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THE BREEDING OF SCAB-RESISTANT FRAME CUCUMBERS IN THE NETHERLANDS

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1. INTRODUCTION

In the Netherlands cucumbers are grown commercially in hothouses (in 1954 about 45 ha) and in frames (in 1954, 506 ha). The soil under Dutch lights is generally heated by fresh manure. In 1954 the total return was 23,578,700 guilders, of which 18,621,900 guilders came from frame cucumbers. Fig. 1 gives a survey of a frame cucumber nursery.

In hothouses only green varieties are grown; under Dutch lights mostly green varieties and occasionally also some white and yellow varieties are used.

The common green varieties, Spotvrije (Spotdisease Resister) for hothouses and Lange Groene Broei, Groene Standaard, Perfecta and Spiers for frames, are uniform in colour, without any mottling and without distinct longitudinal lighter streaks. They are capable of fruiting parthenocarpically. Seed setting is prevented as much as possible by removing the male flowers. If seed would set the fruit tops swell

FIG. 1. SURVEY OF A CUCUMBER NURSERY. (PHOTOGRAPH TAKEN BY PROEFSTATION NAALDWIJK)

considerably and as a result the fruits become unsalable. Both in hothouse and frame culture the plants are pruned regularly.

The most important diseases of frame cucumbers are Fusarium wilt (*Fusarium* species), Sclerotinia (*Sclerotinia sclerotiorum*) and scab (*Cladosporium cucumerinum* ELL. et ARTH.). Fusarium wilt is generally prevented by steam sterilising the soil or grafting the cucumbers on the unsusceptible rootstock *Cucurbita ficifolia*. Sclerotinia can be controlled by steam sterilizing the soil before planting.

Scab, a serious disease in frame cucumbers, is caused by a fungus which attacks both vegetative organs and fruits. The best known scab symptoms are the imbedded spots on the fruits, mostly covered with drops of gum (Fig. 2). The effective German fungicide Bulbosan (trichlorotrinitrobenzene) could not be supplied after 1945. Consequently scab became a serious disease again. In 1954 Bulbosan, made by Farbwerke Hoechst A.G., Frankfurt (M.)-Hoechst, Germany, could be supplied again in sufficient quantity.

2. HISTORY

Before 1920 scab-resistance in pickling cucumbers was already known to growers in the neighbourhood of Venlo. Around 1920 W. G. v. d. KROFT, Horticultural Advisory Officer at Maastricht and J. H. TERCKEN at Baarlo, started intensive selection from material of the variety Vorgebirgstraube, originally a German pickling cucumber, which was grown in the vicinity of Venlo. They obtained a number of scab-resistant lines called Baarlose Nietplekker, of which *Baarlose Nietplekker VI* has become the most widely grown.

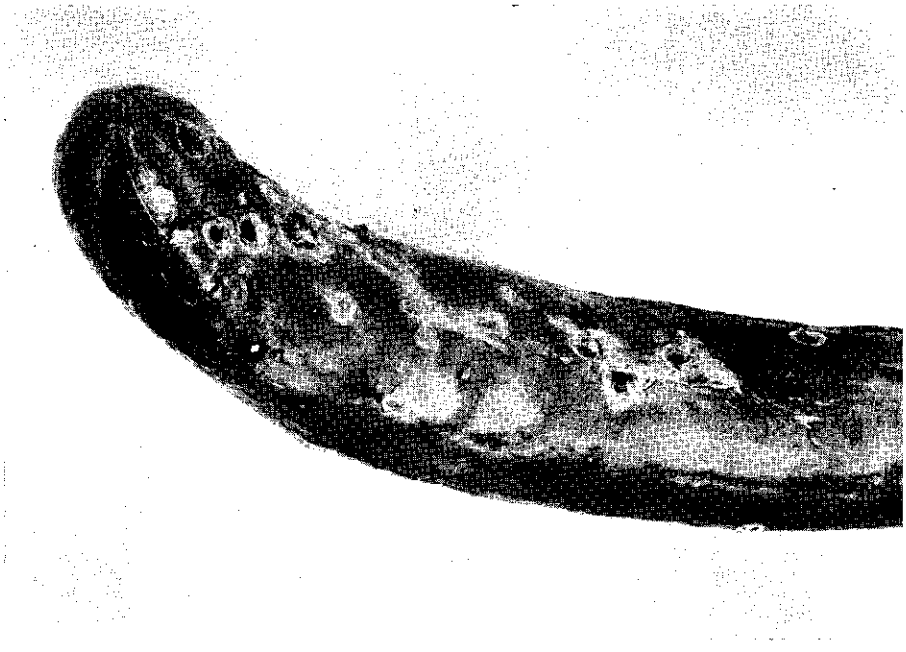

FIG. 2. CUCUMBER FRUIT AFFECTED BY SCAB. (PHOTOGRAPH TAKEN BY PROEFSTATION NAALDWIJK)

In 1931 BAILEY and BURGESS (2) of the Maine Exp. Station U.S.A. started testing a number of slicing and pickling varieties for scab-resistance. The slicing cucumber Longfellow proved to be highly resistant. Crosses with this variety resulted in the variety Maine no. 2 which was introduced in 1939 (3); the slicing cucumber Highmoor is a later introduction of the same Exp. Station.

From crosses with Maine no. 2 WALKER *et al* (10) obtained the pickling varieties *Wisconsin S.R. 6* and *Wisconsin S.R 10*, which were introduced in 1953. Further breeding work resulted in pickling varieties resistant both to mosaic and scab, amongst others *S.M.R. 12*.

In 1936 and 1937 SCHULZ and RÖDER (7), Germany, tested a large number of slicing and pickling cucumbers for scab-resistance. They reached the conclusion that only the pickling cucumber *Delikatess* is definitely field-resistant to scab. SCHULTZ (8) and MÜLLER (6) are, however, of the opinion that rigorous selection by means of artificial tests for scab-resistance should lead to uniformly resistant varieties.

In 1948 G. W. V. D. HELM, Horticultural Advisory Officer in Amsterdam started breeding a scab-resistant yellow slicing cucumber destined for gardeners in the neighbourhood of Amsterdam, who at that time only grew yellow varieties. The resistant variety Highmoor was used as a parent. From this cross the scab-resistant yellow variety *Vios* and the white variety *Mabro* were derived; both were commercialized in 1954.

In 1952 G. W. VAN DER HELM at the Exp. Garden Sloten and J. M. ANDEWEG at the Institute of Horticultural Plant Breeding, Wageningen, simultaneously started breeding green scab-resistant frame cucumbers, using Highmoor as a resistant parent. In 1955 the Experimental garden at Sloten introduced the scab-resistant green slicing cucumbers *Amato* and *Proso* while in 1956 the Institute of Horticultural Plant Breeding introduced the scab-resistant green slicing cucumber *Esvier*.

In 1953 seed of 2 first-backcross populations was supplied by the Institute to interested growers (1). At present intensive breeding for scab-resistance is also being carried out by a number of Dutch seed growers. This paper discusses the breeding work undertaken at Wageningen.

3. METHODS

According to BAILEY (2) scab-resistance depends on one dominant gene. Since the plants can be tested in a juvenile stage, a back-cross scheme can readily be carried out.

In 1952 crosses were made in a hothouse between Highmoor and Lange Groene Broei and between Eminent and Highmoor. In the same year the resulting F_1 hybrids were backcrossed to Lange Groene Broei and Eminent respectively.

In 1953, after testing the young plants, a restricted number of resistant plants of both backcross populations were planted in a hothouse. Plants of the desired fruit type were backcrossed again to Lange Groene Broei and Eminent respectively, the best plants were also selfed. In the same year the freshly produced seed was sown again. The young plants were tested for scab-resistance, after which the resistant plants grown in a hothouse and in frames were selfed.

The crosses with Eminent produced many fruits with badly developed tops. As a result it were mainly the crosses with Lange Groene Broei which were continued.

In 1954 two hothouse cultures and one frame culture were carried out. In order to get lines homozygous for the resistant gene, plants with the desired characters were selfed only. Two lines from the cross Highmoor × Lange Groene Broei, once back-crossed to Lange Groene Broei – for the present called T2 and S4 – gave a very good impression both in a hothouse and a frame.

In 1955 the best lines were again tested for scab-resistance and other characters. T2 and S4 were also tested by practical growers and judged to be very promising.

In January 1956 a licence for the production of seed of the variety S4, later called *Esvier*, was granted to 12 Dutch seed growers. In 1957 sufficient seed of this variety will be available in the trade, but further tests will be needed to show whether it is worth introducing T2 also.

4. Breeding techniques

4.1. *Crossing method.* Cucumber plants are monoecious, the female flowers being readily recognizable by the elongated ovary. Crosses can easily be made because the flowers are large. To prevent insect-pollination both the male and female flowers should be tied up before the petals have unfolded. The female flowers are pollinated at the time when they would have opened normally (fig. 3). The best results are obtained in the morning, as soon as the plants are dry. To prevent seed setting due to subsequent insect-pollination the female flowers are then tied up again. A length of

Fig. 3. Method of pollination

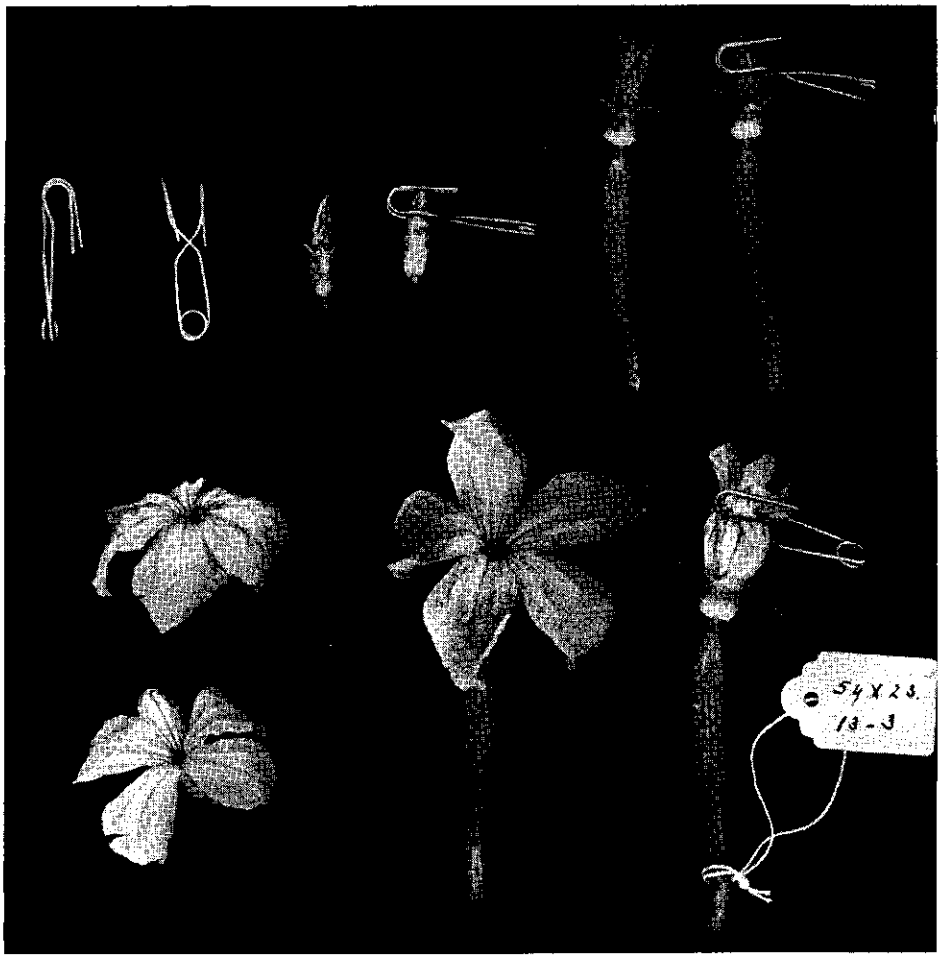

FIG. 4. UPPER PART, FROM LEFT TO RIGHT:
A CLOSED AND AN OPENED RUAP-CLIP; MALE FLOWER BEFORE OPENING, SAME FLOWER PROVIDED WITH A CLIP; FEMALE FLOWER BEFORE OPENING, SAME WITH A CLIP TO PREVENT INSECT POLLINATION.
LOWER PART, FROM LEFT TO RIGHT:
TWO OPENED MALE FLOWERS; FEMALE FLOWER FULLY OPENED; POLLINATED FEMALE FLOWER

raffia is quite effective for tying up the flower, but if many crosses have to be made it is much easier to use a Ruap clip (fig. 4). The clip was at first used in the neighbourhood of Amsterdam to fasten a cucumber scion to the *Cuc. ficifolia* rootstock. At the experimental garden at Sloten this clip proved to be very useful in pinching the flowers. After a few days the clip can be removed from the pollinated flowers. It is undesirable to remove the drying part of the flower from the young fruit, as this might inhibit further development of the fruit.

4.2. *Cuttings.* Cucumber cuttings can easily be rooted, and in our breeding work this property was used to obtain more material of promising plants. Work on plants

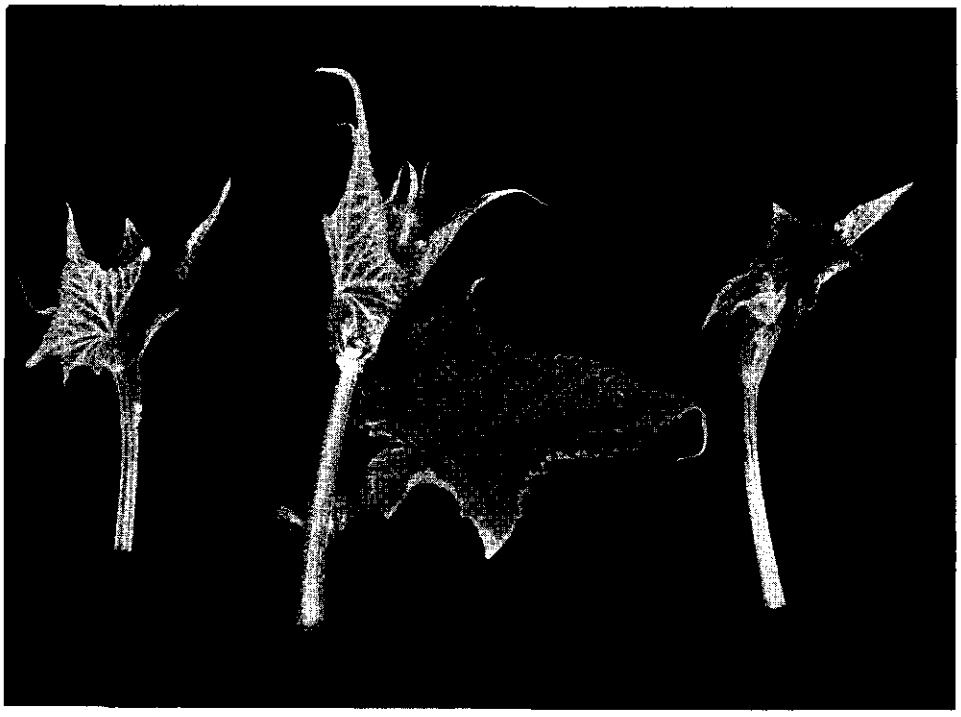

FIG. 5. CUCUMBER CUTTINGS

that have been selected in frames can be continued in a hothouse by using cuttings.

Young plant tops about 10 cm long, cut off with a sharp knife, are used as cuttings (fig. 5). The cuttings are placed slantwise in a loose, moisture-holding soil mixture at a temperature of from 25 to 30°C. The underground part of the stem should not be longer than 2–3 cm. To keep air humidity high, the cuttings are placed under a sheet of glass or plastic and sprayed regularly. They are also shaded on sunny days. After a few days the cuttings start rooting and are placed in pots after a week.

4.3. *Testing for scab-resistance.* Use has been made of the method described by WALKER (9). The plants to be tested are grown on in pots. As soon as the first normal leaf has developed properly and the second leaf has become clearly visible, the pots are placed under a very high humidity. The fungus may be cultured in tubes of agar. An aqueous suspension made of the spores can then be applied to the plants with a mist sprayer. As far as is known strains of *Cladosporium cucumerinum* do not exist, but as a precautionary measure we have always used a mixture of cultures of different origin. For the first six hours at least, air humidity should be kept at 100 %; later it is possible to aerate. The temperature should range from 15 to 20°C, the difference between resistant and susceptible plants being clearest at 17°C. After about 5 days stem tops and petioles of susceptible plants are entirely rotten, the leaves being covered with olive-coloured spores. The resistant plants are hardly affected, although small light-coloured leaf spots always occur which subsequently become more or less necrotic (fig. 6).

FIG. 6. TESTING FOR SCAB-RESISTANCE. BOTH RESISTANT AND SUSCEPTIBLE PLANTS ARE SHOWN IN THE PICTURE

It is also possible to check resistance in full-grown plants (HUBBELING, 5). To this end healthy, actively growing stem tops 15–20 cm long are placed in glass pots or bottles with water under high humidity. Resistance can be judged 5–6 days after inoculation.

4.4. *Heredity.* The number of plants used was too small to give a complete picture of the inheritance of the characters involved. However, such conclusions as may safely be drawn are given below.

Highmoor is an outdoor slicing cucumber with fruits 20–25 cm long, warted and white-spined, in unripe condition green-mottled with distinct greyish-green streaks running from the top to the middle of the fruit (fig. 7). Resistant to scab.

Lange Groene Broei and *Eminent* are frame cucumbers of which the fruits are 40–50 cm long, uniformly green, without or in a later stage with slightly light green streaks at the top, without warts, spineless (fig. 7). Susceptible to scab.

F_1 *Highmoor* × *Lange Groene Broei* and F_1 *Eminent* × *Highmoor* have dark green, mottled, warted and spined fruits with light streaks at the top (fig. 7). Resistant to scab.

Fruit length. Both F_1 hybrids between Highmoor and long frame cucumbers appeared to be long fruited. This was also the case with all plants of the first backcross populations. Consequently the fruit-length of long frame cucumbers must be dependent on one or more dominant factors. When measuring the fruit length of full-grown fruits of once selfed first-backcross populations it appeared that the number of plants

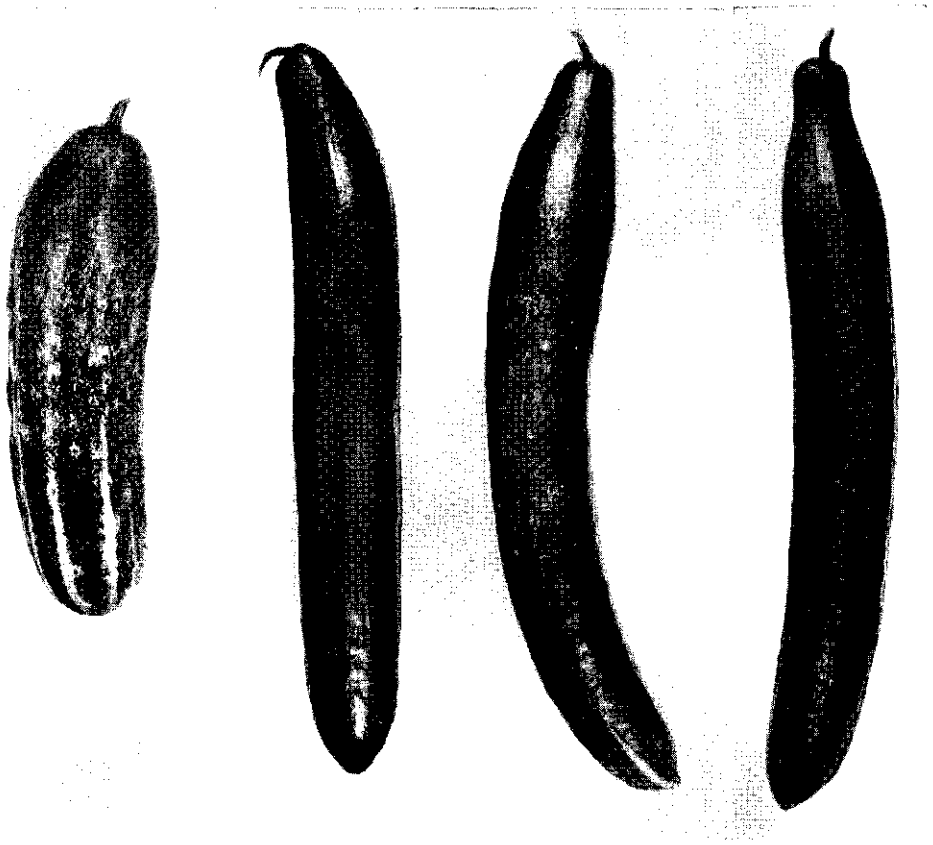

FIG. 7. FROM LEFT TO RIGHT: FRUITS OF HIGHMOOR, LANGE GROENE BROEI, F_1 HIGHMOOR × LANGE GROENE BROEI AND ESVIER

producing short fruits was very small. Eight out of 93 plants produced fruits that were, on average, shorter than 37 cm.

Outward appearance of fruit. The distinct lighter coloured longitudinal streaks and the green-mottled fruit colour of Highmoor are dominant. Half the number of plants of the two first-backcross populations produced fruits of the desired uniform green colour; the remainder produced fruits closely resembling those of the F_1. The presence of warts is dominant.

Parthenocarpic fruits. As the female flowers were pollinated regularly, no data could be collected on the inheritance of parthenocarpy. The lines so far obtained, which possess the fruit characters desired by us, all set fruit parthenocarpically.

Scab resistance. The following figures were obtained:

	Number of plants	
	Resistant	Susceptible
BACKCROSS POPULATIONS:		
(Highmoor × L. Gr. Broei) × L. Gr. Broei	52	50
(Eminent × Highmoor) × Eminent	39	63
	91	113
RESIST. PL. FROM:		
([Highmoor × L. Gr. Br.] × L. Gr. Br.) × L. Gr. Br.	36	52
([Eminent × Highmoor] × Eminent) × Eminent	93	84
	129	136
SELF-POLLINATED:		
(Highmoor × L. Gr. Br.) × L. Gr. Br. 1 × selfed	197	73
(Eminent × Highmoor) × Eminent 1 × „	90	23
	287	96

As already stated, scab-resistance depends on 1 dominant factor. From the first backcross of the F_1 (= Rr) to the susceptible parent (= rr) 50 % susceptible and 50 % resistant plants may be expected theoretically. The same is true of the 2nd backcross of resistant plants to the susceptible parent. Adding up the figures obtained for both parents we get 91:113 and 129:136.

If resistant plants from the first-backcross population (= Rr) are selfed, 3 resistant against 1 susceptible may be expected theoretically. Adding up the figures for both parents gives 287:96.

SUMMARY

Scab caused by the fungus *Cladosporium cucumerinum*, may cause serious damage to frame cucumbers. Bulbosan (trichlorotrinitrobenzene) is an effective chemical means of control. Between 1945 and 1954 this German fungicide could not be supplied, and, as a result, the need for resistant varieties became very great.

Before 1920 scab-resistance in pickling cucumbers was already known to Dutch growers. Selection started around 1920 on the initiative of W. G. v. D. KROFT and resulted in some scab-resistant pickling cucumbers of which *Baarlose Nietplekker VI* is still widely grown. In 1948 G. W. v. D. HELM (Exp. Garden at Sloten) started breeding a scab-resistant yellow slicing cucumber destined for gardeners in the neighbourhood of Amsterdam. The resistant variety Highmoor was used as one parent. In 1954 the yellow variety *Vios* and the white variety *Mabro* were introduced. In 1952 G. W. v. D. HELM at the Exp. Garden Sloten, and J. M. ANDEWEG at the Institute of Horticultural Plant Breeding, Wageningen, simultaneously started breeding green scab-resistant frame cucumbers, using Highmoor as the resistant parent. In 1955 the experimental garden at Sloten introduced the scab-resistant green slicing cucumbers *Amato* and *Proso*, while in 1956 the Institute of Horticultural Plant Breeding introduced the scab-resistant green slicing cucumber *Esvier*. In 1953 seed of 2 first-backcross populations was supplied by the Institute to seed growers. At present intensive breeding for scab-resistance is also being carried out by a number of Dutch seed growers.

Scab-resistance depends on one dominant gene; and young plants can readily be tested for resistance. Consequently a backcross scheme can easily be carried out. Rapid breeding is possible because at least 2 cultures can be carried out yearly. If necessary, cuttings of promising plants can be taken. Before and after artificial pollination the flowers can be tied up with raffia. It is simpler, however, to pinch the flowers with a special stainless clip as originally used for grafting cucumbers.

The uniform fruit colour of the Dutch green frame slicing cucumbers is a recessive character; the fruit length of the Dutch varieties is dominant.

SAMENVATTING

Het kweken van vruchtvuur-resistente platglaskomkommers in Nederland

Vruchtvuur, veroorzaakt door de schimmel *Cladosporium cucumerinum*, kan ernstige schade veroorzaken bij de platglaskomkommerteelt. Met Bulbosan (trichloortrinitrobenzeen) kan de ziekte goed bestreden worden. Tussen 1945 en 1954 kon dit middel van Duitse herkomst niet geleverd worden. Hierdoor ontstond er grote behoefte aan resistente rassen.

Vruchtvuurresistentie bij augurken was vóór 1920 reeds aan de Nederlandse telers bekend. De op initiatief van W. G. v. d. KROFT omstreeks 1920 begonnen selectie leidde tot resistente augurkenrassen, waarvan *Baarlose Nietplekker ras VI* nog steeds veel geteeld wordt. In 1948 begon G. W. v. d. HELM op de proeftuin te Sloten met het kweken van een vruchtvuurresistent geel komkommerras voor de tuinders in de omgeving van Amsterdam. Het Amerikaanse resistente ras Highmoor werd als resistent uitgangsras gebruikt. In 1954 werden het gele ras *Vios* en het witte ras *Mabro* geïntroduceerd.

In 1952 werd op de proeftuin Sloten en bij het Instituut voor de Veredeling van Tuinbouwgewassen gelijktijdig begonnen met het kweken van vruchtvuurvrije groene platglaskomkommers. Ook hierbij werd Highmoor als resistente ouder gebruikt. In 1955 introduceerde de proeftuin H.U.V. te Sloten de rassen *Amato* en *Proso*. In 1956 introduceerde het I.V.T. het ras *Esvier*. Door het I.V.T. werd in 1953 aan belangstellende selectiebedrijven zaad afgegeven van de eerste terugkruisingspopulatie; op enkele bedrijven werkt men thans ook intensief aan vruchtvuurresistentieveredeling.

Vruchtvuurresistentie berust op één dominante erffactor; jonge planten kunnen gemakkelijk kunstmatig op resistentie getoetst worden, waardoor een terugkruisingsschema gemakkelijk uit te voeren is. Er kan snel gewerkt worden daar minstens twee teelten per jaar mogelijk zijn en zo nodig van waardevolle planten gemakkelijk stekken gemaakt kunnen worden. Voor en na de kunstmatige bestuiving kunnen de bloemen met raffia dichtgebonden worden. Nog eenvoudiger is dichtknijpen met een speciale roestvrije clip, die oorspronkelijk gebruikt werd bij het enten van komkommers.

De uniforme vruchtkleur van de Nederlandse groene platglaskomkommers erft recessief over, de lengte van de Nederlandse rassen erft dominant over.

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29-11-'50. Uitslag Practijkproeven Bak- en Zomerwortelen 1949–1950.
29-11-'50. Uitslag Practijkproeven Platronde en Ronde Kroten 1949–1950.
22-12-'50. Uitslag Practijkproeven Pronkbonen 1950.
11- 3-'51. Uitslag Practijkproeven Westlandse Boerenkool 1949–1950.
3- 9-'51. Uitslag Practijkproeven Spitskool 1950–1951.
7-12-'51. Uitslag Practijkproeven Flakkeese Winterwortel 1950–1951.
23- 1-'52. Uitslag Practijkproeven Vroege en Herfst Rodekool 1950–1951.
31- 3-'52. Uitslag Practijkproeven Spruitkool 1950–1951.
4-11-'52. Uitslag Practijkproeven Ronde Rode Radijs 1951–1952.
4-11-'52. Uitslag Practijkproeven Vroege Rijspeulen 1951–1952.
25-11-'52. Uitslag Practijkproeven Lange Kroten 1951–1952.
23- 1-'53. Uitslag Practijkproeven Radijs Ronde Scharlakenrode Extra Kortloof 1951–1952.
13- 5-'53. Uitslag Practijkproeven Bewaar Rode Kool 1951–1952.
10- 9-'53. Uitslag Practijkproeven Vroege Witte Kool 1952–1953.
18-12-'53. Uitslag Practijkproeven Herfst Witte Kool 1952–1953.
3- 6-'54. Uitslag Practijkproeven Bewaar Witte Kool 1952–1953.
17-11-'54. Uitslag Practijkproeven Stoksnijbonen 1953–1954
2-12-'54. Uitslag Practijkproeven Ronde Rode Witpunt Radijs 1953–1954.
12- 2-'55. Uitslag Practijkproeven Knolselderij 1953–1954.
1- 9-'55. Uitslag Practijkproeven Vroege Groene Savoye Kool 1954-1955.
14-11-'55. Uitslag Practijkproeven Tomaten 1954-1955.
27 12-'55. Uitslag Practijkproeven Witlof vroege trek 1954-1955.
2-3-'56. Uitslag Practijkproeven Witlof middelvroege trek 1954-1955.
5-3-'56. Uitslag Practijkproeven Schorseneren 1954-1955.
28- 5-'56. Uitslag Practijkproeven Savoye Kool 1954-1955.
28- 5-'56. Uitslag Practijkproeven Witlof koude kuil en meilof 1954-1955.
30- 7-'56. Uitslag Practijkproeven Tuinbonen 1955-1956.
1- 9-'56. Uitslag Praktijkproeven Amsterdamse Bakwortel 1955-1956
1- 9-'56. Uitslag Praktijkproeven Vroege Rode Kool 1956
1- 9-'56. Uitslag Praktijkproeven Platronde Kroten 1955-1956

Zijn geplaatst in diverse tuinbouwbladen.

RASSENLIJSTEN [1])
UITGEGEVEN DOOR HET INSTITUUT VOOR DE VEREDELING VAN TUINBOUWGEWASSEN

Achtste Beschrijvende Rassenlijst voor Fruit. 1957. . . f 1,75

Achtste Beschrijvende Rassenlijst voor Groentegewassen. 1956. Redacteur Dr. O. Banga . . . . . f 1,75

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Jaarverslag 1950. 1 (1951) . . . . . Uitverkocht

Jaarverslag 1951–1952. 2 (1954) . . . . . f 3.50

PUBLIKATIES VAN HET INSTITUUT VOOR DE VEREDELING VAN TUINBOUWGEWASSEN IN ANDERE ORGANEN OF IN BOEKVORM EVENTUEEL IN SAMENWERKING MET ANDERE INSTELLINGEN [2])

De publikaties, waarvan prijs èn uitgever worden vermeld zijn verkrijgbaar in de boekhandel. Overigens wende men zich tot de opgegeven bronnen of tot de bibliotheek van het I.V.T.

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[1]) Zolang de voorraad strekt kunnen deze publikaties franco worden toegezonden, na ontvangst van het vermelde bedrag op giro no. 425340 van het Instituut voor de Veredeling van Tuinbouwgewassen, S. L. Mansholtlaan 15 te Wageningen onder vermelding van wat verlangd wordt; ook bestaat de mogelijkheid deze publikaties uit de bibliotheek van het I.V.T. te lenen.

[2]) Eerder verschenen publikaties zijn vermeld achterin in de Mededelingen nos 1 t/m 70.

DRUK: H. VEENMAN EN ZONEN, WAGENINGEN