Physiological Significance of Lysigenous Lacunae in the Rice Plant Roots

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Several lines of investigation have been carried out on the formation of lysigenous lacunae of rice plant roots. The results obtained so far, however, do not agree with each other on the mechanism of formation and physiological significance of the lacunae.

It was reported by many investigators[1), 6)] that the development of the lacunae of rice plant roots growing under anaerobic soil conditions was remarkable as compared with that of aerobic soil conditions. It was assumed that oxygen needed for root respiration would be supplied mainly by leaves via stems and lysigenous lacunae when the rice plant was kept in anaerobic soil.

On the other hand, an investigator[3)] asserted that the physiological role of lysigenous lacunae of rice plant roots should be re-examined from the formation of lysigenous lacunae that had relations with the development of lateral roots, the formation of lateral roots in the soil of paddy field that was generally accelerated when it was in an oxidative state and the development of lacunae, on the contrary, that was slowed down when the soil was reductive.

Relation between formation of lysigenous lacunae and lateral roots under oxidative and reductive soil conditions[4)]

In an attempt to throw light on the differences observed in these works, the histogenesis and the changes in the volume of lacunae[2)] and lateral roots were studied in rice seminal roots growing under two kinds of soil conditions in oxidation-reduction potentials.

The formation of lysigenous lacunae (hereinafter referred to as cortical disintegration) may be consisted of two phases, emergence and enlargement.

The emergence of cortical disintegration was always observed with the primordia of

Table 1. Relation between the emergence level (distance from root base) of cortical disintegration and lateral root anlage

Item / Days after bedding	oxidative condition			reductive condition		
	Seminal root length	emergence level of cortical disintegration	emergence level of lateral root anlage	Seminal root length	emergence level of cortical disintegration	emergence level of lateral root anlage
(day)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)
2	3.0	—	—	2.0	0.3	—
3	5.0	2.5	3.0	3.3	2.5	2.2
4	7.3	5.5	5.7	5.1	4.5	4.7
5	13.0	12.0	11.2	8.3	7.5	7.8
7	19.0	17.5	17.4	11.8	10.5	9.8
9	20.5	19.0	18.7	13.0	11.5	11.3
13	21.0	20.0	19.1	13.8	13.0	12.5

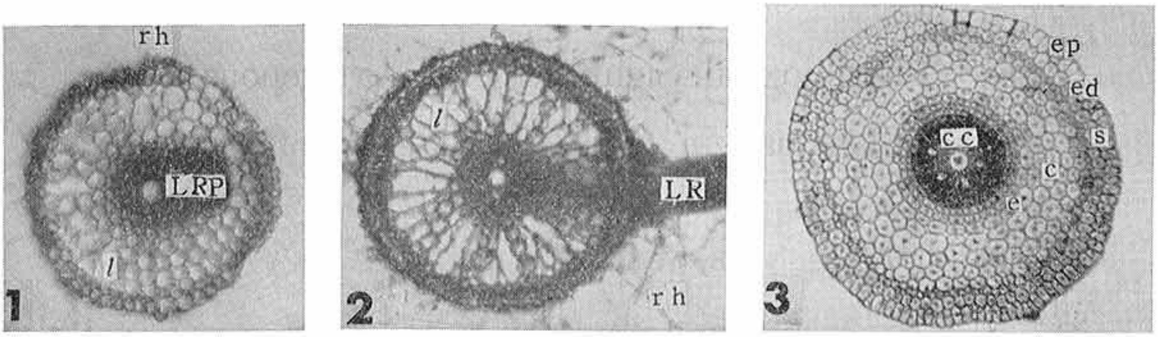

Plate 1 and 2 show the cross sections in rice seminal root at 1 to 3 cm distance from root base, growing under reductive soil conditions 5 days after bedding (× 70). Plate 3 is a cross section at 2 mm distance from root tip, 5 day after bedding (× 75). Plate 1 showes the emergence of lysigenous lacunae. Plate 2 showes the completion of this tissue. Lacunae is separated by cords of a Y character. cc: central cylinder. c: cortex. e: endodermis. ed: exoderims. ep: epidermis. l: lacunae. LR: lateral root. LRP: lateral root primordia. s: sclerenchyma. rh: root hair.

lateral roots (table). Plates indicate that the formation of the lateral root primordial are noticeable in the opposite side of the emergence position of the cortical disintegration, that the cortical disintegration is not a rhexigenetic process of cortical cells but a shizogenous one, and consequently the lacunae are separated by cords which are in equal number of rows of cortical cells radially arranged.

The enlargement of cortical disintegration was observable more distinctively in the roots growing under oxidative soil conditions (hereinafter referred to as O) than in the roots growing under reductive soil conditions (hereinafter referred to as R) for 4 days after bedding. Though there were little differences in the density of lateral roots and the primordial on the same aged parts (e.c. was 0.9 cm length from root base in O and 0.6 cm in R), for 4 days after bedding O exceeded distinctly R in the volume of lateral roots per centimeter

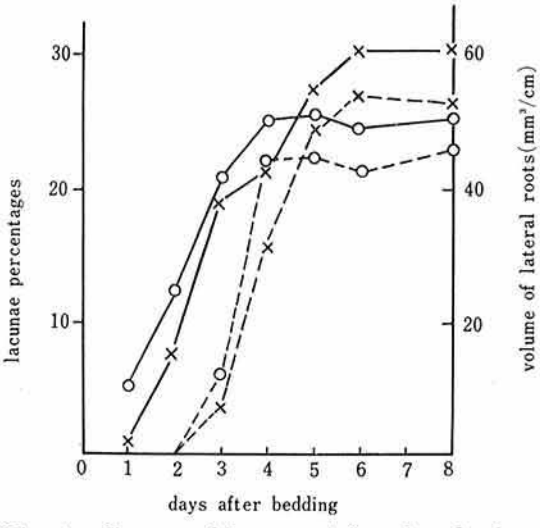

Fig. 1. Changes of lacunae % (——) and volume of lateral roots (. . . .) with time after bedding. ○: oxidative condition. ×: reductive condition.

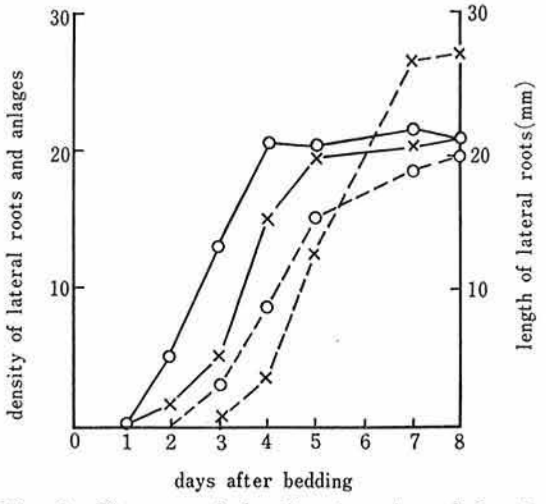

Fig. 2. Changes of density (——) and length (. . . .) of lateral roots and anlages with time after bedding. ○: oxidative condition. ×: reductive condition.

and the growth of lateral roots in length of which the longest lateral roots represented each region mentioned above. On and after the 4th, R was superior to O in the percentages of lacunae, the volume of lateral roots and the growth of lateral root in length (Fig. 1 and 2).

On the basis of such results, it was assumed that the emergence of cortical disintegration and the initiation of lateral roots have a close relationship with each other in time and position, and enlargement of cortical disintegration was restricted by the velocity and the volume of the growth of lateral roots.

Anyhow, the results of this experiment seem to indicate that whether the development of cortical disintegration will become well in R or O, depends mainly on the growth of lateral root in volume or velocity.

A difference, as previously stated, in observations among investigators with reference to the extent of the development of cortical disintegration in R and O may be consolidated by these results.

Energy supply to elongation of root axis and lateral root growth[5)]

These experiments, using the rice seedlings from 1 to 14 days after bedding, were carried out to throw light on the relations among the nitrogen and phosphorus metabolism, the growth of various seedling organs and the cortical disintegration in seminal roots.

In 3 days after bedding, the adventitious and lateral roots emerged on the seedling axis. Length of seminal root elongation per day, and initiation and development of lateral roots were most vigorous in this stage (Fig. 3 and 4).

Increase of the total nitrogen and phosphorus contents in seminal roots came to the saturation level in 6 and 4 days after bedding respectively (Fig. 5). But, after that the elongation of the seminal root went on for 10 days to attain 50 to 60% of the final length. This result indicates that the elongation of the seminal roots depend upon the nitrogen and phosphorus derived from aged tissues after supply of the same to seminal root ceased.

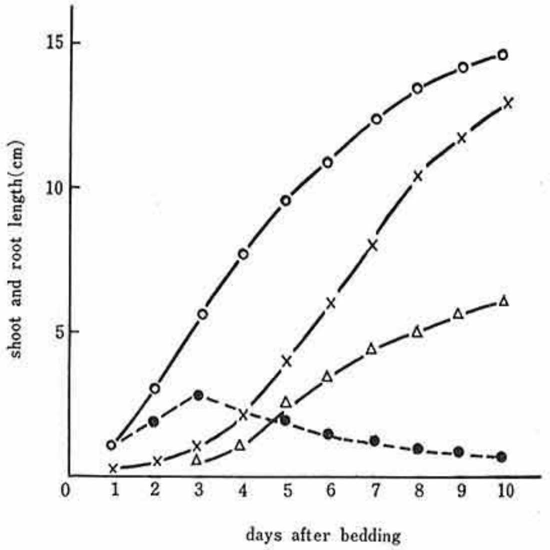

Fig. 3. Changes of shoot (X–X), seminal root (O–O), adventitious root (Δ–Δ) length and per day length of seminal root elongation (●····●) with time after bedding.

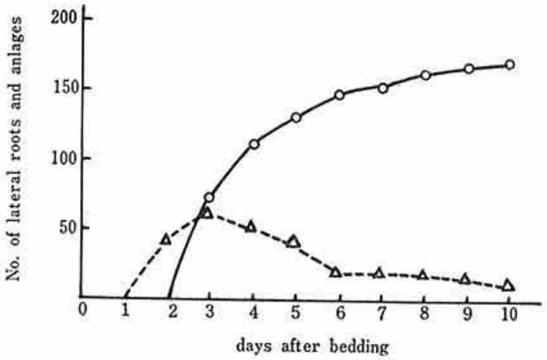

Fig. 4. Changes of No. of lateral root (O–O) and of lateral root anlages (Δ····Δ) with time after bedding. (per seminal root).

While the increase of total nitrogen and phosphorus contents of seminal root cylinder (seminal root cutting off lateral roots) took 3 days after bedding to be saturated it began to decrease later on (Fig. 5). These results show that the nitrogen and phosphorus contents of the root cylinder might have moved to the lateral roots.

The formation of lacunae began 2 days after

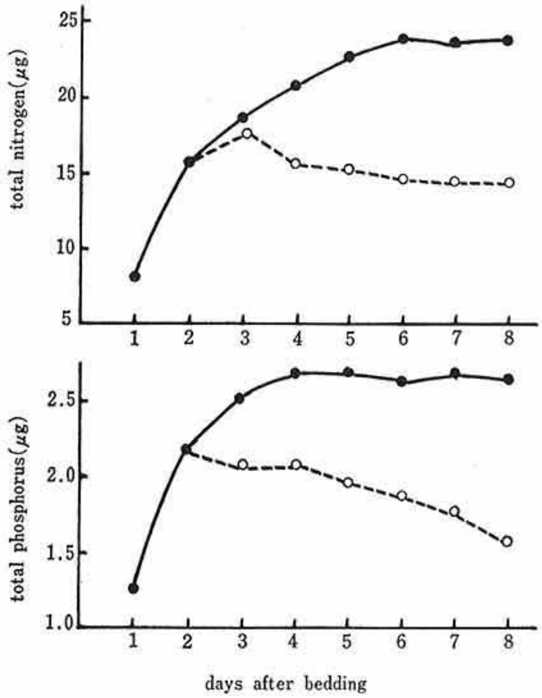

Fig. 5. Changes of total nitrogen and phosphorus contents (μg/seminal root) at seminal root (●—●) and seminal root cylinder (○⋯○) with time after bedding.

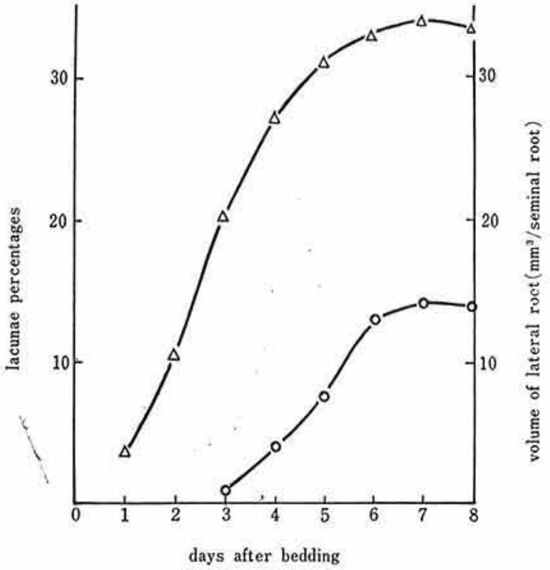

Fig. 6. Changes of lacunae % (Δ—Δ) and volume of lateral roots (○—○) with time after bedding.

bedding and developed rapidly till 6 days after bedding (Fig. 6). The initiation and development of lateral roots, closely related to the lacunae emergence and enlargement, proceeded to keep pace with them (Fig. 6).

On the other hand, soluble fraction of nitrogen and phosphorus compounds changed remarkably from 1 to 4 days after bedding (Fig. 7 and 8). SPN means that the cytoplasmic

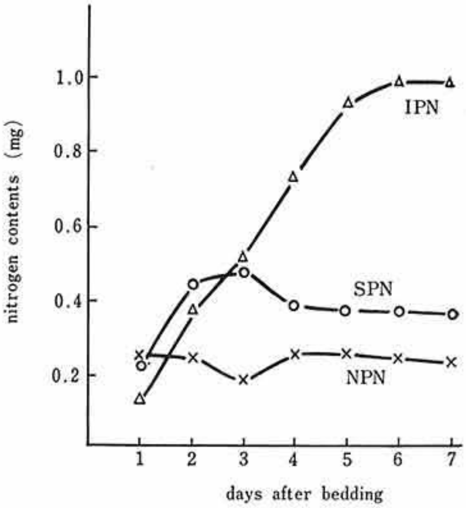

Fig. 7. Changes in nitrogen metabolism with time after bedding. (mg/100. seminal roots) IPN: insoluble protein nitrogen. SPN: soluble protein nitrogen. NPN: non-protein nitrogen.

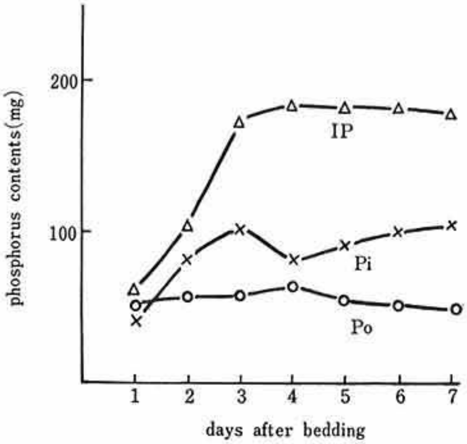

Fig. 8. Changes in phosphorus metabolism with time after bedding. (mg/100 seminal roots) IP: insoluble organic phosphorus. Pi: inorganic phosphorus. Po: soluble organic phosphorus.

protein nitrogen increased from 1 to 3 days after bedding. Nevertheless the maximum growth rate was found at 3 days after bedding, the increasing rate of SPN at 1 to 2 days was higher than 2 to 3 days after bedding. As the process of the cortical disintegration can be regarded as the catabolic process of cytoplasmic protein, the synthetic process of cytoplasmic protein is superior than that of catabolic one for 1 to 2 days after bedding; both processes are in equilibrium for 2 to 3 days after bedding and after that the catabolic one is dominant.

In 4 days after bedding, SP containing soluble organic phosphorus compounds decreased, whereas the inorganic phosphorus increased (Fig. 8). Generally speaking the decrease of $\sim$P level shows that in the metabolic pattern synthetic character is converted into the catabolic and in the functional pattern, the developmental one into the preservative. This result indicates that these changes of metabolic pattern take place in the seminal root at 4 days after bedding.

The collective estimation of the physiological significance of the cortical disintegration by these results is that this physiological role may be the system of energy supply to elongation of the root axis and lateral root development.

The stage of the changes of the metabolic pattern in seminal root agrees with that of the beginning of adventitious root growth. The root system of rice plant consists of numerous adventitious roots emerged from the nodes. The seminal root is an adventitious root emerged from the node of coleoptile. It seems that there is a hard competition of nutrients, supplied from endosperm or shoot so that the process of cortical disintegration may be considered a reasonable one, taking into account the material economy for rice plants, having much load of roots.

At the same time, other roles of lysigenous lacunae seem to be proper that it may serve as air pipe(1), (8) for rice roots, growing under anaerobic soil conditions, and that it may give the rice roots the physical stability,(7) fixing a plant body in the soil, like that suggested by many investigators.

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