

Effect of morphactin IT 3456 (methyl-2-chloro-9-hydroxyfluorene-(9)-carboxylate) on parthenocarpic fruit development of tomatoes

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Abstract

It was found that parthenocarpy could be induced by morphactin IT 3456 (0.5 and 1 ppm) in prior emasculated flowers, those left to free-pollination and even flowers pollinated with the pollen of control plants (New Yorker). When morphactin IT 3456 in 0.5 and 1 ppm concentrations was used 88% and 100% of parthenocarpy was noted in the greenhouse, respectively (Earliest of All).

The highest percentage of parthenocarpy in the total number of fruits in the field was recorded in the 'New Yorker' variety. The lowest percentage of parthenocarpy was observed in the variety 903.

The symptoms of the destructive influence of morphactin IT 3456 (0.5 and 1 ppm) on plant development were noted, but they were stronger in the greenhouse than in the field.

INTRODUCTION

Morphactins are new groups of growth regulators synthesized in the period 1960-1963 by the Research Laboratories E. Merck AG, Darmstadt in the German Federal Republic (Technical data sheet, 1965, E. Merck AG). These compounds are taken up by plants via leaves or roots and act effectively at very high dilutions.

The movement of morphactins in plants has not, as yet, been clarified, however, accumulation in meristematic tissues seems to take place to a certain extent (Maciejewska-Potapczykowa 1970).

Among many effects of morphactins, the influence retarding the apical buds development and disturbing the phototropism of shoots and the geotropism of roots should be mentioned; when applied at the right

stage of growth, they also inhibit the formation of flowers and in certain species induce parthenocarpy (Khan 1967; Schneider 1964, 1970).

The purpose of this paper was to determine the influence of morphactin IT 3456 treatments on parthenocarpic fruit development of four tomato varieties in different conditions of pollination. Besides, the investigation included some observations on morphological changes in shoots, leaves and flowers of tomatoes effected by morphactin IT 3456.

MATERIALS AND METHODS

Experiment I

The experiments were carried out on the 'Earliest of All' and 'New Yorker' tomato varieties in the greenhouse.

The plants were grown in pots ϕ 16 cm in standardized soil. After the development of two leaves, the seedlings were fed weekly with 150 ml/pot of nutrient solution containing about 0.15 g ammonium nitrate; 0.30 g superphosphate and 0.40 g potassium sulphate.

Morphactin IT 3456 was dissolved in 2-3 ml of ethanol and used in the form of foliage sprays in 0.001% Tween 20 solution. The control plants were treated with 0.001% Tween 20 solution with 2-3 ml of ethanol added.

During the vegetation of tomato plants, the temperature in the greenhouse was kept at the level of 22-25°C in the daytime and of 15-17°C at night.

The 'Earliest of All' variety was treated with IT 3456 twice in two separate combinations with solutions of 0.5 and 1 ppm concentration. For each treatment 7 plants were used.

The first spraying was done about 7 days before the blooming of the first cluster (5 IV) and the second at the time when the third cluster bloomed (20 IV).

The 'New Yorker' variety was treated with IT 3456 once in 0.01; 0.1; 0.5 and 1 ppm concentrations, 5-6 days before the blooming of the first cluster (2 XII). The number of plants in every treatment was 10-15.

The 'Earliest of All' variety was left to free-pollination, however, in the 'New Yorker' variety only some flowers were emasculated, and the rest was used for crossing the plants treated with IT 3456 with control plants. Crossing was supposed to determinate in vivo the pollen ability for fertilization in treated and untreated plants.

Crossing of plants was begun on the third day after morphactin spraying and it was continued usually every second day for the subsequent four weeks, that is, till the moment of probable decline of morphactin activity. Pollination was carried out with fresh pollen collected from flowers (a few plants) situated in the same clusters.

At harvest time, the fruits of both varieties were counted and the total number, as well as the number of parthenocarpic fruits were determined.

Experiment II

The experiments were carried out on four varieties of tomatoes: 'New Yorker', '903'*, 'Mory 33' and 'Earliest of All' under conditions of free-pollination in the field. The investigated varieties differ first of all in the length of the growing season, the type of growth and the shape and size of fruit. The dwarf 'New Yorker' variety is characterized by the shortest period of vegetation, but '903', also dwarf, is the latest. 'Mory 33' (dwarf) and 'Earliest of All' (middle high) are later than the 'New Yorker' variety. It is worth noting that the '903' variety differs from the others by a very strong set of fruit.

Tomato seedlings were prepared in sowing boxes in a greenhouse and after the development of cotyledones they were transferred to the field in the stage of about four leaves on the Experimental Farm, Felin—Lublin, 20 V 1972. The cultivation procedure and soil nutrition were conducted according to the accepted agrotechnical rules.

IT 3456 was used twice in 0.25; 0.5 and 1 ppm concentrations in the same way as in Experiment I. The first spraying was done at the time when the plants had flower buds on their first cluster (30 V). The second spraying took place after the individual flowers had bloomed on the third or fourth cluster depending on the variety (17 VI).

Experiments were carried out by random block design in four replications. Individual plots included 9 plants (80×60 cm). At the time of harvest the fruits were counted and weighed, the total number of fruits, the number of parthenocarpic fruits and the average weight of one fruit were also recorded.

As parthenocarpic the following fruits were considered: those which did not include seeds at all (complete parthenocarpy) and fruits which did not have seeds at least in one chamber (partial parthenocarpy).

RESULTS

Total number of fruits and the average weight of one fruit

As seen from Table 3, the '903' and 'New Yorker' varieties treated with IT 3456 (0.25; 0.5 and 1 ppm) in the field produced more fruits than those untreated. Under the same conditions of growth the 'Earliest of All' and 'Mory 33' varieties treated with IT 3456 developed less fruits than the untreated ones. Besides, a decrease in the total number of

* The author of this variety is R. W. Robinson, Geneva, New York.

Table 1

Parthenocarpy of fruit as % total number of fruits in the 'Earliest of All' variety treated with morphactin IT 3456 in the greenhouse. (Data for seven plants)

Dose of morphactin IT 3456 (ppm)	Total number of fruits (in brackets number of fruits with blossom-end rot)	Parthenocarpy as % of total number of fruits
0.0	82 (0)	0.0
0.5	61 (2)	88.2
1.0	30 (15)	100.0

fruits under the influence of morphactin (0.5 and 1 ppm) was observed in the 'Earliest of All' variety in the greenhouse (Table 1).

When the average weight of a single fruits from the varieties treated with morphactin in the field is analysed, first of all, a decrease of the mean weight of one fruit in the 'New Yorker' variety is noted. Similar tendencies, but to a smaller extent exist in the 'Earliest of All' variety.

The average weight of one fruit in '903' and 'Mory 33' is similar to that of control plants (Table 3).

Parthenocarpy of fruits

On the basis of Table 1 the conclusion may be advanced that IT 3456 applied twice in 1 ppm concentration, evoked 100% parthenocarpy in the 'Earliest of All' variety in conditions of free-pollination in the greenhouse. A very high percentage (88.2) of parthenocarpy in the experiments was found in the plants treated with morphactin in a 0.5 ppm concentration.

Parthenocarpy was observed in the 'New Yorker' variety treated with IT 3456 (0.5 and 1 ppm) in the greenhouse. It involved both the exclusively emasculated flowers and in many cases flowers pollinated with pollen from control plants (Table 2). It is worth mentioning that, in the flower buds situated on the second and third clusters in the plants treated with IT 3456 (0.5 and 1 ppm), the ovary developed very fast. At the same time the development of anthers was inhibited. The latter they usually contained very little or no pollen, even after the flowers had opened. Three to four weeks after spraying there came a gradual decrease of the destructive effect of morphactin used in 0.5 and 1 ppm concentrations.

The plants treated with IT 3456 in 0.01 and 1 ppm concentrations developed over the entire vegetation season, flowers with viable pollen what is proved by the positive results of crosses with control plants (Table 2).

Table 2

Results of crosses of some tomato plants ('New Yorker' variety) treated with the morphactin IT 3456 and untreated ones

No.	Kind of crosses (Nos 1-7) and flowers unpollinated after emasculation (Nos 8-12). In brackets — morphactin IT 3456 dose in ppm	Total number of crosses and of flowers subjected only to emasculation	Total number of developed fruits	
			normal fruits	parthenocarpic fruits
1	♀ (0.0) × ♂ (0.0)	25	20	—
2	♀ (0.01) × ♂ (0.0)	47	40	—
3	♀ (0.1) × ♂ (0.0)	34	28	2
4	♀ (0.5) × ♂ (0.0)	23	3	12
5	♀ (1.0) × ♂ (0.0)	17	1	11
6	♀ (0.0) × ♂ (0.01)	31	25	—
7	♀ (0.0) × ♂ (0.1)	28	23	—
8	♀ (0.0)	21	—	—
9	♀ (0.01)	13	—	—
10	♀ (0.1)	18	—	2
11	♀ (0.5)	14	—	12
12	♀ (1.0)	10	—	8

Pollen from control plants exhibited fertilization ability both in the case of self-pollination and when put on the stigma of pistil of plants treated with IT 3456 in 0.01 and 0.1 ppm concentrations (Table 2).

Among the four varieties examined in the field, the highest percentage of parthenocarpy was noted in 'New Yorker'. In this variety it was found that under the influence of IT 3456 (1 ppm) 25.4% of fruits had no seeds, and in about 38% of fruits partial parthenocarpy was observed (Table 3). When comparing other varieties it was noticed that the highest percentage of parthenocarpy in the 'New Yorker' also occurred in the case of morphactin treatments in concentrations 0.5 and 0.25 ppm. Contrary to the presented results, in the '903' variety parthenocarpy appeared sporadically. Morphactin spraying (1 ppm) caused complete parthenocarpy in about 3% of the total number of fruits of this variety and partial parthenocarpy in about 4% of all fruits. Parthenocarpy of fruits in the 'Earliest of All' and 'Mory 33' varieties sprayed twice with IT 3456 in the field was also rare (Table 3).

Morphological changes in the growth of tomato plants caused by morphactin IT 3456 treatment

IT 3456 used in the greenhouse in 0.5 and 1 ppm concentrations caused considerable deformations of plants in the 'New Yorker' and

Table 3

Percentage of fruits containing no seeds (complete parthenocarpy) and having few seeds (partial parthenocarpy) in the total number of fruits and average weight of one fruit in four tomato varieties treated with morphactin IT 3456 in the field (Experimental Farm Lublin — Felin, 1972). Mean for nine plants

Dose of morphactin IT 3456 in ppm	'New Yorker'				'Earliest of All'				'903'				'Mory 33'			
	Total number of fruits*	Parthenocarpy as % of total number of fruits		Average weight of one fruit in g	Total number of fruits*	Parthenocarpy as % of total number of fruits		Average weight of one fruit in g	Total number of fruits*	Parthenocarpy as % of total number of fruits		Average weight of one fruit in g	Total number of fruits*	Parthenocarpy as % of total number of fruits		Average weight of one fruit in g
		par-tial	com-plete			par-tial	com-plete			par-tial	com-plete			par-tial	com-plete	
0.00	369.0	7.8	1.8	82	140.3	0.3	0.9	42	626.3	1.5	0.2	42	63.8	19.7	2.6	47
0.25	433.8	40.3	7.6	67	918.5	4.0	2.6	42	773.3	1.3	0.8	38	515.3	36.2	4.8	50
0.50	504.3	48.3	12.0	59	911.3	5.9	2.9	36	176.5	4.6	2.7	42	625.5	36.2	5.2	47
1.00	380.3	37.6	25.4	68	885.3	6.0	7.3	37	923.3	3.9	3.4	40	529.0	29.4	8.8	45

* Differences nonsignificant at $p = 0.05$ and 0.01 .

'Earliest of All' varieties, visible in the form of twisted stems and leaf petioles, seasonal blight on all plants and frequent abscission of flower buds. Besides, in the 'New Yorker' variety four weeks after the single morphactin spraying (1 ppm), development of potato leaves, unknown in this variety was observed. It is noteworthy that some parthenocarpic fruits in 'New Yorker' and 'Earliest of All' varieties treated with IT 3456 (0.5 and 1 ppm) in the greenhouse underwent marked deformation and blossomend rot was noticed.

Morphological development disorders in plants treated with IT 3456 (0.5 and 1 ppm) were observed in field experiments as well. Yet, the degree and extent of their occurrence were much smaller than in the greenhouse.

The reaction of the particular varieties upon morphactin application in the same concentration was different. The most conspicuous symptoms of damage to the plants (partial blight and flower buds abscission) occurred in the 'Mory 33' variety treated with IT 3456 in 1 ppm concentration. However, in the varieties 'Earliest of All' and 'New Yorker', apart from partial leaf blight, fruit deformation and occurrence of blossomend rot (mainly during the first harvest) was observed. Only in the '903' variety, the symptoms of the destructive effect of IT 3456 in the field were almost invisible.

DISCUSSION

Schneider (1964) was the first to notice parthenocarpy in tomato flowers after their prior emasculation. Robinson et al. (1971) found that morphactin IT 3456 treatments induced parthenocarpy in cucumbers (Wisconsin SMR 18) developing fruits with normal seeds in natural conditions.

The data obtained in this paper showed that morphactin IT 3456 (0.5 and 1 ppm) used in the form of foliage sprays, once or twice, stimulates the development of parthenocarpic fruits both in flowers only emasculated and in flowers left to free-pollination.

Parthenocarpic development of the ovary was noticed in many cases in flowers of plants treated with IT 3456 (0.5 and 1 ppm) even after they had been pollinated with pollen from control plants (Table 2). It leads to the supposition that the lack of fertilization in the flowers left to free-pollination after morphactin application could be due not only to the underdeveloped pollen, but also to its unnormal development or complete inhibition of its germination.

Among the morphogenetic and physiological changes caused by morphactins having a connection with the above discussed results, disorder in normal meiotic cells division and in translocation as well as in auxins

and kinins synthesis should be mentioned (Pieniążek and Saniewski 1967). These compounds, like gibberelins, take part in the mechanism of the parthenocarpic ovary development in many plants (Audus 1959; Black and Edelman 1970; Crane 1964; Listowski 1970; Maciejewska-Potapczykowa 1967).

The parthenocarpy occurring in emasculated but non-pollinated tomato flowers from plants treated with morphactin (0.5 and 1 ppm) indicates that this phenomenon can also be considered from the point of view of the physiological changes taking place in the ovary itself, without the help of the growth regulators situated in the pollen grains or pollen tubes.

As seen from Table 3, the percentage of parthenocarpy in relation to the total number of fruits in the examined tomato varieties underwent considerable fluctuation depending, to a great extent, on the concentration of morphactin solutions. When comparing the morphactin-treated plants of the 'New Yorker' and '903' varieties in conditions of free-pollination with the control plants one can notice an increase of the total number of fruits. On the contrary, in the 'Mory 33' and 'Earliest of All' varieties, a decrease of the total number of fruits from the plants treated with this compound is visible. It seems possible that the differences in the discussed results can be interpreted on the basis of the double influence of morphactin on the process of fruit development as shown in greenhouse experiments (Table 2). Probably, on the one hand, by inhibiting pollen germination, morphactin had a negative effect on fruiting in conditions of free-pollination ('Mory 33' and 'Earliest of All' varieties). On the other hand, stimulating the parthenocarpic development of the ovary, in the same conditions of free-pollination in the field, it influenced profitably the number of developed fruits '903' and 'New Yorker' varieties) — Table 3.

SUMMARY AND CONCLUSIONS

Experiments on the parthenocarpy of tomatoes treated with morphactin IT 3456 were carried out in the greenhouse ('Earliest of All' and 'New Yorker' varieties) and in the field ('Earliest of All', 'New Yorker', '903' and 'Mory 33' varieties).

Morphactin was used in the form of foliage sprays once or twice at different growth stages of plants.

The following conclusions are based on the data of the experiments:

1. Morphactin IT 3456 (0.5 and 1 ppm) stimulates the development of parthenocarpic fruits both in tomato flowers exclusively emasculated (Table 2) and in intact (free-pollinated) ones (Table 1 and 3). Partheno-

carpy was observed also in crosses of plants (♀) treated with morphactin (0.5 and 1 ppm) with control plants (♂) — Table 2.

2. Morphactin IT 3456 spraying in the greenhouse in 0.5 and 1 ppm concentrations caused 88% and 100% parthenocarpy in plants left to free-pollination (Earliest of All) — Table 1.

3. When using morphactin IT 3456 (0.25; 0.5 and 1 ppm) in the field, an increase of the total number of fruits was noted in the '903' and 'New Yorker' varieties, but in the 'Mory 33' and 'Earliest of All' varieties the total number of fruits decreased as compared with adequate control plants (Table 3).

4. The percentage of parthenocarpic fruits developed in the studied varieties in the field underwent considerable changes and depended on the dose of morphactin.

Among the four varieties, the highest percentage of parthenocarpy was found in the 'New Yorker' and the lowest in '903' (Table 3).

5. Morphactin used in 0.5 and 1 ppm concentrations caused deformation of plants, misshapen fruits and occurrence of blossom-end rot. These symptoms were more pronounced in the greenhouse than in the field.

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Wpływ morfaktyny — IT 3456

(ester metylowy kwasu 2-chloro-9-hydroksyfluoreno-(9)-karboksylowego)
na wykształcenie się owoców partenokarpicznych u pomidorów

Streszczenie

Badania nad partenokarpia pomidorów wywołaną działaniem morfaktyny IT 3456 prowadzono w szklarni (odmiany: 'Najwcześniejszy', 'New Yorker') i w gruncie (odmiany: 'Najwcześniejszy', 'New Yorker', '903' i 'Mory 33').

Morfaktynę IT 3456 stosowano w postaci dolistnych oprysków, jednorazowo lub dwukrotnie, w różnych fazach wzrostu roślin.

Wyniki uzyskane w niniejszych badaniach pozwalają na wyprowadzenie następujących wniosków:

1. Morfaktyna IT 3456 (0,5 i 1 ppm) stymuluje rozwój owoców partenokarpicznych zarówno u kwiatów pomidorów poddanych wyłącznie kastracji (tab. 2), jak też u kwiatów pozostawionych swobodnemu zapylaniu (tabele 1 i 3). Partenokarpie owoców stwierdzono również u krzyżówek roślin (♀) traktowanych morfaktyną (0,5 i 1 ppm) z roślinami kontrolnymi (♂) — tab. 2.

2. Opryski morfaktyną IT 3456 zastosowaną w roztworach o stężeniu 0,5 i 1 ppm wywołały w warunkach swobodnego zapylania w szklarni (odmiana 'Najwcześniejszy') odpowiednio 88% i 100% partenokarpie owoców (tab. 1).

3. Przy stosowaniu morfaktyny IT 3456 (0,25; 0,5 i 1 ppm) w gruncie zaobserwowano wzrost ogólnej liczby owoców u odmian '903' i 'New Yorker', natomiast u odmian 'Mory 33' i 'Najwcześniejszy' nastąpił pod wpływem tego związku spadek ogólnej liczby owoców w porównaniu do odpowiednich kombinacji kontrolnych (tab. 3).

4. Procentowy udział owoców nie zawierających nasion w stosunku do ogólnej liczby owoców wykształconych u poszczególnych odmian w gruncie ulegał znacznym wahaniom i zależny był od koncentracji zastosowanych roztworów morfaktyny.

Najliczniejsze występowanie partenokarpii (w procentach ogólnej liczby owoców) stwierdzono u odmiany 'New Yorker'. Najmniejszy zaś procent partenokarpii zanotowano u odmiany '903' (tab. 3).

5. Morfaktyna IT 3456 zastosowana w roztworach o stężeniu 0,5 i 1 ppm spowodowała uszkodzenie roślin i zniekształcenie oraz porażenie owoców suchą zgnilizną wierzchołkową. Objawy destrukcyjnego działania tego związku wystąpiły w większym stopniu w warunkach szklarniowych niż w polowej uprawie pomidorów.