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journal or publication title	Tohoku journal of agricultural research
volume	12
number	1
page range	1-8
year	1961-05-30
URL	http://hdl.handle.net/10097/29335

INTERRELATIONS BETWEEN GIBBERELLIN AND DORMANCY OF POTATO TUBER

By

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(*Received, January 28, 1961*)

The multitude of effects that gibberellin has induced led to an investigation of its use as an activator in breaking the rest period of the dormant potato tuber.

The rest period which is caused by internal factors in the plant, is defined as that period when the plant will not grow even when the environmental conditions are favorable. Dormancy coincides with a cessation of growth caused by internal factors within the organism or organ. The growth is arrested since the mechanisms controlling the increase in size are inhiibited. Among such mechanism is the production or effectiveness of auxin. Dormancy may be broken by submitting buds to treatments apt to release inhibitions. Among external stimuli, in general, cold is common, but similar effects may be achieved by using ethylene chlorohydrin, thiourea or gibberellin.

Potato tuber dormancy is released with time if cold does not intervene. The rest period of the Irish Cobbler tuber is the longest among the leading varieties cultivated in Japan. For the fall crop culture, it is necessary ot break artificially the long-time dormancy of the Irish Cobbler tubers.

In this report, the release of growth inhibition is dealt with as compared with the trend of the gibberellin-like substances and inhibitors in the Irish Cobbler tubers.

Materials and Methods

General procedure: New tubers of Irish Cobbler potato plants were dug up on July 7 from the experimental field of the Tohoku University.

Uniform tubers, 100~150 g in weight, were selected for the experiments. Some of them were stored in the dark room at 5°C and others were stored in the dark room at room temperature.

Gibberellin application: Gibberellin treatment was carried out on July 8, 19, and Aug. 23. The whole tubers and sometimes cut tubers were immersed in gibberellin solution of 50 ppm for 30 minutes that is recommended by Tsukamoto et al (5, 6). At the same time the tubers were soaked in 0.5 per cent ethylene chlorohydrin for two hours. The control was soaked in water for two hours.

After soaking, the treated and control were washed thoroughly with running water for five minutes and dried overnight. In the following day they were planted in the soil of the nursery bed.

The investigation of sprouting of tubers was made at the intervals of five days after the treatment.

Bioassay of native gibberellin: *Extraction*; Ten grams of the apical parts from ten tubers were extracted on July 29, Aug. 18, 28, Sept. 5, and 21. The apical parts include the apical eyes and peels around them.

As shown in Fig. 1 A, B, it is evident that the extractions with alcohol were considerably more effective than with ether in the preliminary experiment. Therefore, extraction was carried out with alcohol. Samples were cut into pieces and extracted with 80 per cent alcohol for 48 hours at room temperature. After three extractions, the total extracts were concentrated under reduced pressure and fractionated with chloroform and ether.

As shown in Fig. 1 C, this fractionation was very effective for separation of native gibberellin and its inhibitors as reported by Okazawa (3).

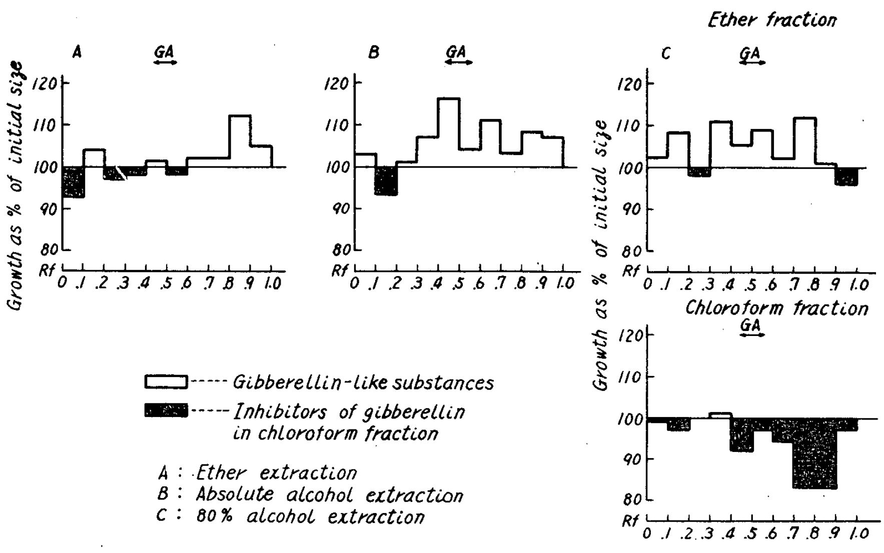

Fig. 1. Effect of solvent on the gibberellin content of extracts in potato tubers.

Paper chromatography; Each fraction was concentrated and chromatographed on Toyo No. 51 filter paper in the solvent (isopropanol, ammonia and water in a ratio of 10:1:1). After 25cm of the solvent migration by the ascending method at room temperature, the paper was dried and cut into ten equal sections. Each section was eluted with 2cc of distilled water.

Rice seedling test; The method employed in the bioassay was similar to that described by Murakami (2).

Five seedlings, whose coleoptiles attained about 1 mm were planted in 5 g sand in each dish and allowed to grow under the continuous fluorescent lamp at 28°C for seven days. They were supplied with 1 cc of water every day. The length of the second leaf-sheath was measured after seven days.

Results

1. Effect of gibberellin application on sprouting of potato tubers.

To examine the effect of gibberellin on the sprouting of potatoes, uniform tubers, stored in the dark room at room temperature, were treated with gibberellin solution of 50 ppm for 30 minutes on July 19 and Aug. 23, comparing with the effect of ethylene chlorohydrin treatment.

The percentage of sprouting tubers is presented in Table 1.

Gibberellin was very effective for the promotion of sprouting and shoot elongation of the tubers, comparing with ethylene chlorohydrin treatment and control.

As tubers become mature, this sprouting increased with or without chemical treatments.

It is shown in Fig. 2 that the shoots grown on the gibberellin soaked

Table 1. Effect of gibberellin application on sprouting of potato tubers.

Date of treatment	Treatment	Number of days after treatment		
		5	10	30
July 19	Control	—	0 %	10 %
	Ethylene	—	0	20
	Gibberellin	—	0	90
Aug. 23	Control	90 %	—	—
	Ethylene	100	—	—
	Gibberellin	100	—	—

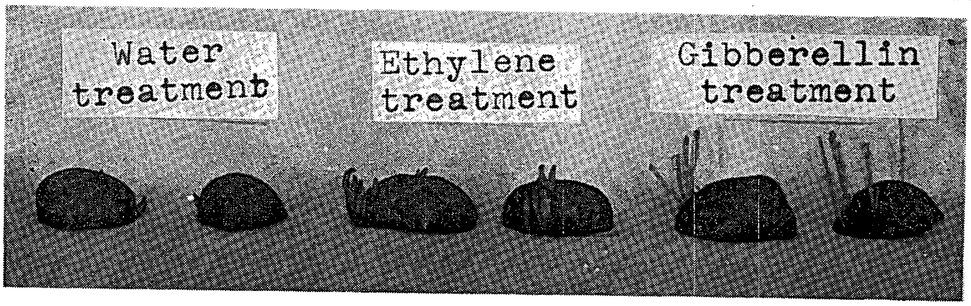

Fig. 2. Shoots of potato tubers treated with ethylene chlorohydrin and gibberellin, five days after the treatment.

tubers are slender than those on the others which are stocky.

2. Effect of time of gibberellin application on sprouting of potato tubers.

Sprouting is accelerated by gibberellin application, but the days to sprouting are remarkably different depending on the time of application (Fig. 3).

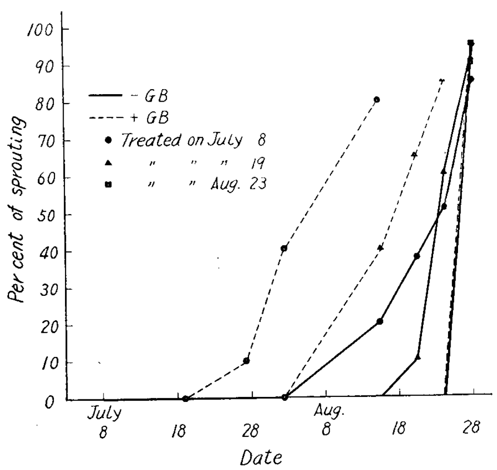

Fig. 3. Effect of the time of gibberellin application on sprouting of potato tubers.

Fifty per cent of tubers sprouted out after about 30 days when soaked immediately after or 10 days after harvest, and tubers treated on Aug. 23 sprouted within 5 days.

The sprouting of tubers increased by aging, with or even without gibberellin application.

3. Seasonal trend of native gibberellin in potato tubers.

It is evident in chromatograms in Fig. 4, that in addition to gibberellin with the *Rf* value 0.5~0.6, other gibberellin-like substances and inhibitors are present.

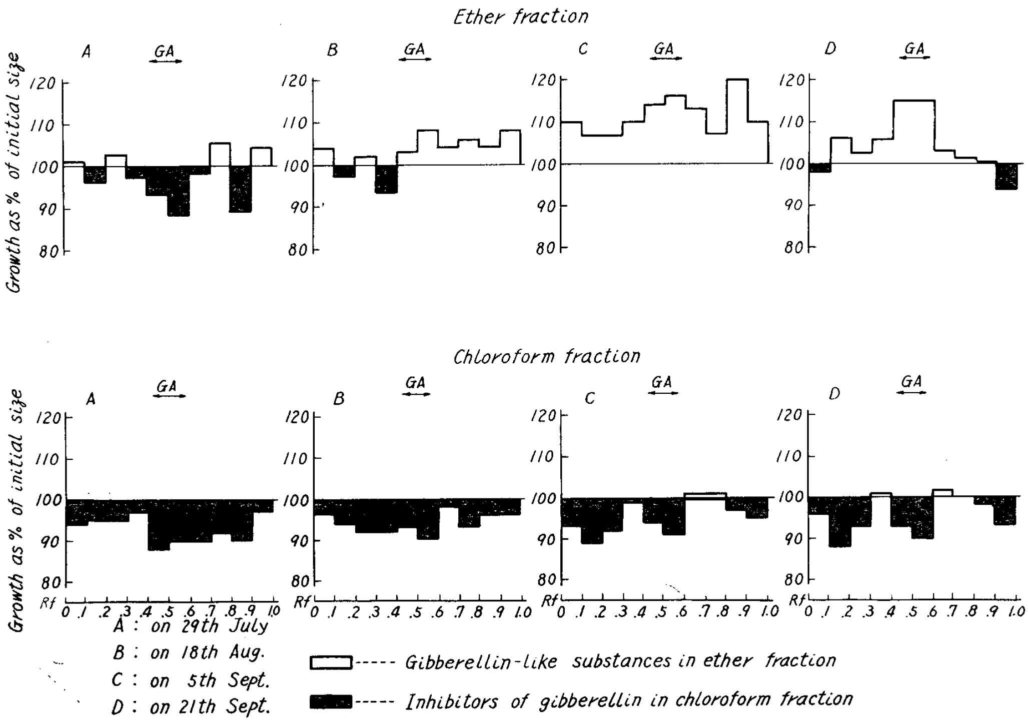

Fig. 4. Seasonal trend of gibberellin with the age of tubers.

Native gibberellin is not found in the freshly harvested tubers and many inhibitors of gibberellin are found in the chloroform fraction. At the end of July, gibberellin appears and thereafter gradually increases with the age of tubers. Finally, gibberellin contents of the apical eyes reach to the same amount as that of the treated tubers.

It seems that the inhibitors in the chloroform fraction decrease to some extent with the age of tubers.

4. Effect of gibberellin application on the native gibberellin content in potato tubers.

As shown in Fig. 5, it is clear that the content of native gibberellin of the apical eyes is enriched by gibberellin treatment, and further steadily increase with the progress of after-ripening process of tubers. But the effect on the inhibitors is not so remarkable.

Gibberellin content of the apical eyes is not so much affected by ethylene chlorohydrin as by gibberellin treatment, but still, it is higher than that of the control.

On Aug. 18, 30 days after treatment with ethylene chlorohydrin (soaked July on 19), the content of gibberellin is seen in the apical eyes as much as that of gibberellin-soaked tubers.

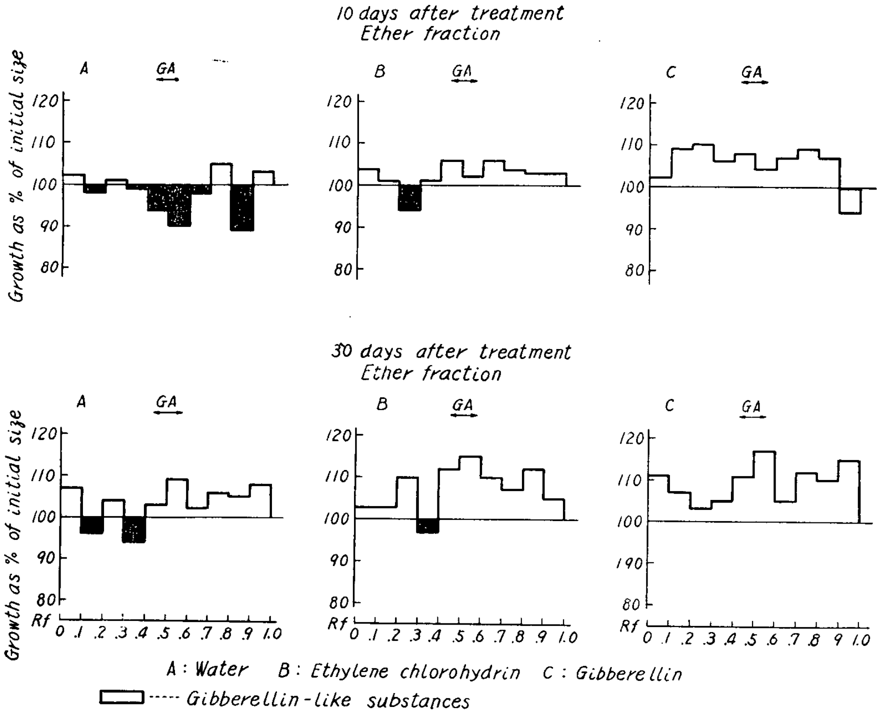

Fig. 5. Chromatograms showing the distribution of gibberellin-like substances from the apical eyes of potato tubers treated with gibberellin and ethylene chlorohydrin on July 19.

The result of extraction on Aug. 28 is shown in Fig. 6.

It seems that there is no difference in the amount of native gibberellin among the treatments about 50 days after harvest.

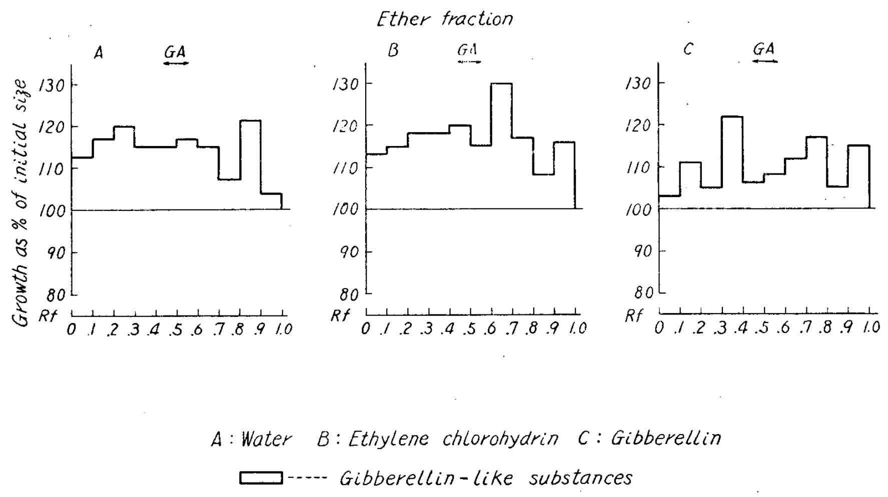

Fig. 6. Chromatograms showing the distribution of gibberellin-like substances from the apical eyes of potato tubers treated with gibberellin and ethylene chlorohydrin on Aug. 23.

5. Effect of chilling on the native gibberellin content in potato tubers.

It is well known that the cold storage prolongs the dormancy of the

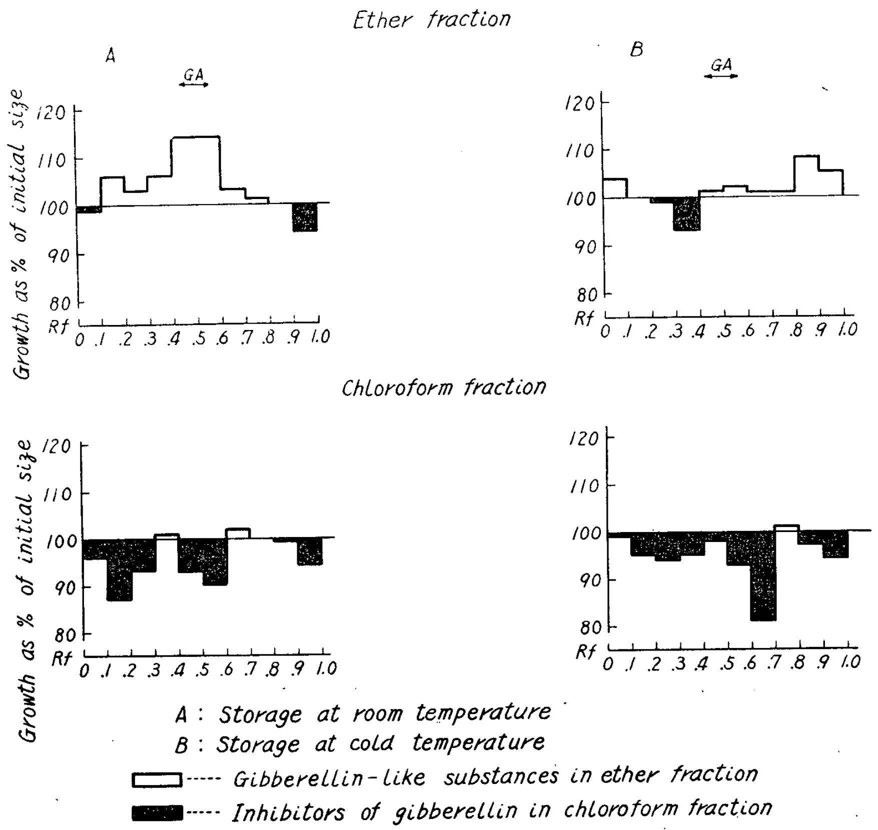

Fig. 7. Effect of cold storage on the native gibberellin content in potato tubers.

potato tubers. To clarify the effect of chilling on the trend of the gibberellin content, native gibberellin was extracted with 80 per cent alcohol from the tubers stored in the cold room as compared with the tubers stored at room temperature.

The result is shown in Fig. 7. It is apparent that the chilling treatment prevent the increase of gibberellin in tubers.

Discussion

Buds of Irish Cobbler tubers did not sprout till middle August, about 40 days after digging out from the field.

Gibberellin and ethylene chlorohydrin-soaked tubers, contrary to expectation, failed to sprout till early August, too (Table 1, Fig. 3). On Aug. 18, 90 per cent of gibberellin-soaked tubers, treated on July 19, sprouted in contrast to 20 per cent of ethylene chlorohydrin-soaked tubers and 10 per cent of water-soaked tubers.

Gibberellin and ethylene chlorohydrin did not appear actually to break the dormancy of potato tubers, but they eventually promoted the growth of the buds released from inhibition. A similar finding has recently been reported by Doorenbos (1).

Native gibberellin-like substances appeared in the samples taken on July 29, and gradually increased in the later samples till Sept. 5 and decreased in the samples taken on Sept. 21.

First appearance of native gibberellin-like substances preceded to the release from growth inhibition. Buds did not sprout before August (Fig. 4, 5).

In the chloroform fraction, inhibitors appeared and remained even in samples taken on Sept. 21, stored at the room temrerature and initiated to sprout profusely.

Hence, these inhibitors did not appear to associate necessarily with the growth inhibition.

In the tubers, stored in the cold, dark room, native gibberellin-like substances did not increase and inhibitors did not decrease through the whole season.

It may be safely concluded that gibberellin promoted bud sprouting released from growth inhibition.

Summary

Irish Cobbler tubers, dug out July 7 from the university field, were stored and examined as to the effect of gibberellin application on sprouting and seasonal trend of native gibberellin in the apical eyes in relation to aging of tubers and application of gibberellin and ethylene chlorohydrin.

1. Tubers were soaked in gibberellin (50 ppm, 30 min), ethylene chlorohydrin (0.5 %, 2 hr) solution and as control in water for 2 hr, on

July 8, 19, and Aug. 23.

2. Gibberellin and ethylene chlorohydrin application increase the native gibberellin of the apical eyes of tubers and, on the contrary, cold storage prevents the increase of gibberellin production.

3. Buds failed to sprout before August. Gibberellin and ethylene chlorohydrin failed to release the buds from growth inhibition. On Aug. 18, 90 per cent of gibberellin-soaked tubers sprouted in contrast to 20 per cent of ethylene chlorohydrin-soaked and 10 per cent of water-soaked tubers (soaked on July 19).

Gibberellin promoted bud sprouting released from growth inhibition.

4. Native gibberellin appeared in the samples taken on July 29, preceding to the growth release from inhibition.

5. In the chloroform fraction, inhibitors of gibberellin-like substances appeared and remained even in the Sept. 21 samples which sprouted profusely.

6. It is concluded that gibberellin does not appear actually to break the dormancy of potato tubers, but that it eventually promoted the growth of the bud released from growth inhibition.

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