PHYSIOLOGICAL STUDIES ON THE PROMOTIVE EFFECT OF GIBBERELLIN ON THE GROWTH OF CELERY PLANT

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By

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(*Received, March 15, 1962*)

Introduction

It is well known that vegetative growth is promoted by foliar application of gibberellin in many vegetable crops. Increase in the length of leaf-stalk and fresh weight of field-grown celery plant following gibberellin application has proved to bring a fair profit (2, 3, 8, 15, 17). Recently gibberellin spray on celery plant about 20 days before harvest is carried out practically in Japan.

The synergistic interaction between auxin and gibberellin has been found (4, 5, 7, 10, 11, 14) using the isolated section of avena coleoptiles and etiolated pea epicotyls, but there are few reports with intact plants, the results being confused on their interactions (6, 13).

It seems to be significant to ascertain the interactions of auxins with gibberellins with intact plant to contribute to an understanding of the role of gibberellins in promoting the tissue elongation. Thus, the changes in natural gibberellins and auxins which accompany the increase in the length growth of the leaf-petiole in celery plant were traced.

Material and Methods

Seeds of Cornell 619 were sown on May 20 in the bed of sandy soil in the greenhouse and the seedlings were subsequently transplanted 15 cm apart and later 30 cm apart in rows 100 cm apart in the experimental field of the Tohoku University. Normally recommended cultural practices were followed for all experiments.

Foliar spray treatments were started on Oct. 13. The foliage was thoroughly wetted by spraying with the designated solutions of gibberellin. Prior to gibberellin treatments the just expanded young-leaf was marked with

enamel paint to measure the increase in the length of the first internodal leaf-stalk at intervals of five days.

During the course of experiments two outer leaves next to the marked young-leaf were used for the bioassay of gibberellin and auxin. Hormone estimation was made on the first internode of the leaf-stalk, 50 gr in fresh weight. The method employed in the bioassay was the same as that descibed by Kato and Ito (9, 12).

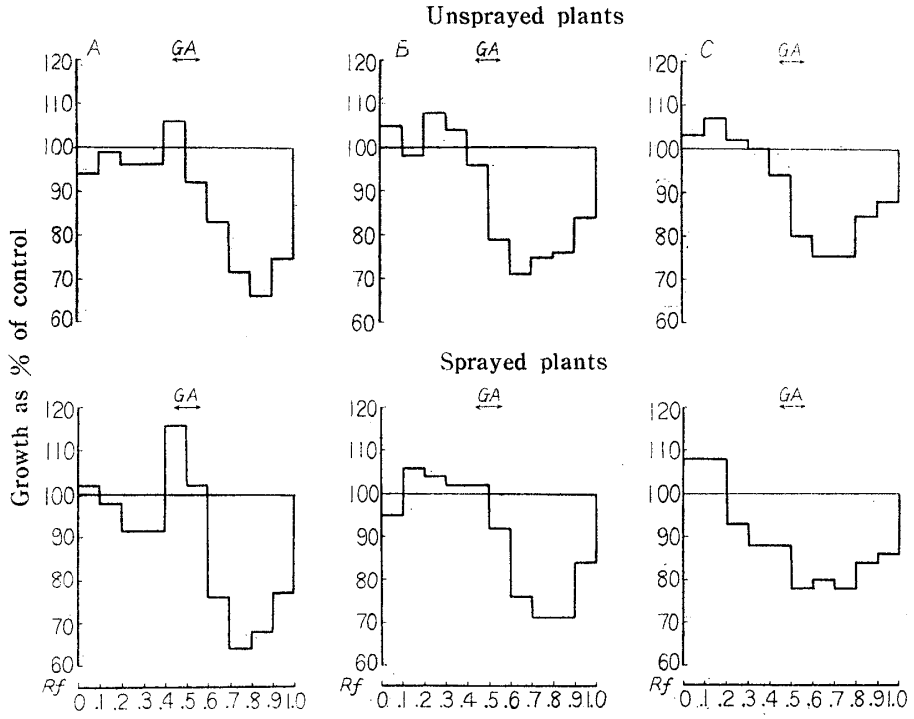
Auxin; Extracts obtained with peroxide free ether at 0°C for 24 hours were separated into acid and neutral fraction. After chromatographic separation by the ascending method with isopropanol : ammonia : H_2O (10 : 1 : 1V/V), avena coleoptile straight growth test was made.

Gibberellin; Extracts obtained with 80 per cent alcohol at room temperature for 48 hours were separated into chloroform and ether fraction. After chromatographic separation with the same solvent as auxin separation, rice seedling test was made.

Results

1. *Duration of the effect of gibberellin application*

Twenty plants were sprayed with gibberellin at 50 ppm on Oct. 13. The increase in the length of the first internode of the leaf-stalk was measured at



A : 3 days after GB application B : 10 days after GB application C : 17 days after GB application

Solid line gives the growth of controls. GA : Gibberellin A_3

Fig. 1. Effect of gibberellin application on the gibberellin content in the first internode of the leaf-stalk in celery plants.

intervals of 5 days and the estimation of gibberellin was made 3 days, 10 days and 17 days after the treatment respectively.

As shown in Fig. 1, the bioassay with rice seedlings indicates that the first internode of the young leaf-stalk contains a small amount of gibberellins, and three days after the gibberellin application, the amount of gibberellins, espesially at *Rf* 0.5—0.6, markedly increases.

Thus, the gibberellins in leaf-stalk increases soon after the treatment and gradually declines to zero in the following 17 days.

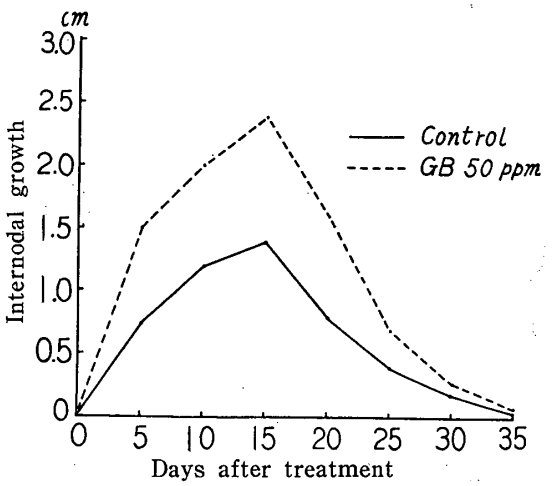
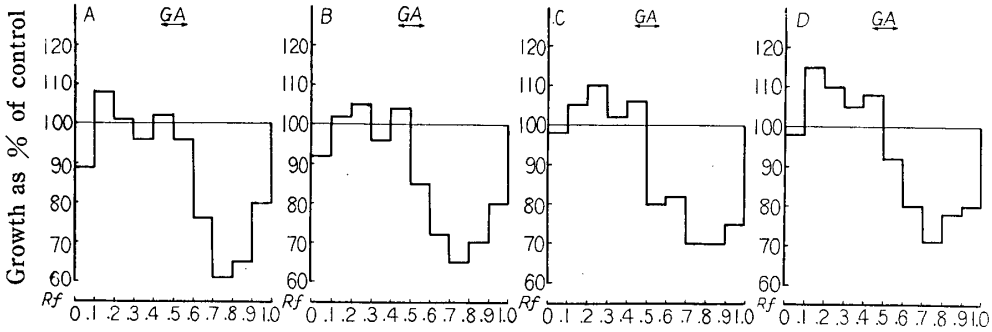


Fig. 2. Effect of gibberellin application on the first internodal growth of the leaf-stalk in celery plants.

It appears that the effect of gibberellin continues at least for about 15 days from the rise of gibberellin content. This corresponds with the result of the measurement of the internodal growth of the leaf-stalk as shown in Fig. 2.

2. *Effect of concentration of gibberellin solution on the content of gibberellins in the leaf-stalk.*

Sixty plants were sprayed with solutions of gibberellin at 0, 10, 100 and 1000 ppm on Oct. 13 and were sampled 5 days later to examine the content of native gibberellins with special reference to the promotive effects of gibberellin. The results are represented in Fig. 3.



A : Control B : GB 10 ppm C : GB 100 ppm D : GB 1000 ppm
Solid line gives the growth of controls. GA : Gibberellin A_3

Fig. 3. Effect of concentration of gibberellin on the gibberellin content in the first internode of the leaf-stalk in celery plants five days after treatment.

The higher the concentration of gibberellin applied is, the more the content of native gibberellins increases in the first internode of leaf-petiole.

It is clearly indicated in Table 1 that the growth of celery plant is

promoted as the concentration of gibberellin is raised, and pithy petioles increase.

Table 1. Effect of concentration of gibberellin on the growth of the leaf-stalk in celery plants.
The growth of celery plants was investigated on Nov. 17, 35 days after gibberellin foliar application.

	Top weight (g)	Number of edible leaf-stalk	plant height (cm)	per cent of pithnees*
Control	1000	17.2	41.5	13.4
GB 10 ppm	1060	15.8	44.0	14.2
100 ppm	1250	13.8	47.0	24.8
1000 ppm	1500	12.2	50.2	26.2

* Investigated on the first internode of leaf-stalk.

3. *Effect of number of applications of gibberellin on the content of native auxins and gibberellins in the leaf-stalk.*

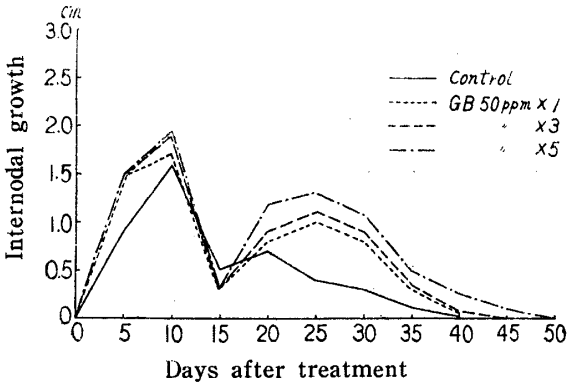
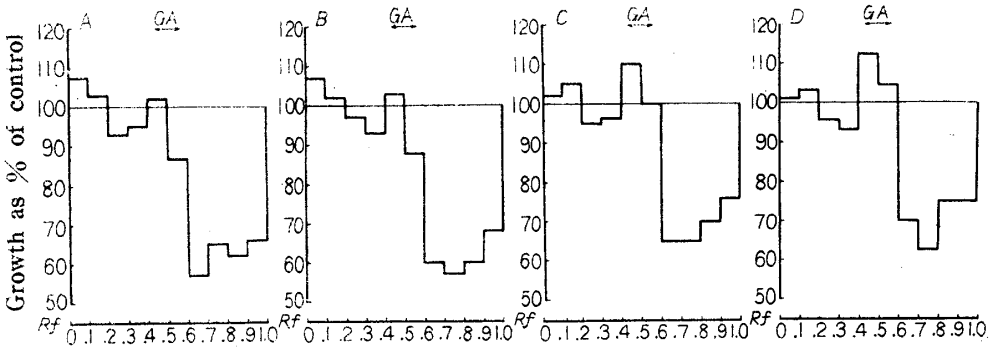


Fig. 4. Effect of number of gibberellin application on the first internodal growth of the leaf-stalk in celery plants.

Commencing on Nov. 2, foliar sprays of 50 ppm at intervals of 5 days, resulted in the promotive elongation of first internode of the leaf-stalk as shown in Fig. 4.

It is suggested, however, that the elongating effect of gibberellin is reduced by the low temperature condition that prevailed for 10 days from Nov. 10.

Bioassay of auxins and gibberellins in these samples was made on Nov. 26.

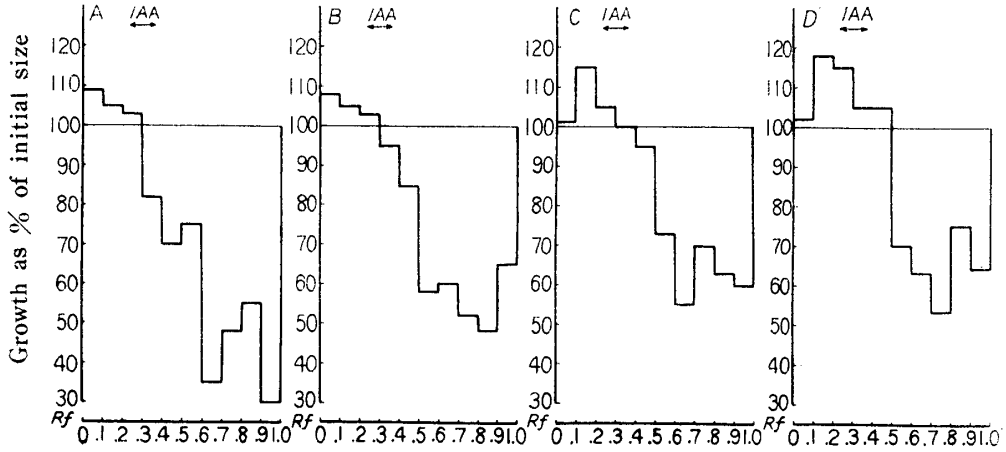


A : Control B : GB 50 ppm × 1 C : GB 50 ppm × 3 D : GB 50 ppm × 5
Solid line gives the growth of controls. GA : Gibberellin A_3

Fig. 5. Effect of number of gibberellin application on the gibberellin content in the first internode of the leaf-stalk in celery plants.
Spray was made at intervals of five days, commencing on Nov. 2.

It is shown in Fig. 5 that the content of native gibberellins in the first internode of the leaf-stalk increases as the number of application is multiplied.

At the same time auxin content in the first internode of the leaf-stalk increases with the number of gibberellin application as shown in Fig. 6.



A : Control B : GB 50 ppm×1 C : GB 50 ppm×3 D : GB 50 ppm×5
Solid line gives the growth of controls.

Fig. 6. Effect of number of gibberellin application on the auxin content (acid fraction) in the first internode of the leaf-stalk in celery plants.
Spray was made at intervals of five days, commening on Nov. 2.

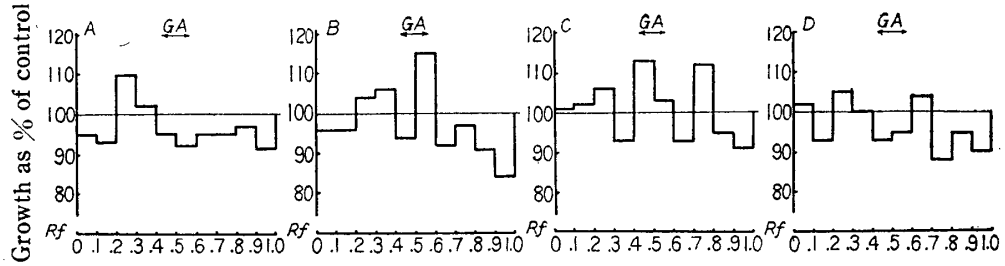
Accordingly it appears that the foliar sprays of gibberellin increase the content of native auxins and gibberellins.

4. *Effect of combination of gibberellin with naphthaleneacetic acid or maleic hydrazide on the content of native auxins and gibberallins in the leaf-stalk.*

The following foliar applications were carried out on Nov. 11, with ten plants per treatment;

(i) Control (water spray),
(ii) Gibberellin 50 ppm,
(iii) Gibberellin 50 ppm + NAA 10 ppm,
(iv) Gibberellin 50 ppm + MH 10 ppm.

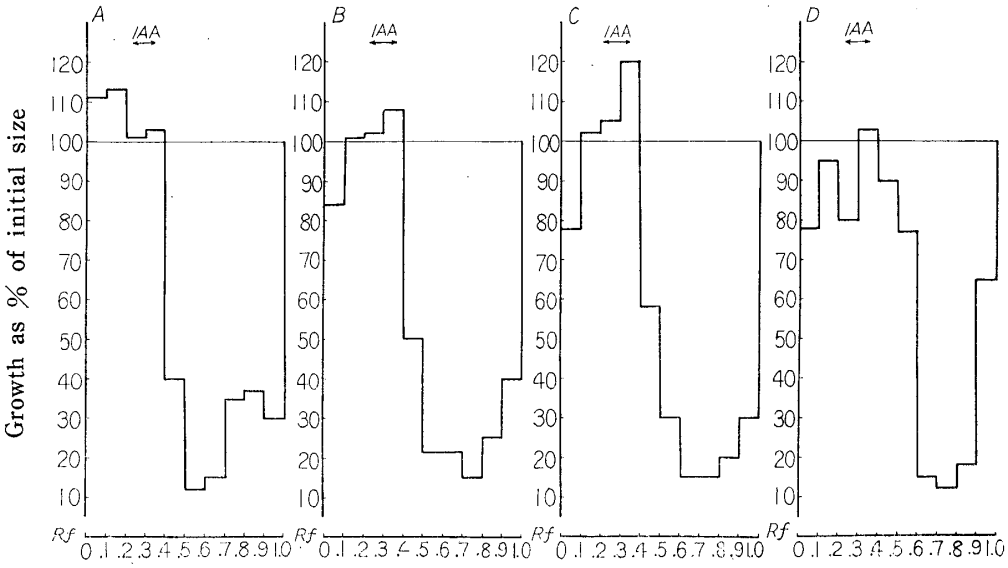
Five days after the treatment, the treated plants were sampled to investigate



A : Control B : GB 50ppm C : GB 50ppm+NAA 10ppm D : GB 50ppm+MH 10ppm
Solid line gives the growth of controls GA : Gibberellin A_3

Fig. 7. Effect of combination of gibberellin with hormones on the gibberellin content in the first internode of the leaf-stalk in celery plants.

the content of native auxins and gibberellins. The results are illustrated in Figs. 7, 8.



A: Control B: GB 50ppm C: GB 50ppm+NAA 10ppm D: GB 50ppm+MH 10ppm

Fig. 8. Effect of combination of gibberellin with hormones on the auxin content (acid fraction) in the first internode of the leaf-stalk in celery plants.

The results show in Fig. 7 that the addition of NAA failed to induce the higher content of gibberellins than that of single application of gibberellin, while the addition of MH diminished the gibberellin content.

Fig. 8 shows that auxin content in the first internode of the leaf-stalk increases by addition of NAA, but, on the contrary, decreases by the addition of MH, an antiauxin. It is evidently indicated that the elongating effect of gibberellin is modified, corresponding with these internal conditions in the leaf-stalk. In other words, relatively small amount of NAA invigorates elongating effect of gibberellin, while MH suppresses it as shown in Fig. 9.

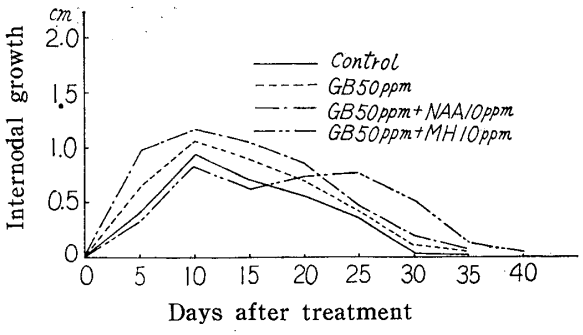


Fig. 9. Effect of combination of gibberellin with hormones on the first indernodal growth of leaf-stalk in celery plants.

5. *Effect of gibberellin application on the partial growth of the leaf-stalk.*

On Nov. 18 the celery plants grown in five inch clay pots were transferred into the greenhouse of 24°C and their young leaf-stalks, about 10 cm long, were marked every 1.0 cm in length with indian ink from the distal end.

The elongation of leaf-stalk was measured every 5 days after spraying with gibberellin solution at 100 ppm.

It is shown in Fig. 10 that the growth of leaf-stalk is basipetal, showing the longer elongation at the basal part of leaf-stalk, but at each part including the node of leaf-stalk the increase in length is to some extent suppressed.

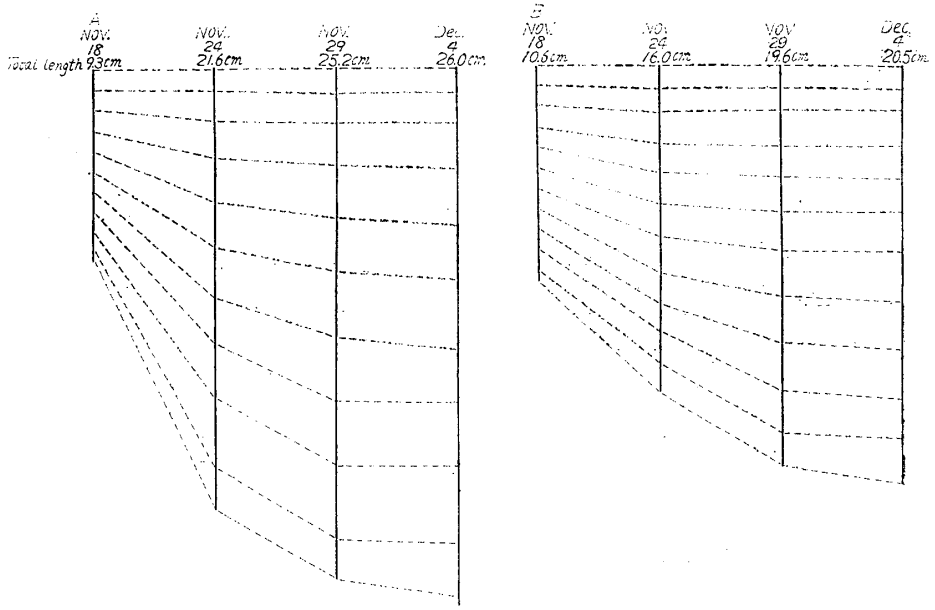


Fig. 10. Effect of gibberellin application on the partial growth of the leaf-stalk in celery plants.
A: GB 100 ppm B: Control

The elonagating effect of gibberellin is more remarkable at the basal part and less at the distal part of the leaf-stalk.

Consequently it seems that gibberellin is more effective in the elongation of young tissues in the leaf-stalk.

Discussion

Increases in the leaf-stalk and fresh weight of field-grown celery following treatment with gibberellin were found as shown in Figs. 2, 4, 9, and Table 1.

These are in agreement with Bukovac's findings (2, 3). It is evident that the content of native gibberellins in the leaf-stalk influences upon the growth of leaf and increases by gibberellin application as shown in Figs. 1, 3, 5, 7. It is also shown in Fig. 1 that the gibberellin content is affected for 15 days at least as the result of a single application of gibberellin.

Figure 10 shows that gibberellin is most effective in promoting the elongation of the basal part, the youngest tissue of leaf-stalk.

It is cearly suggested that the elongating effect of gibberellins is limited to the young tissue of the celery plants.

Takahashi *et al.* (16) have found that the increase in plant height by gibberellin application is confined to the elongation of the heart and adjacent leaves of the whorl and there was no elongation of the whorl. It is suggested

that the young leaves and tissues are more sensitive to gibberellin. In this manner it is possibly considered that the physiological conditions in the young tissue of the leaf-petiole is ready for the gibberellin effect.

From Avery's report (1) with tobacco leaves, one of the physiological factors in the young tissues of the leaf-petiole is considered to be native auxins.

Nitsch (13) found that the application of gibberellin to Rhus typhina caused a rise in the level of native auxin, but Hayashi and Murakami (6) found no effect on auxin level in the pea, tomato and cucumber.

It appears that an increase of auxin is induced by the decreased IAA-oxidase activities as a result of gibberellin treatment (4).

Fig. 6A and Fig. 8A show that only a small amount of active auxins is contained in the young leaf-petiole of celery plant and by gibberellin treatment, both native auxins and gibberellins increase (Figs. 5, 6, 7, 8). Thus it is suggested that auxins and gibberellins are closely related to the growth of the leaf-petiole.

It is known that the effect of gibberellin and auxin supplied simultaneously are additive in the isolated section test of avena coleoptiles and of the etiolated pea (4, 5, 7, 10, 11, 14). In this experiment it is found as shown in Fig. 9 that the combination of gibberellin with naphthaleneacetic acid shows synergistic increases in the internodal growth of leaf-stalk, while the combination of gibberellin with maleic hydrazide shows decreases.

In the other experiments it is found that a single application of auxin does not induce the visible growth of leaf-stalk in celery plants.

The addition of a small amount of NAA increases considerably the auxin content in the leaf-petiole, and an addition of MH decreases it conversely as shown in Fig. 8, whereas it appears that their effect on gibberellin content is not so remarkable as on auxin content (Fig. 7).

From the result mentioned above, it may be possibly concluded that the high level of both of gibberellins and auxins is favorable and effective for the elongation of the leaf-stalk in celery plants being accompanied by the synergistic interactions between auxins and gibberellins.

Summary

The present paper dealt with the physiological effect of gibberellin on the growth of the leaf-stalk in celery variety Cornell 619.

Increases in the length growth of leaf-stalk and fresh weight of field-grown celery plant following gibberellin application were found.

1. Gibberellin content in the young leaf-stalk increases for 15 days at least by a single application of gibberellin.

Corresponding with the high gibberellin level, the increase in length growth of the leaf-stalk continues for 15 days, but thereafter gradually decreases,

2. The higher the concentration of gibberellin applied is, the more the content of gibberellins increases in the leaf-stalk.

3. As the number of applications of gibberellin increases, the contents of both native auxins and gibberellins in the leaf-stalk are raised and the internodal growth of the leaf-stalk is promoted.

4. The effect of gibberellin and auxin supplied simultaneously are additive to the increase of growth and auxin content in the leaf-stalk, while the effect of gibberellin added with antiauxin depresses them.

Gibberellin content in the leaf-stalk is not so much more increased by the gibberellin application added with auxin as compared with the single application of gibberellin.

5. Gibberellin application is very effective in the increase of the growth of the basal part, but not in the distal part of the leaf-stalk, growing basipetally. It seems that the young tissues of the leaf-stalk are most sensitive to the gibberellin effect, being rich in auxin.

6. Synergistic interactions between auxins and gibberellins are found in the leaf-stalk of celery plant.

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