キュウリ果実の発育に及ぼすジベレリンA4+7及びベンヂルアデニンの促進作用について

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Prominent Promotion on the Fruit Growth in *Cucumis sativus* L. by Gibberellin A_{4+7} and Benzyladenine

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Summary

The aqueous solution of GA_3, GA_{4+7}, BA or IAA was applied by spraying the ovary of an opening flower on the main stem of cucumber, *Cucumis sativus* L. cv. Chozitsuochiai No. 2, which was grown in the greenhouse in autumn and winter. GA_{4+7} and BA were found to be highly active in promoting the fruit setting and development. GA_3 was less active and IAA was not active. The fresh fruit treated with GA_3, GA_{4+7} or BA at 100 ppm was three, ten and five times greater in weight than the control, respectively. The promotion of GA_{4+7} or BA on fruit growth was obtained by treatment of the ovary at different stages of flower development.

Introduction

Cucumbers are commonly cultured in many greenhouses even in autumn and winter in Japan for the production of their fruits, as well as in other moderate seasons. Cucumbers grown in the cool seasons produce only female flowers on their main stem from a relatively low position, where the fruits are formed without pollination. As it is cool and short of sunshine in winter, the fruit setting and the fruit development in cucumbers are inferior to those in other seasons. The application of GA_3 to the flower of cucumber plants grown in field during late summer has been proposed in order to obtain increasing yield of fruit (6). The present paper will describe the prominently promoting activity of GA_{4+7} and BA on the setting and development of fruit cucumbers in the greenhouse during winter when environmental conditions are unfavorable for fruit growth.

Materials and Methods

Cucumber plants, *Cucumis sativus* L. cv. Chozitsuochiai No. 2, were used through the present study. The plants formed only female flowers and produced natural parthenocarpic fruits in the glasshouse heated above 13°C from the beginning of November to the end of January. The cucumber plants were grown by the method of water culture of Ohtsuka house-fertilizers by means of M-type equipment of Tohkaibussan Co. (3). The aqueous solution of GA_3, GA_{4+7} which consisted of A_7 at 63.5 percent and A_4 at 36.5 percent, BA or IAA was applied by means of a small sprayer on the ovary of opening flowers occurring in a node from the 24 th to 26 th node of main stem, where each of the nodes bears continuouslly female flower. The control ovary was treated with distilled water. Each test solution was applied to ten flowers, each of which was born by a different plant. Each ovary was wetted with about 0.02 m*l* of test solution by spraying. About two weeks later, the setting, the length, the diameter and the fresh weight of fruit were measured. The fruit setting was represented as percentage of the number of normally developing fruits for the ten fruits treated, and the rest, undeveloping fruits appeared to be aborted. The length, the diameter or the fresh weight was represented as the average value of ten fruits which comprised undeveloping fruits as well as normally developing fruits in some instances.

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Abbreviations : GA_3, gibberellin A_3 : GA_{4+7}, mixture of gibberellin A_4 and gibberellin A_7 : BA, 6-benzylaminopurine : IAA, indole-3-acetic acid.

Results

1. Effects of various growth substances

The aqueous solution of 10 and 100 ppm GA_3, GA_{4+7}, BA or IAA was applied to the ovary of opening flowers. The fruit set, fruit

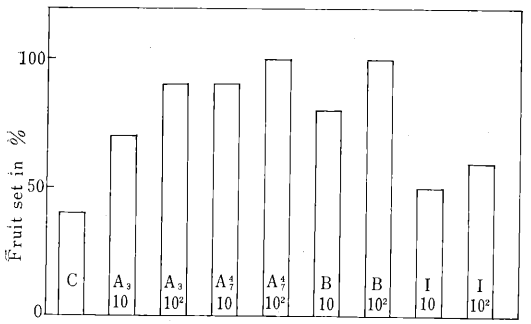

Fig. 1 Effects of GA_3 (A_3), GA_{4+7} (A^4_7), BA (B) and IAA (I) at 10 and 100 ppm concentration on fruit setting of cucumber.

Each bar represents the number of fruits developing normally in percent.

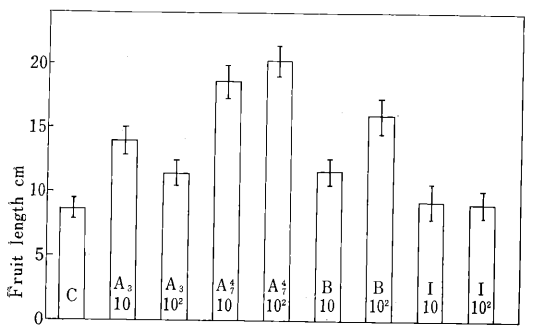

Fig. 2 Effects of GA_3 (A_3), GA_{4+7} (A^4_7), BA (B) and IAA (I) at 10 and 100 ppm concentration on fruit length of cucumber.

Each bar represents the mean of 10 fruits. Standard error is given by vertical line.

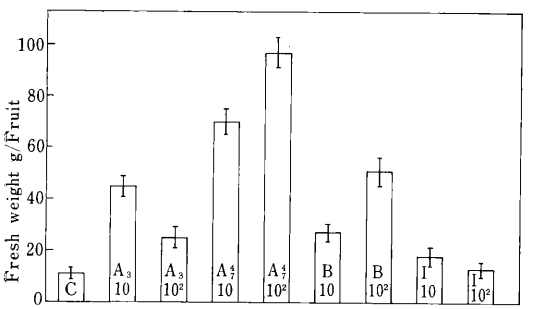

Fig. 3 Effects of GA_3 (A_3), GA_{4+7} (A^4_7), BA (B) and IAA (I) at 10 and 100 ppm concentration on fresh weight of fruit in cucumber.

Each bar represents the mean of 10 fruits. Standard error is given by vertical line.

length and fresh weight of fruit are shown in Figs 1, 2 and 3, respectively. The development of fruit was promoted by either GA_3, GA_{4+7} or BA. Especially, the fruit treated with GA_{4+7} or BA was already found to be stimulated 3 days after the treatment, and the great increase in length and fresh weight of fruit occurred with GA_{4+7} and BA. The promotive activity of GA_3 was much lower than that of GA_{4+7}, and the activity of GA_3 was also lower than that of BA. No significant growth response, however, was induced by IAA.

2. Effect of GA_3, GA_{4+7}, or BA at various concentrations

The ovaries of opening flowers were treated with the aqueous solution of GA_3, GA_{4+7} or BA at various concentrations. The results of GA_3 are shown in Fig. 4. The fruit setting was

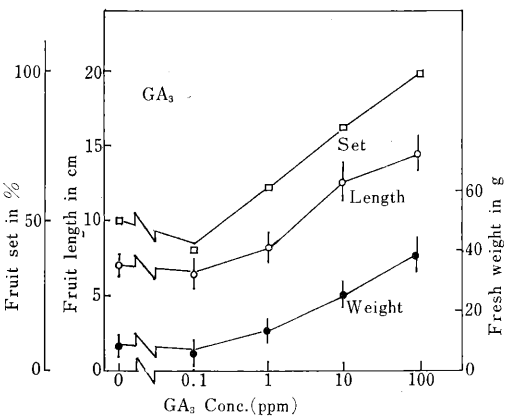

Fig. 4 Effects of GA_3 at various concentrations on growth of cucumber fruit.

Each point represents the means of 10 fruits. Standard error is given by vertical line.

also promoted by 10 and 100 ppm concentrations, as mentioned above. The length and fresh weight at 100 ppm concentration was two times and three times as the control, respectively. The results of GA_{4+7} are shown in Figs. 5 and 6. The promotion in fruit setting was observed even at the low concentration as 0.1 ppm, and the treatment with 1 ppm and more was able to induce the setting of all the ovaries. The fruit treated with 100 ppm was about three times more in length, and ten times more in weight than the control. The results of BA are shown in Figs. 7 and 8. The BA application resulted also in prominent promotion of fruit growth, in which the stimulation was brought on even by low concentration as 3 ppm. All the ovaries treated with 30 ppm and more developed to normal

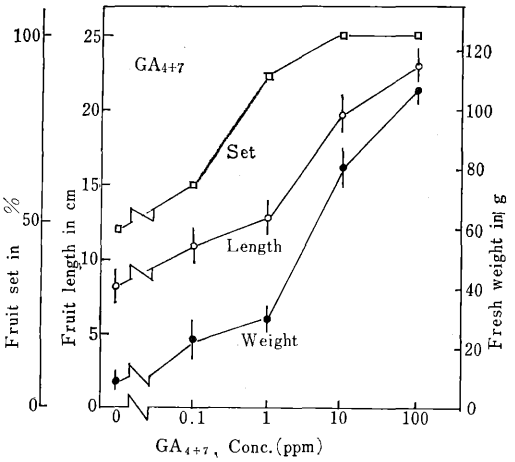

Fig. 5 Effects of GA_{4+7} at various concentrations on growth of cucumber fruit.
Each point represents the means of 10 fruits. Standard error is given by vertical line.

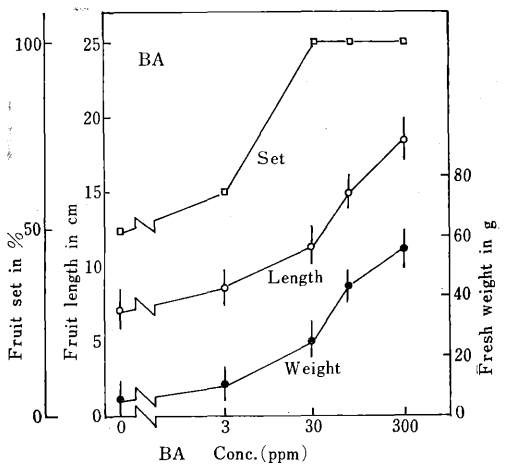

Fig. 7 Effects of BA at various concentrations on growth of cucumber fruit.
Each point represents the means of 10 fruits. Standard error is given by vertical line.

size. The fruit treated with 300 ppm was about two times more in length, and five times more in weight than the control.

3. Effect of GA_{4+7} or BA applied to ovary at different stages of development

The aqueous solution of 100 ppm GA_{4+7} or BA was applied to the ovaries at three stages during the flower development. First, the ovary of flower bud which would open 2 or 3 days later, with the flower petal being still closed. Second, the ovary of opening flower and third, the ovary of flower which had opened 2 or 3 days before, bearing wilting

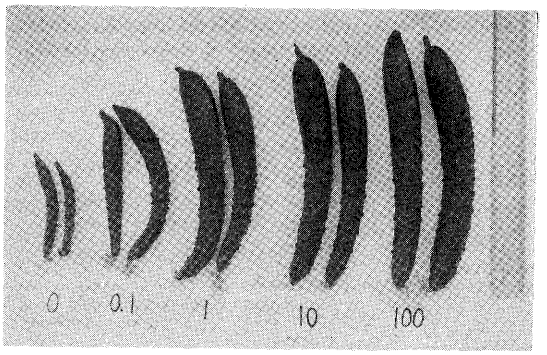

Fig. 6 Photograph of cucumber fruits treated with GA_{4+7} at various concentrations (0, 0.1, 1, 10 and 100 ppm).

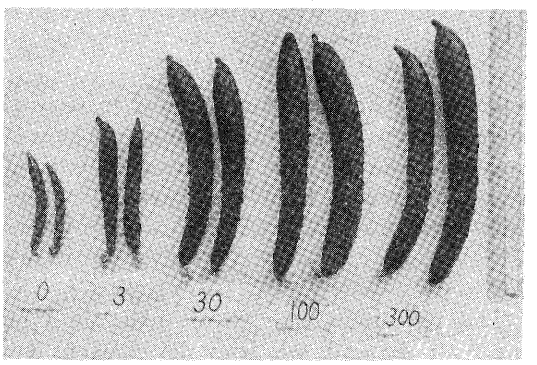

Fig. 8 Photograph of cucumber fruits treated with BA at various concentrations (0, 3, 30, 100 and 300 ppm).

petals. The fruits were harvested two weeks later and were measured for the setting, length, diameter and weight. The results are shown in Tables 1 and 2. The growth of ovaries at all three stages was stimulated remarkably,

Table 1 Effect of 100 ppm GA_{4+7} applied to cucumber ovary at different stages of flower development on subsequent growth of fruit

Stage	Fruit set	Length	Diameter	Fresh weight
	%	cm	cm	g
Before flowering*	100	19.8	1.8	87.5
During flowering**	100	20.4	2.2	100.4
After flowering***	100	21.5	2.5	110.3
Control****	40	8.4	1.0	9.3

* : The ovary of flower bud which would open 2 or 3 days later.
** : The ovary of opening flower.
*** : The ovary of flower which had opened 2 or 3 days before.
**** : Control was treated with distilled water during flowering. Fruit set is represented as the percent of 10 fruits treated, and the other observations are represented as the mean of 10 fruits.

Table 2 Effect of 100 ppm BA applied to cucmber ovary at different stages of flower development on subsequent growth of fruit

Stage	Fruit set	Length	Diameter	Fresh weight
	%	cm	cm	g
Before flowering*	70	13.7	1.5	39.3
During flowering**	80	16.7	1.9	52.6
After flowering***	90	19.5	2.1	89.5
Control****	40	8.4	1.0	9.3

* : The ovary of flower bud which would open 2 or 3 days later.

** : The ovary of opening flower.

*** : The ovary of flower which had opened 2 or 3 days before.

**** : Control was treated with distilled water during flowering. Fruit set is represented as the percent of 10 fruits treated, and the other observations are represented as the mean of 10 fruits.

although younger ovaries appeared to respond more weakly. However, the lower response of young ovaries may be due mainly to short length of period from the flowering to the fruit harvest.

Discussion

The promotive activity of gibberellins on the fruit set and the fruit development has been reported in many species including cucumber (2), and the marked difference in the activity of gibberellins A_1 through A_9 on the fruit development has been observed in tomato (9) and grape (5). The present experiments have shown the higher response of cucumber fruit to GA_{4+7} in comparison with lower response to GA_3. This suggests that also in promoting activity on the cucumber fruit, the difference of gibberellins is qualitative as well as quantitative. Incidentally, greater elongation of stem in cucumber seedling treated with GA_4 or GA_7 than that with GA_3 has been observed by Brian and Hemming (1), and Wittwer and Bukovac (9). The fruit enlargement evoked by GA_{4+7} might be due to the additive activity of each of GA_4 and GA_7. Judging from their chemical structures, GA_4 and GA_7 are thought to be active in almost the same degree. The activity of these gibberellins in cucumber fruit is worthy to investigate further separately. The promotive activity of cytokinin on fruit setting and development has been found in many species such as grape (7), muskmelon (4) and apple (8). The present report has denoted also a good demonstration of cytokinin activity in cucumber. Fruit development is dependent upon many environmental factors in the greenhouse, namely air temperature and sun light. In fact, the various factors in the greenhouse during cool seasons are insufficient so that many ovaries of flowers opening on plants failed to develop to normal fruit. Thus, the present results suggest that the application of GA_{4+7} or BA has a sequential role in releasing from such physiological retardation. In some other experiments, it is noted that the onset of female flowers on the main stem of the present variety is not affected by GA_{4+7} or BA which has been applied exogenously to the respective flowers occurring successively on the main stem over a long period such as two months. Cucumber fruit has failed to respond to IAA application. These observations lead to the consideration that in cucumber GA_4, GA_7 and some cytokinin must be involved more directly in fruit development than GA_3 and IAA. The present evidences that GA_{4+7} or BA promote remarkably the setting and the development of cucumber fruit suggest immediately their usefulness in the study of the physiological role of plant hormones in the development of cucumber fruit as well as in the practical production of fruit.

Acknowledgments

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キュウリ果実の発育に及ぼすジベレリン A_{4+7} 及びベンヂルアデニンの促進作用について

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摘　要

キュウリの促成栽培や抑制栽培は，低い気温や弱い日光など，果実の発育に不適当な環境条件のもとで行なわれている．この時期は，果実の生長が低下し，“ながれ果”とよばれる発育不良果を生じることが多い．このような時期のキュウリ果実の発育に及ぼす植物生長物質の作用を調べた．

11 月から翌年の 2 月まで，大型ガラス室内で栽培されているキュウリ，長日落合 2 号を用い，その主茎上で，当日開花した花の，1 個体の植物当り 1 個体づつの花の子房へジベレリン A_3，ジベレリン A_{4+7}，ベンヂルアデニンならびにインドール酢酸の水溶液を散布した．1 つの試験液ごとに，10 個体の花の子房を用いた．2 週間後，その子房の着果率，果実の長さ，直径ならびに重さを調査した．

ジベレリン A_3，ジベレリン A_{4+7} ならびにベンヂルアデニンは着果及び果実の発育を促進したが，インドール酢酸は促進を示さなかった．特に，ジベレリン A_{4+7} とベンヂルアデニンの促進作用は著しく，それぞれ 100 ppm 濃度区の果長は，対照区の 2.5 倍と 2 倍となり，重さは，対照区の 10 倍と 5 倍になった．これらの促進作用は，開花中はもちろん，開花 2～3 日前ならびに開花 2～3 日後の花の子房に処理してもみられた．

上の実験結果から，ジベレリン A_4, A_7 あるいは或る種のサイトカイニンが，キュウリ果実の発育により強く関係していると考えられる．更に，この実験結果は，不適当な環境条件下で生じる果実の発育を抑制するなんらかの内的生理機構が，外から与えた植物ホルモンによって除かれることを示唆している．