Cultural Significance of Physical Strength of Rice Root

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In recent years, the problem of the difficulty in pulling out seedlings from nursery beds is becoming more important for mechanization of transplanting operation, and the request for prevention of root lodging[7] is increasing with the progress of extension of direct sowing culture.

Both problems—pulling out seedlings and root lodging—are related to the physical strength of the root. However, very little information on it has been available as yet.[8] Thus, some investigations have been attempted.[4,5]

Materials and methods

The materials used as samples are the crown roots of 27 varieties in all shown in Table 1.

The method of measuring the root strength is shown in Fig. 1. Each root was cut into pieces of 5 cm in length. Both ends of the cut root were kept uniform and held between the thumb and forefinger to be drawn on a spring balance.

Fig. 1. Method of measuring physical strength of root.

Table 1. Rice varieties used

Japanese varieties		
(1) *Manryoo*	(2) *Koshihikari*	(3) *Yamakogane*
(4) *Tangin*	(5) *Yachikogane*	(6) Noorin-No. 37
(7) *Shinanohikari*	(8) Hokuriku-No. 77	
(9) *Hooyoku*	(10) Noorin-No. 25	(11) *Koshihibiki*
(12) *Murasaki-ine*	(13) Noorin-No. 36	
(14) Hokuriku-No. 52	(15) *Hatsunishiki*	
(16) Noorin-No. 41	(17) *Chibaasahi*	
Foreign varieties		
(18) Rituchiang*	(19) Yinnen**	(20) Nira
(21) Loktjan	(22) Tetep	(23) Tadukan
(24) Oerang Oeragan	(25) Zenith	(26) Balilla
Japanese deformed variety		
(27) *Yachikogane*-mutant		

* Reishikoo in Japanese
** Ginnen in Japanese

The least load of spring tension for snapping the material was regarded as the strength of the root. The position of the root for measuring the root strength was unified at the point 5 cm apart from the root base.

Results and discussions

1) Significance of root strength in pulling out seedlings

The varietal difference in difficulty in pulling out seedlings was examined by using four varieties grown under the same raising condition.

This experiment was made by regarding both the root strength and the number of roots as the constituents of the resistant power for pulling out the seedlings.

As shown in Fig. 2, the average strength

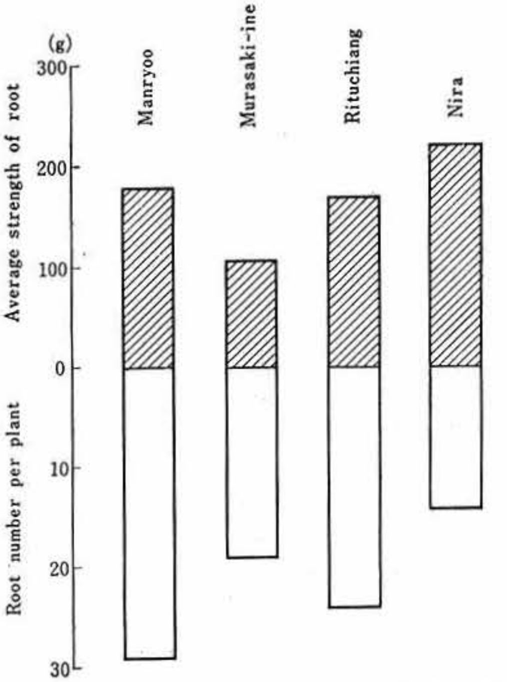

Fig. 2. Varietal difference in the root strength and in the root number of rice seedling.

of the root was in the following order: Nira>Manryoo>Rituchiang>Murasaki-ine, while the number of the root stood in the order: Manryoo>Rituchiang>Murasaki-ine>Nira.

The order of the product of the average strength and the number of roots among different rice varieties were the same with that in the difficulty found in pulling out the seedlings.

In order to clarify the cause for the varietal differences in the root strength, the cross-sectional area of roots of the 27 varieties was measured just before transplanting. The results are shown in Fig. 3.

The average cross-sectional area of the roots showed a close relationship with the average root strength. However, it was recognized that there were some varieties that had different

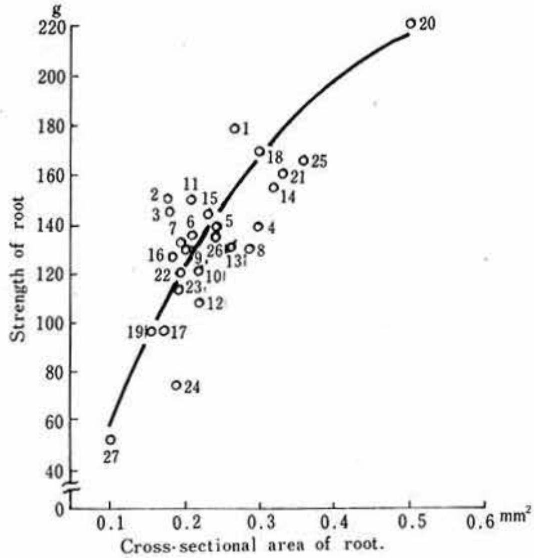

Fig. 3. Varietal difference in relationship between average cross-sectional area and average strength of rice roots just before transplanting.

Note: Symbols are the same as Table 1.

root strength, but had no significant difference in the average cross-sectional area.

In order to make clear this point, studies were conducted on the regression formula between two characters and on the inner structure of roots.

The relationship between the root strength (y) and the cross-sectional area (x) of the individual root was represented by a hyperbolic curve on each variety (Fig. 4). However,

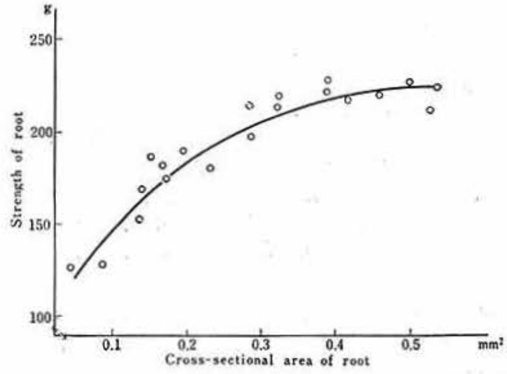

Fig. 4. Relationship between cross-sectional area and strength of individual root in variety Manryoo.

logarithms of a and b about each variety are plotted on a straight line whose regression formula is represented by the expression: $\log y/x = a + b \cdot \log x$ (where a and b are constants, and $0<b<1$).

And the varietal difference in constants a and b seems to cause the one in rate of root strength to cross-sectional area.

This varietal difference in a and b led to the investigation on the structure of the root.

As the results of histological study, the number of vessels of metaxylem II[2] and the thickness of fiber cell wall in xylem were proved to be the most important among many properties of roots.

As shown in Fig. 5, the root strength has

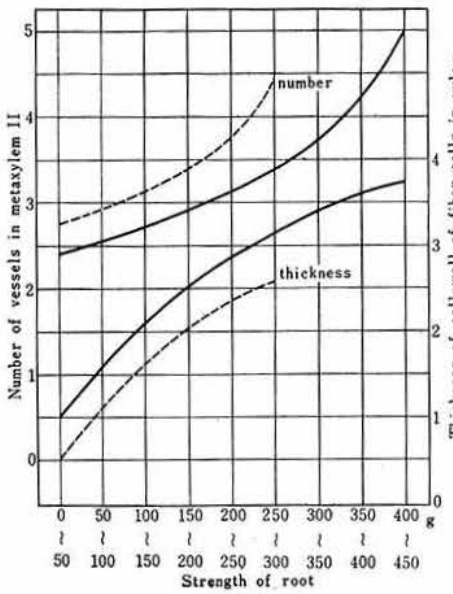

Fig. 5. The relationship between strength of root and number of vessels in metaxylem II or thickness of cell-wall of fiber cells in xylem.

Note: 1. —: Manryoo; - - -: Murasaki-ine.
2. Thickness of cell-wall was classified into 4 grades by observation.

a close bearing upon the number of vessels. This seems to be ascribed to the effect of the mechanically strong action of thick wall of vessels on the roots. A close relationship can also be found between the thickness of the fiber cell wall and the strength of the root.

The fact that Manryoo is greater than Murasaki-ine in root strength and different in the values of constants a and b might be explained not only by the superiority in the number of vessels but also the one in the thickness of the fiber cell wall.

2) Relationship between root strength and lodging

(1) Effect of drainage on the strength of individual root

Among three ways of water management shown in Table 2 in the condition of shallow

Table 2. Three ways of water management

Type of plots	Water management
Control plot	Water-logging throughout the entire stage.
Earlier drainage plot	Irrigation was stopped during the period from the end of the valid tillering stage to panicle primordium differentiation stage.
Later drainage plot	Irrigation was stopped during the period from the panicle primordium differentiation stage to heading stage.

transplanting into soil, the rice plant in control plot was subject to root lodging. On the contrary, the one in "later drainage plot" inclined a little only, and the one in "earlier drainage plot" scarcely inclined. To explain this difference in resistance for root lodging, the individual root strength was measured on a shoot unit[3] basis with special reference to the upper and lower roots.[3]

As can be seen in Fig. 6, the strength of the lower root is greater than that of the upper one. This can be explained by the superiority of the lower root in the cross-sectional area because the positive correlation was found between the strength and the cross-sectional area as aforesaid.

Of all shoot units, the strength of the tenth one was the greatest. This can be explained by Fujii's observation[1] showing that the cross-sectional area is greatest in this shoot unit.

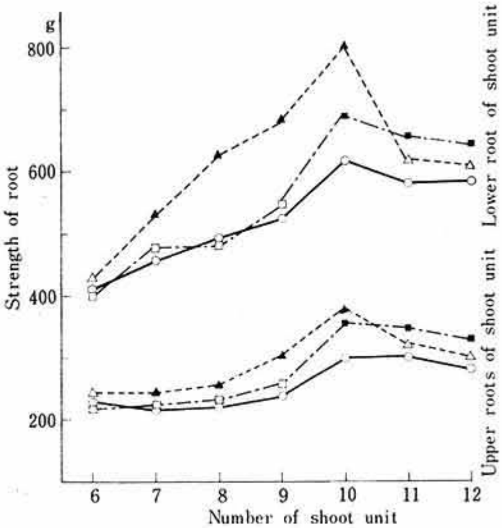

Fig. 6. Effect of drainage on the strength of individual root.

Legend:

	Grown in water-logged period	Grown in drained period
Control plot	○	
Earlier drainage plot	△	▲
Later drainage plot	□	■

Note: * Number is counted from the lowermost. Strength of root is represented by the average value of 30 roots.

It is interesting to note that the shoot unit which has the greatest root strength coincides with the one which has vertically elongated roots at the highest ratio.[3] Accordingly, it can be concluded that the anchoring action of this shoot unit is greatest in case of root strength as well as in case of elongating direction.

Distinct increase of the root strength by drainage practice can be recognized only in the shoot unit whose roots have developed in the draining period and can not be recognized in the strength of roots which developed after re-irrigation.

The increase of the root strength by drainage seems to be supported both by diminution of the root rot and promotion of the thickening of the cell wall.[6]

(2) Varietal difference

Some experiments were tried in order to trace the relationship between the root strength and the breaking strength of culm of 27 varieties after two weeks of each heading.

The following results were gained by measuring the average strength of roots that emerged from the ninth and tenth shoot units, the breaking strength[9),10] of the No. 3 internode (culm together with leaf-sheath), and the oxidation capacity of α-naphtylamine of root.[11]

As shown in Fig. 7, close relationship exists

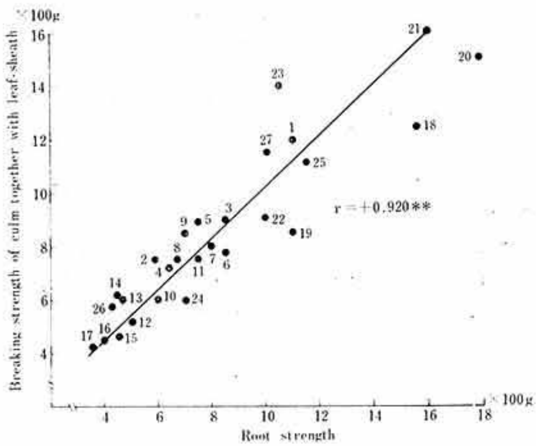

Fig. 7. Relationship between root strength (average strength of root that emerged from the ninth and tenth shoot units) and breaking strength of culm (No. 3 internode).

Note: Symbols are the same as those in Table 1.

between the strength of the root and the breaking strength of the culm. Varieties that have bigger root strength tend to become greater in the breaking strength of the culm. Accordingly, culm strength at the ripening stage can be estimated by the root strength at the same stage with a certain degree of accuracy.

Such varietal differences in root strength at the ripening stage were closely related with the oxidation capacity of α-naphtylamine of roots examined 20 days before heading as shown in Fig. 8.

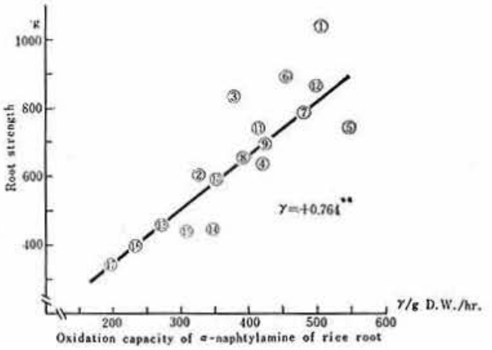

Fig. 8. Relationship between oxidation capacity of α-naphtylamine of rice root and root strength.

Note: Symbols are the same as those in Table 1.

This seems to give a suggestion that thickening of the cell-wall of the root tissue which is related with the root strength is promoted in case of having greater oxidation capacity of α-naphtylamine at its growing period.

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