

水稻体に与えたIAA-14Cの移動・分布に及ぼす重力の影響 について(続報)

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Effects of Unilateral Gravitational Stimulation on the Transport and Distribution of Indoleacetic Acid-2-¹⁴C Exogenously Applied to the Rice Plant (Further Report)

—Distribution of unmetabolized IAA-2-¹⁴C in the middle portion of stems*—

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In the previous paper⁵⁾, the writer dealt with the subject of distribution of ethanol-soluble radioactive substances recovered from the intact rice plant which was supplied with indole-3-acetic acid (IAA)-2-¹⁴C, in association with investigation of morphological changes in the horizontal stem. So far as the experiment was concerned, it could hardly verify his assumption that acceleration in morphogenesis of the horizontal rice stem, compared with the vertical, would be intimately associated with a higher concentration of auxins in the former.

Recently, he has found the fact that larger amount of unmetabolized IAA-¹⁴C separated from the ethanol extracts which were obtained in the previous experiment was contained in the middle portion of the horizontal stem rather than in that of the vertical one. The present paper makes reference to the contents with a general discussion.

MATERIALS AND METHODS

In order to get the amount of unmetabolized IAA-¹⁴C which was contained in the same ethanol extracts from the middle portion extending from just beneath the fourth leaf node to just beneath the eighth of the rice stem as described in the previous paper⁵⁾, remnant of the extracts was made to concentrate to a small volume under a decreased pressure at

35°C, and then about 0.03 ml of each of the concentrated sample solutions was chromatographed on Tōyō No 51 A filter paper for 15 h, using isopropanol, concentrated ammonium hydroxide and water (80:10:10) as the solvent. The filter paper was cut into 13 divisions of 2 cm width on each sample, and every piece of them was put into a vial together with scintillation solution (4 g PPO** and 0.1 g POPOP*** in 11 toluene). The radioactivities were measured on them by a liquid scintillation counter (Packard Tri-Carb. 314-EX) for 10 min. In addition, the ratio between the radioactivity of the same Rf region (about 0.59) as that of standard IAA-2-¹⁴C developed simultaneously with the test sample and the whole radioactivity of each sample was determined. On the basis of this ratio the amount of unmetabolized IAA-2-¹⁴C in each ethanol extract was calculated. Since the values of measurement obtained from the two samples for the same portion were found to be closely similar to each other in almost every case, the values cited in the following tables were shown the mean of those from the two samples.

EXPERIMENTAL RESULTS

Specific radioactivities of the ethanol extracts, which were obtained from two longitudinal halves through the middle portion of stems extending from the fourth leaf node to the

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** 2, 5-diphenyloxazole.

*** Dimethyl POPOP-1, 4-bis-2-(4-methyl-5-phenyl oxazolyl)-benzene.

Table 1. Distribution of radioactivities (cpm/g fr wt) of ethanol-soluble substances and unmetabolized IAA-¹⁴C extracted from each half segment in the middle portion of the stem in the vertical or horizontal rice plant, to which IAA-¹⁴C solution was applied through the eighth leaf for the preceding three hours.

sampling time	orientation of axis	each half of stem	radioactivity of ethanol extract*	% of IAA- ¹⁴ C	radioactivity of IAA- ¹⁴ C	ratio between two halves
0 h	vertical	left	6,042	51.60	3,118	50.5
		right	6,115	50.05	3,061	49.5
	horizontal	upper	4,612	52.05	2,401	40.0
		lower	7,149	50.45	3,607	60.0
3 h	vertical	left	10,251	52.65	5,500	50.7
		right	10,042	52.30	5,252	49.3
	horizontal	upper	5,908	63.05	3,725	32.0
		lower	12,421	63.70	7,912	68.0

Table 2. Average of radioactivities (cpm/g fr wt) in two halves of the same stem as described in table 1.

sampling time	orientation of axis	radioactivity of ethanol extract**	% of IAA- ¹⁴ C	radioactivity of IAA- ¹⁴ C	ratio of horizontal to vertical
0 h	vertical	6,079	50.83	3,090	100
	horizontal	5,882	51.25	3,015	97.6
3 h	vertical	10,137	52.48	5,320	100
	horizontal	8,974	63.38	5,688	106.9

*, ** Cited from the previous paper⁵⁾.

eighth internode and those of unmetabolized IAA-¹⁴C contained in the extracts are shown in table 1. In the plants from the vertical plot, radioactivities detected in the extracts from two halves were nearly equal in amount to each other, and they were increased from about 6,100 cpm at start to about 10,100 cpm three hours later. Among these radioactivities the rate of unmetabolized IAA-¹⁴C was at about 50.8% in the former and about 52.8% in the latter. Accordingly, specific radioactivities of IAA-¹⁴C itself amounted to about 3,100 cpm and 5,300 cpm, respectively, and IAA-¹⁴C distributed on each half of the stem showed a ratio of 50 : 50.

On the other hand, it was noticed evidently in both samples separately collected from the horizontal plot at two different times that the radioactivities of IAA-¹⁴C were detected in larger amount on the lower half of the stems, although they increased with the lapse of time,

as was seen in case of the vertical plot. And there was little difference in the rate of unmetabolized IAA-¹⁴C among the radioactivities of the extracts between upper and lower halves with the value of 51.3% at start and 63.4% three hours later, merely showing a large amount as the collecting time was delayed. Thus, it followed that the distributed amount of IAA-¹⁴C on both upper and lower halves was 2,400 cpm and 3,600 cpm at start with the distributed ratio of 40 : 60 and 3,700 cpm and 7,900 cpm three hours later with that of 32 : 68, respectively.

Making a comparison of the average of IAA-¹⁴C in the middle portion through summing up IAA-¹⁴C contents in each of two halves of the stem, there was no great difference between the vertical and horizontal plots either in specific radioactivities of the ethanol extracts or those of IAA-¹⁴C itself in the extracts at the time of the finish of IAA supply (table 2).

But three hours later, in spite of that specific radioactivities of the extracts were obviously larger in the vertical plot than in the horizontal, the rate of unmetabolized IAA-¹⁴C content in the extracts was reversely at 52.5% in the former and 63.4% in the latter, and it was thus noticed that the side of the horizontal plot had somewhat higher concentration in IAA-¹⁴C itself than that of the vertical plot.

DISCUSSION

The eighth internode in the middle portion of the stems is the region which is 13~22 mm long and in an advanced stage of the internodal elongation. In horizontal stems, furthermore, it is the region which is undergoing physiological changes for geotropic bending. As already mentioned, ethanol-soluble radioactive substances and IAA-¹⁴C itself were detected in equal amount from each of two left and right halves of the stems in the vertical plot both at the finish of IAA supply and three hours later, respectively. But in the horizontal plot radioactive substances soluble in ethanol and IAA-¹⁴C itself were detected at a higher level of concentrations from the extracts of the lower half of the stems than those of the upper, and an amount of lateral transport of IAA-¹⁴C increased with the lapse of time within the limits of six hours passage after start of the source supply. On the basis of general acceptance that auxins exogeneously applied to an intact plant move through phloem elements^{1,7)}, it naturally follows that the transportation and distribution of IAA-¹⁴C applied to the eighth leaf are probably controlled by the closeness of vascular connection between this leaf and each portion of the stems⁹⁾. Nevertheless, IAA-¹⁴C actually recovered from each of the left and right halves of the same stem in a vertical position was equal in amount. This may be attributable to the conditions in which the stem was longitudinally cut through the plane involving respective center of all tillering buds bearing on either side. In the horizontal plot,

all the plants were so fixed beforehand that they took a horizontal position together with that plane, and accordingly the ratio between IAA-¹⁴C content distributed in upper side and that in lower side of the horizontal stem is considered to indicate a general state of lateral distribution of IAA in the rice plant, independently of the closeness of vascular connection between each portion of the stem and the eighth leaf.

It was found that the horizontal stems exceeded to some extent the vertical in the average of auxin concentrations in the two halves three hours after the cessation of source supply. This is due to the fact that the horizontal plot exceeds the vertical by 10% or more in the rate of unmetabolized IAA-¹⁴C content among the ethanol-soluble radioactive substances, even though the former is lower in specific radioactivities of the extracts. On this connection, there is an evidence that unmetabolized IAA-¹⁴C is at higher rate in the region where growth is more vigorously occurring, and reverse in the region where it is less⁹⁾. According to the writer's observations earlier reported^{3,4)}, rice plants fixed their basal portions in a horizontal position just in the starting stage of internodal growth show marked elongation in their internodes with geotropic bending as well as an increase in the number of roots relative to those kept in a erect position, and also rice plants vertically kept bring about an acceleration of rooting and internodal elongation through the application of auxins.

Taking all these facts into account, the writer tentatively reached the following conclusions: when stems of the rice plant are placed in a horizontal position, not only auxins distributed in a radial symmetry in the stems become to redistribute in an asymmetrical manner with a concentration gradient from lower side to upper, but also auxins in an inactivated state at the time when the stems were kept in an usual, vertical position become to be activated in part through the stimulation

of unilateral pull of gravity, and thus the concentration of activated auxins in the stems is elevated to a level higher than that in the stems in a vertical position. It may be concluded that an increase of amounts of activated auxins in the lower halves of the stem in the rice plant horizontally kept is responsible for a marked geomorphosis brought about in the middle portion of the stem.

SUMMARY

For the purpose of inquiring into the effects of gravity on⁷⁾ formative activities, especially, accelerated geotropic elongation in internodes and acceleration in rooting activity of the rice plant, amounts of unmetabolized IAA-2-¹⁴C involved in the middle portion of the stem horizontally kept and supplied with the radioactive IAA were investigated.

Unmetabolized IAA-¹⁴C was separated through chromatography from the same extracts of middle portion of the stems as described in the previous paper⁵⁾, and was detected the radioactivities by a liquid scintillation counter.

An amount of unmetabolized IAA-¹⁴C in upper and lower halves in the middle portion of the stems horizontally placed shows a ratio of 40 : 60 at the finish of the source supply for three hours later, while that of the stems vertically kept shows a ratio of 50 : 50 in both left and right halves, irrespective of the passage of time.

It was found that in three hours after the finish of the source supply, horizontally placed stems have a tendency to somewhat exceed vertically kept stems in the average of unmetabolized IAA-¹⁴C content in the middle portion, because metabolized-¹⁴C in the latter is larger in amount.

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LITERATURE CITED

1. CRAFTS, A. S. 1951. Movement of assimilates, viruses, growth regulators and chemical indicators in plants. *Bot. Rev.* **17** : 203—284.
2. INOSAKA, M. 1962. Studies on the development of vascular systems in rice plant and the growth of each organ viewed from the vascular connection between them (in Japanese, with English resumé). *Bull. Fac. Agric. Univ. Miyazaki* **7**(1) : 15—116.
3. ISHII, S. 1969. Effects of gravity on intercallary growth in rice plant (in Japanese, with English resumé). *Bull. Nara Univ. Educ. (Nat.)* **17** : 117—130.
4. ISHII, S. 1969. Effects of Gravity and some growth regulators on the formation of roots and leaves in rice plants (in Japanese). *Report Kinki Branch Crop Science Soc. Japan* **14** : 61—66.
5. ISHII, S. 1969. Effects of unilateral gravitational stimulation on the transport and distribution of indoleacetic acid-2-¹⁴C exogenously applied to the rice plant (in Japanese, with English resumé). *Bull. Nara Univ. Educ. (Nat.)* **18** : 111—120.
6. LYON, C. J. 1965. Auxin transport in geotropic curvatures on a branched plant. *Plant Physiol.* **40** : 18—24.
7. WOODFORD, E. K., K. HOLLY and C. C. MCCREARY 1958. Herbicides. *Ann. Rev. Plant Physiol.* **9** : 311—358.

〔和 文 摘 要〕

水稲体に与えた IAA-¹⁴C の移動・分布に及ぼす重力の影響について（続報）——茎の中位部における未代謝の IAA-¹⁴C の分布量——

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水稲の形態形成，とくに背地的節間伸長と発根の促進に及ぼす重力の影響を明らかにするために，主軸を水平にして与えた放射性オーキシン（IAA-2-¹⁴C）が茎の中位部に未代謝の状態に含まれている量を測定した。すなわち，前報⁵⁾で述べた茎の中位部のエタノール抽出液からペーパークロマトグラフィーによつて未代謝の IAA-¹⁴C を分別し，液体シンチレーションカウンタを用いてその放射能を計測した。

水平茎の上下両半側における未代謝 IAA-¹⁴C の分布比は3時間のソース供与終了時には 40 : 60，その3時間後には 32 : 68 となり，時間が経過するにつれて茎の下側に分布するオーキシンが増加する傾向を認めた。しかし，直立茎ではいずれの場合にも左右両半側にほぼ等量の IAA-¹⁴C が分布していた。

ソース供与終了後3時間たつたときには，茎中位部に含まれる未代謝 IAA-¹⁴C の濃度を平均すると，直立茎よりも水平茎が若干優り，水平茎の中位部で背地的節間伸長と発根が促進される現象にこれら二つのことが関与しているのではないかと示唆された。