the injured leaves.

EXPERIMENTAL FIELDS AND METHODS

Seven experimental fields were laid out for the investigation, one in an industrial area near the sea, one far from any industry and main road but at the same distance from the sea, three on different soil types in Wageningen and finally two in areas where, according to the investigation of BARKMAN (1958), air pollution does not exist (control plots). The purpose of the second plot was to investigate if sea wind, atomizing sea water which contains fluoride, could influence the measurements. In the industrial area low concentrations of HF still occur even though industry has taken measures to decrease as far as possible the quantity of HF evolved into the air.

In Wageningen plants sensitive to HF were every year gradually damaged in the same manner as occurred in the above-mentioned industrial area. HF-absorbing meters placed on a tower 58 m above sealevel (N.A.P.) and used to analyse the air at weekly intervals for HF during a three months period (10 April–11 July 1962), indicated that a relatively high concentration of HF in the air occurred during the period that the wind came from the direction of some nearby brick factories. It points to the brick factories as a source of industrial contamination.

The experimental fields were planted with the very susceptible gladiolus variety 'Snow Princess' and at regular intervals the injury to plants was estimated by measuring the length of the leaf tip injury. Furthermore, 15 cm lengths of these leaf tips were afterwards cut and analysed for their fluorine content. The average HF content of the air was estimated according to the method published

TABLE 1. Average length (cm) of leaf tip injury on gladiolus leaves (1st to 4th leaf) from the experimental fields in 1962.
Gemiddelde lengte (cm) van bladtopbeschadiging van gladiolebladeren (1e tot en met 4e blad) van de proefvelden in 1962.

Origin of the samples	Date of the measurements				
	July 5	July 30	Aug. 13	Aug. 28	Sept. 10
Control plot 1 *Controle-veld 1*	0.03	0.12	0.24	0.21	0.21
Control plot 2 *Controle-veld 2*		0.30	0.45	0.21	0.35
Control plot near the sea *Controle-veld nabij de zee*	0.03	0.19	0.15	0.14	0.28
Clay soil *Kleigrond*	0.32	0.78	0.91	0.86	0.95
Black sandy soil *Zwarte zandgrond*	0.22	0.96	1.04	1.19	1.42
Yellow sandy soil *Gele zandgrond*	0.31	0.86	0.83	1.09	2.22
Industrial area *Industriegebied*	0.40	1.18	1.45	1.75	2.53

Herkomst van de monsters — *Datum van de metingen*

by McINTIRE *et al.* (1956). A quantitative study of this method was made by ADAMS (1961). Filter-papers imbibed with $Ca(OH)_2$ were placed in a wooden case, screened against rain and the direct rays of the sun, but with sufficient ventilation. The wooden case was placed next to the trial field at a height of 1.5 m above the soil.

RESULTS AND CONCLUSIONS

Table 1 shows that plants in the three fields in areas with hardly any HF air pollution (see Table 3), displayed very slight and very gradually developing leaf

TABLE 2. Fluorine content (ppm) of leaf-tips of the gladiolus variety 'Snow Princess' from the experimental fields, 1962.
Fluorgehalte (dpm) van de gladiool 'Sneeuwprinses' van de proefvelden in 1962.

Origin of the samples	Date of the measurements				
	July 5	July 30	Aug. 13	Aug. 28	Sept. 10
Control plot 1 *Controle-veld 1*	3	7	7	9	7
Control plot 2 *Controle-veld 2*		5	7	9	9
Control plot near the sea *Controle-veld nabij de zee*	5	5	12	11	13
Clay soil *Klei-grond*	16	18	24	34	42
Black sandy soil *Zwarte zandgrond*	10	25	23	40	33
Yellow sandy soil *Gele zandgrond*	26	32	50	65	56
Industrial area *Industriegebied*	22	22	59	48	42

Herkomst van de monsters — *Datum van de metingen*

TABLE 3. Measurements of HF air pollution, using absorbing meters next to the gladiolus experimental fields, 1962.
Metingen met HF-absorptiemeters naast de gladioleproefveldjes in 1962.

Origin of the samples	Average daily amounts of fluorine in ppm F absorbed during periods of two months		
	April–May	June–July	Aug.–Sept.
Control plot 1/*Controle-veld 1*	0.2	0.2	0.2
Control plot 2/*Controle-veld 2*	0.4	0.2	0.2
Control plot near the sea *Controle-veld nabij de zee*	0.3	0.3	0.5
Clay soil/*Kleigrond*	1.2	1.0	1.2
Black sandy soil/*Zwarte zandgrond*	1.2	0.7	1.2
Yellow sandy soil/*Gele zandgrond*	1.7	1.1	1.8
Industrial area/*Industriegebied*	2.4	1.6	1.7

Herkomst van de monsters — *Gemiddelde hoeveelheden fluor in dpm F, geabsorbeerd in tweemaandelijkse perioden*

tip injury. In the four fields in areas with a measurable degree of air pollution, more serious injury occurred.

As will be seen from Table 2, the plants in the three control plots had a very low fluorine content, whereas those in the other four fields (three at Wageningen and one in an industrial area) had a much higher content.

The data provided by the HF-meters (Table 3) corresponded generally with the fluorine contents found in the leaves in the various experimental fields (Table 2). A low HF-content of the atmosphere was found near fields where the leaves contained little fluorine. On the other hand, the HF-content of the air was high where the plants in the corresponding experimental field contained much fluorine.

Both the leaf tip injury and the fluorine content of the leaves increase with increasing HF-content of the atmosphere. As the gladiolus variety 'Snow Princess' is known to be highly sensitive to hydrogen fluoride, these facts would indicate that the leaf tip injury in the field should be ascribed to HF.

SAMENVATTING

Op verschillende plaatsen in Nederland kwam bij bepaalde tulpe- en gladiolerassen een geelwitte verkleuring voor, die zich vanuit de bladpunt zeer langzaam uitbreidde. Dat deze rassen zeer gevoelig voor HF zijn, werd aangetoond door middel van kunstmatige begassingen, waarbij dezelfde verkleuringen ontstonden. Om na te gaan of zeer kleine hoeveelheden HF in de atmosfeer tot deze zich geleidelijk ontwikkelende bladbeschadiging aanleiding kunnen geven, werden in bovengenoemde gebieden en op plaatsen waar geen luchtverontreiniging voorkomt proefveldjes aangelegd en beplant met het gladioleras 'Sneeuwprinses'. Van deze planten werd de lengte van de bladpuntbeschadiging tijdens het groeiseizoen verscheidene keren gemeten. Bovendien werden bladpunten van 15 cm lengte op fluorgehalte geanalyseerd. De bij de proefvelden opgestelde HF-meetapparaten leverden gegevens over de gemiddelde HF-gehalten van de lucht tijdens de teelt op.

Uit dit onderzoek is gebleken dat in gebieden waar de zich zeer geleidelijk ontwikkelde bladverkleuring werd waargenomen, meer fluor in het blad en in de lucht werd gevonden dan op plaatsen waar dit zeer gevoelige gladioleras vrijwel niet beschadigd werd.

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