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DR. IR. W.A. WIEBOSCH en IR. J. BERGHOEF

PARTHENOCARPIC FRUITING IN PICKLING
CUCUMBER INDUCED BY CHLORFLURENOL

W.A. Wiebosch and J. Berghoef*

Research Station for the Fieldproduction of Vegetables, Alkmaar
(The Netherlands)

Abstract

Chlorflurenol (methyl-2-chloro-9-hydroxyfluorene-(9)-carboxylate) is a morphactin that induces parthenocarpic fruitset in pickling cucumber. This enables to eliminate the unfavourable effect of pollination on the number and size of the fruits produced by a once-over harvested crop. The characteristic fruiting habit of such a crop results in only 2-3 gherkins on a plant of a rather unfavourable size.

In some greenhouse experiments 7-11 fruits per plant were gained from 40-60 ppm a.i. of the methylester of chlorflurenol, applied once between one and three weeks after the begin of flowering. The number of fruits is dependent on the prevailing temperature and the number of induceable flowers present at the time of application. By atomizing 100 ppm a.i. of the chemical to 500 l solution per ha on a closed trailing crop resulted in 13 fruits per plant with an average fruit weight of 23 gram. The majority of the gherkins belonged to the most desired gradings.

Although these results are very promising for the mechanical once-over harvesting, it still remains to be proved in fieldexperiments, which will also be carried out by our research station.

The chemical is neither acute nor chronically poisonous to man and animals.

1. Introduction

The pickling cucumber requires pollination for its fruit setting. The characteristic fruiting habit of this crop generally results in only 2-3 gherkins on a plant, if harvested once-over. The small yield in the desired gradings is the major stumbling block for once-over mechanical harvesting of this crop (1, 5, 6).

* present address : Department of Plant Physiology, Agricultural University, WAGENINGEN (Neth.)

However, early in 1973 Barrett and Amling (1) suggested that "the machine harvest may be just around the corner" ! They based their statement on result obtained with the application of chlorflurenol (methyl-2-chloro-9-hydroxyfluorene-(9)-carboxylate) causing parthenocarpy in this crop. Their result and those of others (3, 4, 7, 8) indicated that the number of fruits produced per plant depends on several factors as the sex expression of the cultivar, the stage of development at the time of application and the concentration, the temperature, the absence or presence of pollination, etc. For that reason we started in 1973 with the testing of chlorflurenol in some experiments in the greenhouse.

2. Methods and materials

Two experiments were carried out with climbing plants growing in Mitscherlich vessels and one experiment with a trailing crop grown in the soil of the greenhouse. All the experiments were made with the preponderate gynocious cv. "Kora" hybrid.

The climbing plants were sprayed to run off with solutions of 20, 40 or 60 ppm a.i. of the methylester of chlorflurenol (formulation EMD-7301 W) in tap water, or with the Na-salt of chlorflurenol (formulation CME-73103 P). These morphactins have been developed by the Merck Research Group and CELAMERCK respectively. The methylester was formerly known under the code-name EMD-IT3456 (9).

The solutions were applied with a hand sprayer in three manners :

1. spraying the whole plant.
2. spraying only the upperside of the leaves to run off.
3. spraying only the inflorescences (buds, full bloom and overblown flowers) and an adjoining part of the petiole and the vine (stem).

Spraying the whole plant was performed with the methylester once or twice in May and June. The stages of development ranged from the 4th true leaf to a stage three weeks after the begin of flowering. The treatments of only the leaves or only the inflorescences with adjoining parts were performed once with the methylester and the Na-salt seperately, both 10 and 14 days

after the begin of flowering (September). The trailing crop was treated only once with the methylester varying from 50-125 ppm a.i. by atomizing or spraying to 500 or 800 l solution per ha respectively (September). These treatments were carried out 13 days after the begin of flowering. In both of the September trials the main vine started with male flowering. The first female flowers appeared from the 7th - 9th internode on. Branches flowered almost completely female. In all the experiments the plants have been harvested once-over after the largest fruit of most of the plants had developed to grading D-fine (3.6 - 4.5 cm \emptyset). The time between application and harvest mostly varied from 10 - 15 days.

3. Results

3.1. Spraying the whole plant

The number of fruits produced per plant after spraying the whole plant once with the methylester is given in table 1. The number produced after spraying twice is given in table 2 and 3. In the latter series the highest and lowest concentrations were changed at the second application, aiming to bring broadly the same quantity of the chemical upon all the plants of that series. Every figure in the tables represents the average of three plants. The figures between brackets are the number of misshapen fruits.

From table 1 it is clear that the effect of a concentration on the number of fruits produced and the difference in effect between the concentrations under investigation are dependent on the stage of development at the application. The effect of each of these concentrations increased from the 4th or 6th leaf stage to a maximum at two or three weeks after the begin of flowering. Applied later did not changed essentially the number of harvestable fruits. A second spraying after one week or more with the same or with a complementary concentration did not improved the results or even reduced the number of fruits (table 2 and 3) compared with a single application.

The difference between the results presented in table 2 and 3 can be caused by the larger interval between the first and second spraying. The second

TABLE 1. Number of fruits developed * per plant after spraying the whole plant once with the methylester

Chlorfluoreno ppm a. i.	Stage of application					
	4th leaf	6th leaf	begin of flowering	1 week later	2 weeks later	3 weeks later
20	0.0	0.3 (0.3)	1.7 (0.3)	4.7 (0.7)	6.0 (1.7)	5.3 (1.6)
40	0.0	1.0 (1.0)	3.0 (1.0)	5.0 (0.3)	7.0 (3.3)	7.0 (2.0)
60	0.3 (0.0)	0.7 (0.7)	4.7 (1.3)	6.7 (0.7)	7.3 (4.3)	7.7 (3.3)
untreated	0.0 - 2.0 (pollination ?)					

* Fruits > 7 mm Ø but shorter than 4 cm are left aside at harvest

TABLE 2. Number of fruits developed per plant by spraying the whole plant twice with the methylester

Chlorflurenol ppm a.i.	Stage of application		
	begin flowering + 1 week later	weeks after begin flowering	
		1 and 2	2 and 3
20	4.3 (1.7)	5.0 (2.8)	8.6 (5.3)
40	3.7 (1.3)	6.7 (2.7)	7.7 (4.7)

TABLE 3. Number of fruits developed per plant by spraying the whole plant twice (interval 9 - 11 days) with the methylester

Chlorflurenol ppm a.i.	First stage of application				
	4th leaf*	6th leaf*	begin of flowering	1 week later	2 weeks later
20/60	7.0 (3.7)	3.7 (1.0)	3.7 (1.0)	3.3 (0.3)	7.0 (4.0)
40/40	2.7 (1.3)	2.7 (1.0)	2.3 (1.3)	4.0 (1.0)	3.3 (1.0)
60/20	3.0 (1.3)	4.3 (2.0)	3.0 (0.7)	4.0 (1.7)	5.7 (2.7)

* second application after 15 days

application mainly enhanced the number of misshapen fruits compared with a same number of harvestable fruits in table 1. As far as the number of fruits increased by spraying twice, the number of misshapen fruits mostly increased stronger in this experiment (table 2).

3.2. Spraying the leaves or the inflorescences

Two series of climbing plants were sprayed once in these different manners with the methylester or with the Na-salt of chlorflurenol. The series were sprayed 10 or 14 days after the begin of flowering (started with male flowers).

The yields have been determined 16 or 12 days after the application respectively. The number of harvestable fruits per plant obtained from the various treatments is presented in table 4. Fruits larger than 0,7 cm diameter but shorter than 4 cm were not included in the yield.

The figures in table 4 clearly indicate that the application to the inflorescences was more effective than to the leaves. This holds true for both the methylester and the Na-salt. The methylester was more effective than the Na-salt, both on the leaves and on the inflorescences. On the latter the ester reached already its maximum effect at 40 ppm a.i.

On the leaves it was not yet reached at 60 ppm.

The effect of the Na-salt sprayed on the leaves was very small with no difference between the concentrations. Sprayed on the inflorescences the concentration of the Na-salt did not display a maximum effect. The number of fruits per plant in each diameter grade after spraying with the methylester is given in table 5.

This table demonstrates that the increase in number is contributed mainly by the smaller grades. By spraying the inflorescences, the increase was spread over more grades than by spraying only the leaves.

TABLE 4. Number of fruits developed per plant* by spraying the leaves or the inflorescences with different concentrations of the methylester or the Na-salt of chlorflurenol

Chlorflurenol compound	Concentration ppm a.i.	leaves sprayed on		inflorescences sprayed on	
		17/9	21/9	17/9	21/9
methylester	0	4.3	3.7	4.3	3.7
	20	5.3	5.7	8.3	4.0
	40	7.0	6.7	10.0	11.3
	60	7.3	9.3	10.0	9.3
Na-salt	20	5.3	5.3	6.7	7.7
	40	5.0	4.7	4.3	8.0
	60	5.0	5.0	7.7	5.3

* every figure mean of 3 plants

TABLE 5. Number of fruits per plant obtained in each diameter grade after spraying with methylchlorflurenol

Concentration ppm a.i.	leaves					inflorescences				
	A	B	C	D-fine	Total	A	B	C	D-fine	Total
0	1.8	0.5	0.7	1.0	4.0	1.8	0.5	0.7	1.0	4.0
20	3.3	1.0	0.2	1.0	5.5	3.5	0.7	1.3	0.6	6.1
40	4.1	1.2	0.6	0.9	6.8	7.3	1.3	1.5	0.5	10.6
60	5.5	1.5	0.8	0.5	8.3	6.6	1.3	0.2	0.5	9.6
grading Ø cm	0.7- 2.4	2.4- 3.0	3.0- 3.6	3.6- 4.5	Total	0.7- 2.4	2.4- 3.0	3.0- 3.6	3.6- 4.5	Total

TABLE 6. Number of fruits and total weight per plant* obtained by atomizing (500 l) or spraying (800 l) the methylester on a trailing crop

Methyl- ester ppm a.i.	Number of fruits						Weight (gr)			
	main-vine		branches		total		total/plant		mean fruit weight	
	500	800	500	800	500	800	500	800	500	800
0	1.9	-	1.7	-	3.6	-	72	-	20.0	-
50	-	2.0	-	3.3	-	5.3	-	117	-	22.0
75	3.3	3.8	7.5	4.3	10.8	8.1	221	165	21.0	20.0
100	4.4	2.1	8.3	5.5	12.7	7.6	299	155	23.0	20.0
125	4.1	-	9.2	-	13.3	-	193	-	15.0	-

* average of 9 or 25 plants with 500 or 800 l solution per ha respectively

3.3. Spraying or atomizing on a trailing crop

Thirteen days after the begin of flowering concentrations of 50 - 125 ppm a.i. of the methylester were sprayed or atomized to a volume of 800 or 500 l solution per ha respectively. Several treatments resulted in an important increase of the number of fruits produced. In table 6 the number of fruits obtained from the main vine or from the branches and the total number per plant are presented.

By atomizing to 500 l/ha more fruits were produced than by spraying to 800 l with the same concentrations. In both cases the branches produced more fruits than the main vine. This feature must be attributed to the initial male flowering of that vine.

The treatments with the atomized solutions naturally yielded an important larger total weight than the normally sprayed ones. The mean fruit weight of the various treatments differed but little from the check plants, except 125 ppm being markedly smaller.

The number of fruits produced by the checkplants in this experiment agreed very well with that in the previous one. But, also the numbers from spray-

ing or atomizing agreed rather well with the numbers obtained per plant by spraying the leaves or the inflorescences respectively in the previous experiment.

In both experiments hardly any deformed fruits occurred in contrast to the earlier one. This difference may be caused by the temperature. It is known from literature (2) that moderate temperatures ($\pm 17^{\circ}\text{C}$) are favourable for parthenocarpic fruit set. This tendency is reduced to nil with the increase of the temperature. In the experiment discussed firstly, the daily temperature in June got very high, up to 35°C . This had reduced undoubtedly the intensity of the parthenocarpic growth, causing deformed fruits.

4. Some conclusions and additional remarks

- . Our greenhouse experiments confirmed the favourable effect of the morphactin Chlorflurenol on the parthenocarpic fruiting in pickling cucumber as reported by some American investigators (1, 3, 4). It enables to eliminate the unfavourable effect of pollination on the number and size of fruits produced by a once-over harvested crop. The maximum effect can be expected from gynocious cultivars without a pollinator.
- . In the experiment with the trailing crop in the greenhouse, the best two treatments yielded 260 gram per plant on the average of fruits between 0.7 - 4.5 cm diameter. At the plantdensity (40.000 plants/ha) used in that experiment, this production equals with a yield of some 10 tons/ha. At a plantdensity of 100-125.000 plants per ha, being rather low for a once-over harvested crop, a production of at least 15-20 tons of this grade can be expected. This result would be very promising for the mechanical once-over harvesting. It still remains to be proved in field experiments, which will be carried out this year in our research station.
- . A general feature of the treatment is a temporary loss of the antigeotropism of the tops of the vines. The leafblade of the fullgrown leaves displayed some epinasty, the outer part of the younger leaves on the contrary curled up. The degree of these effects was larger the higher the concentration. These symptoms remained during the further part of the growing period.

- . The number of parthenocarpic fruits developing per plant is dependent on the number of inducible ovaries. We have established that the ovaries of the flowers in full bloom on the day of application, which flowered one and two days before as well as those that will flower to-morrow and to-morrow next are inducible. Of the last category more ovaries are inducible than of overblown flowers. The condition of the plant in which the number of inducible ovaries is greatest will yield the highest number of fruits from a treatment with chlorflurenol.

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Samenvatting

Parthenocarpe vruchtzetting bij augurk teweeggebracht door chloorflurenol

Bij augurk is bestuiving nodig voor de vruchtzetting. Als het gewas in één keer wordt afgeoogst, worden slechts 2 - 3 vruchten per plant verkregen. Daarom is de opbrengst aan vruchten van de meest gewenste sorteringen laag, wat het voornaamste struikelblok is voor de toepassing van éénmalig machinaal oogsten bij de vollegrondsteelt.

Chloorflurenol (methyl-2-chloro-9-hydroxyfluoreen-(9)-carboxylaat) is een morphactine, die parthenocarpe vruchtzetting bij augurk teweegbrengt. In enige kasproeven zijn bij de overwegend vrouwelijk bloeiende cv "Kora" hybride door éénmalige bespuiting met 40 - 60 dpm a.i. methyl-chloorflurenol, uitgevoerd tussen één en drie weken na het begin van de bloei 7 - 11 vruchten per plant verkregen. Dat aantal hangt af van de heersende temperatuur en het aantal induceerbare bloemen, dat op het tijdstip van de bespuiting aanwezig is. Door vernevelen van 100 dpm a.i. van het middel naar 500 l oplossing per ha op een kruidend gewas, werden 13 vruchten per plant verkregen. Het merendeel daarvan behoorde tot de meest gewenste sorteringen met een gemiddeld vruchtgewicht van 23 gram. Het middel is noch acuut, noch chronisch giftig voor mens en dier. De vermelde resultaten zijn veelbelovend voor de (mechanische) éénmalige oogst van augurken. Ze zullen echter eerst nog moeten worden bevestigd in veldproeven, die als vervolg op dit onderzoek worden uitgevoerd.