Stiffness of Clums in Cereals

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Lodging is one of the central problems associated with the low yield of cereals in Asia and is regarded frequently in the following cereals: rice, barley, wheat, corn and soybean.

Plant growth and kernel development are inhibited by lodging, and the above mentioned phenomena are one of the causes for the low yield of cereals.

Moreover, the kernels are injured by lodging so that the kernels quickly become inferior, and lodging is the cause of decreasing the efficiency of farming operations, too.

As we have seen, it is our problem to overcome lodging in order to obtain high yield in cereals.

Types of lodging study

Four types of the study in lodging are described in the literatures of cereals: (1) the interrelationships between plant stand and external forces to the plant, (2) the dynamics of culms for culm strength, (3) the physiological characteristics of culms versus the dynamical properties, (4) the effect of lodging to plant growth and plant production.

As one of the above mentioned, the study of item No. 1 has progressed as follows: the effect of rainfall energy or wind force to plant stand[1]. Moreover, the study of item No. 4 is conducted concerning the effect of lodging on nutrient absorption and translocation of photosynthates in plant[1].

At the present, the interrelationship between the growth regulators and plant growth is being actively investigated, the effect of prevention in lodging becomes clear, and the study of growth regulators in lodging of cereals is fraught with interesting facts.

Next, we will introduce a few of our recent studies on items Nos. 2 and 3 in six-rowed barley.

Stiffness of culms

In general, lodging occurs often at the heading stage in cereals. The main causes of lodging occurrence are considered as follows: the increase of moment in the whole plant and the increment of ear weight. On the other hand, as other important causes, we indicated the decline of growth in the culm tissues for the translocation from the culms and leaf sheaths to the ears.

The moment of the whole plant is indicated as follows: $M=WL\cos\alpha$, M=moment of the whole plant, W=load to the plant, α=bending angle of culms, L=distance of fulcrum (plant height).

It is considered necessary to obtain the resistancy of culms to the external forces for balancing the value of bending moment. Research has been conducted on the strength of culms in the aspects of structure and function of the culms for resisting external forces.

Physically, it has been studied from the aspect of dynamics. Those dynamical characteristics of culms are shown as follows: Young's modulus (E), moment of ineritia in cross sectional area (I), and bending moment at breakdown of culms (M).

A brittle culm variety, Sekitorisai-No. 1, and a stiff culm variety, Haganemugi (*Hordeum sativum*, Jessen) were to study the relation between Young's modulus (E), moment of inertia (I), and bending moment[2), 3), 4)].

There was not much difference of Young's modulus between both varieties, but Young's modulus in Sekitorisai-No. 1 was slightly larger than that of Haganemugi[4)]. Regarding the position of internodes and nodes, it was recognized that the uppermost position of internode and node had the largest Young's modulus, medium in the base position, and the smallest in the intermediate position (Fig. 1).

The bending moment and moment of inertia in Haganemugi were apparently higher than in Sekitorisai-No. 1, because there was more sufficient growth of culms given in the former (Fig. 1).

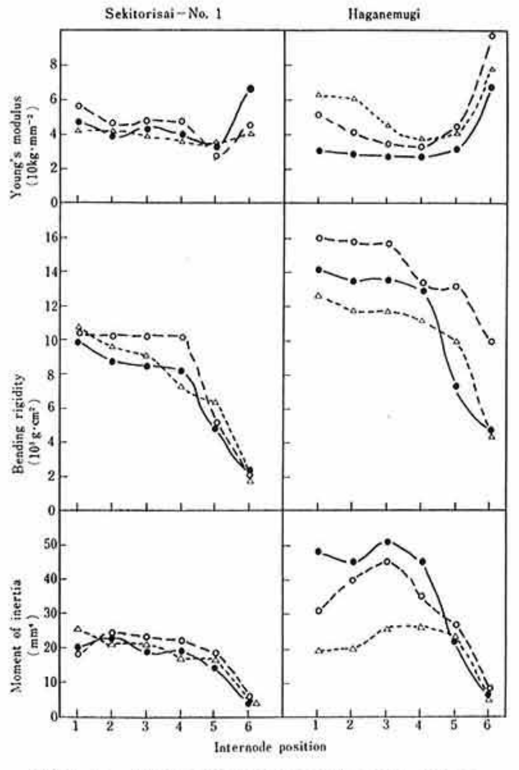

Fig. 1. Dynamical properties in culms.

Note:	Sign	Measuring date
	—●—	April 22
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In this case, on the assumption that the culm is a long pillar, the described formula obtained: $P=\pi EI/4L^2$, P=buckling load, E=Young's modulus, I=moment of inertia, L=length of pillar.

In the formula, assuming that the length of pillar (L) is constant, the value of (P) is influenced by the value of (EI) (=bending rigidity).

Theoretically, Young's modulus and moment of inertia have the same relation to the bending rigidity. Therefore, culm stiffness is obtained by improvement of (E) value or (I) value (Fig. 1, Fig. 2). Subsequently, it may be indicated that improvement (E) or (I) value is different in kinds of cereals.

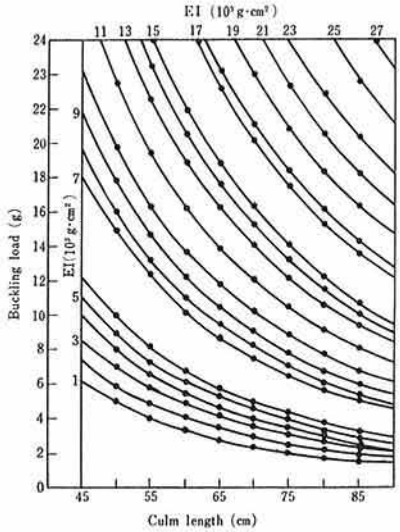

Fig. 2. Interrelation of buckling load and culm length.

Interrelationship between dynamical properties and physiological characters

It is necessary to clearify the interrelationships of (E), (I) and other dynamical properties and morphological, physiological characteristics of plant.

The moment of inertia (I) is determined from the different outer and inner diameter of culms. So, the moment of inertia is related to the structure and growing amount of culms. Next, Young's modulus (E), it is not clear from the experiment data; it may be related to the vascular bundle number per unit cross sectional area in culms and turgor pressure of culm tissues.

On the above mentioned, the moment of inertia (I) is related to the quantitative character of culms and Young's modulus (E) is related to the qualitative character in morphogenic process of culms.

On the other hand, localized accumulation of some chemical substances (pectin and lignin) in the tissues during the culm formation may be highly related to culm stiffness

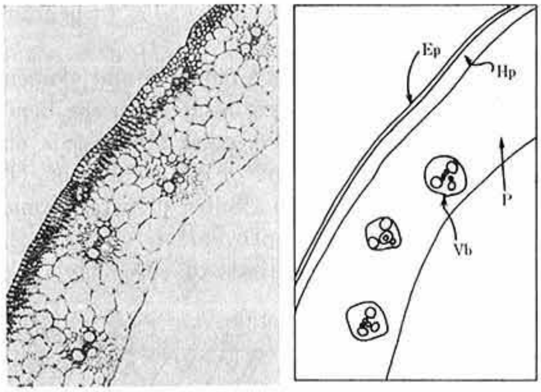

Fig. 3. Photographs showing histochemical features of culms.
Fig. 3-1. Variety, Sekitorisai-No. 1.
2nd internode.
Reaction for lignin.
7 × 10

Note:
(1) Ep; epidermis
Hp; hypodermis
P; parenchyma tissue
Vb; vascular bundle
(2) Position of internode and Node was determined from base to top, 1, 2, . . ., n.

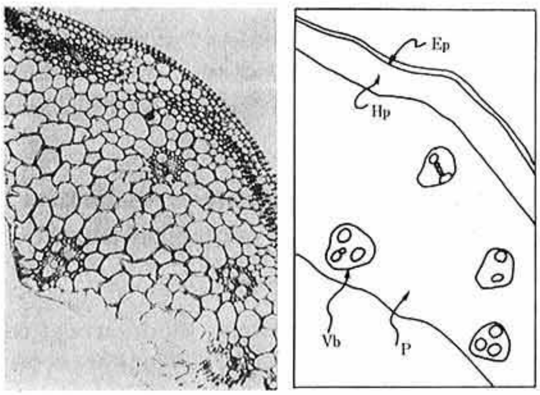

Fig. 3-2. Variety, Haganemugi.
2nd internode.
Reaction for lignin.
7 × 10

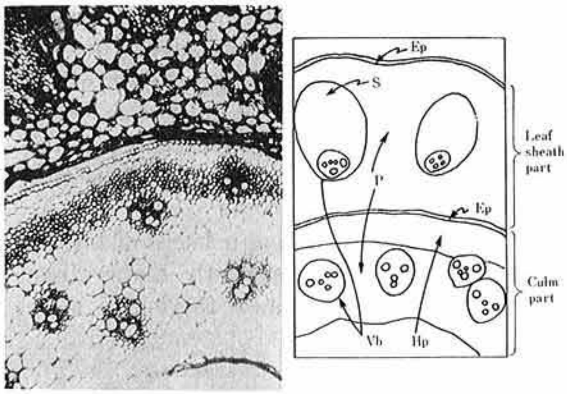

Fig. 4. Photograph showing histochemical features of thickness part in the nodes.
Fig. 4-1. Variety, Sekitorisai-No. 1.
1st node.
Reaction for lignin.
7 × 10

Note:
Ep; epidermis
Hp; hypodermis
P; parenchyma tissue
Vb; vascular bundle
S; sclerenchyma tissue

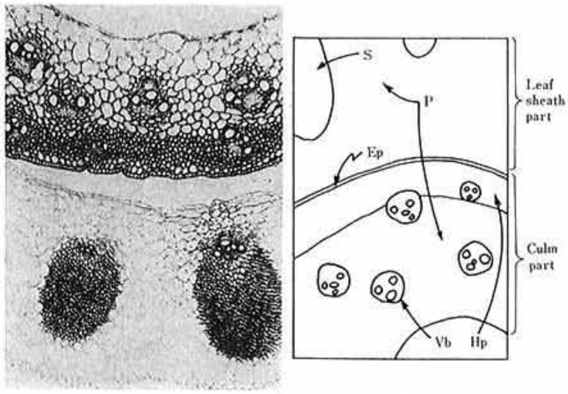

Fig. 4-2. Variety, Haganemugi.
1st node.
Reaction for basophile substances.
7 × 10

from the histochemical study (Photo. 1 and Photo 2)[5), 6)].

In conclusion, high resistancy to lodging in plant is obtained by the promotion of culm growth. But, on the assumption that the photosynthates amount in plant is constant, it is considered meaningless that the ear growth is declined and the culm growth is promoted dominantly for culm stiffness and high yield.

From the ^{14}C-tracer methods study of photosynthates, the distribution balance of photosynthates to the culms and the ears is vital for culm stiffness and high yield in cereals (Fig. 3)[7), 8)].

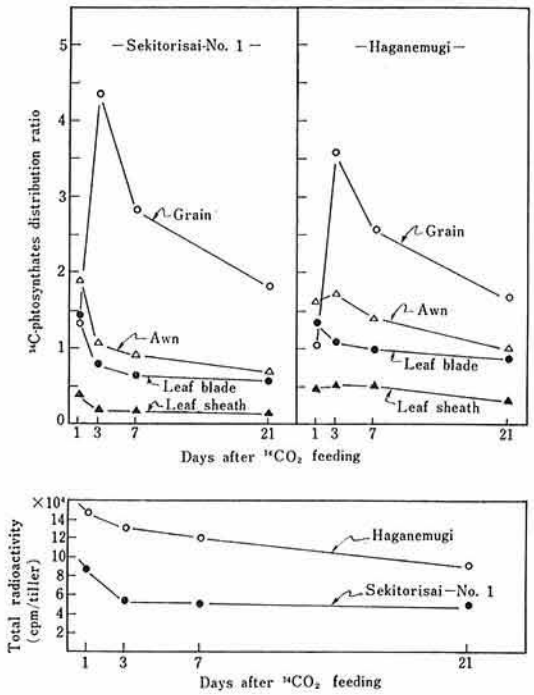

Fig. 5. Distribution pattern of ^{14}C-photosynthates.

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