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Relation between Characteristics and Rooting Activity of Rice Seedlings (*Oryza sativa* L.) with Special Reference to Amylase Activity**

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Abstract : The authors examined the difference in the characteristics of rice seedlings (*Oryza sativa* L.) grown under different growth conditions, especially the relation between rooting activity and amylase activity.

The characteristics of rice seedlings on 14 days after seeding were judged by the rooting activity test. In the low density and high temperature plot the qualities of seedlings were good : in the upland, 1/2N, 3/2N and low temperature plots qualities were the same as in the control plot, but in the high density, lowland and shaded plots they were poorer than those in the control plot. While on 28 days after seeding, in the low density, upland and low temperature plots the qualities were better than those in the control plot : in the high density, lowland and high temperature plots the qualities were not so good, and in the shaded plot they were even poorer.

On 14 days after seeding, rooting activity showed a significant correlation with leaf age, plant length, leaf sheath diameter, leaf dry weight, root dry weight and amylase activity. While on 28 days after seeding, rooting activity showed a highly significant correlation with nitrogen content, starch content and amylase activity.

Seedlings with higher starch accumulation, that is higher amylase activity, showed better rooting activity and good quality.
Key Words : Amylase activity, Characteristics of Rice Seedling, *Oryza sativa* L., Rooting activity.

水稲苗の素質と発根力との関係—とくにアミラーゼ活性に着目して—：田中尚道・*西川欣一・*秋田謙司（神戸大学大学院自然科学研究科・*神戸大学農学部）

要　旨：水稲苗の発根力と苗の素質並びにアミラーゼ活性との関係を明らかにするために，水稲品種日本晴を用い，異なる10種類の育苗条件下で苗を栽培し，苗の素質と発根力及びアミラーゼ活性との関係を播種後14日目及び28日目の苗について解析した．

苗の発根力から判断すると，14日苗では薄播区，高温区の苗の素質は良く，畑区，1/2 N 区，2/2 N 区，3/2 N 区及び低温区の苗は標準区と同様の素質であったが，厚播区，湛水区及び遮光区の素質は劣った．一方，28日苗では薄播区，畑区，低温区及び3/2 N 区標準区に比べ苗の素質は良く，厚播区，湛水区，高温区及び1/2 N 区の素質は劣り，遮光区の苗の素質は著しく劣った．

発根力と苗の諸形質との関係は，14日苗では葉令，草丈，葉鞘の太さ，葉身重，根重及びアミラーゼ活性との間に有意な正の相関関係が認められた．一方，28日苗では発根力と窒素含有率及びアミラーゼ活性との間に正の相関関係が認められたが，形態的特性との間には関係はみられなかった．また，どの生育段階においても苗の発根力とアミラーゼ活性との間には極めて密接な関係がみられ，発根力試験におけるアミラーゼ活性の高い苗ほど素質はよいものと思われた．
キーワード：アミラーゼ活性，水稲，苗の素質，発根力．

It is well known that the rooting activity of rice seedlings is related with higher starch accumulation in leaf sheath and a good quality of rice seedlings[1,2,4-6,10-12], therefore the rooting activity test of seedlings is used to evaluate quality of rice seedlings. And also since saccharides, such as sucrose in concerned in rooting[3,10-12], we regard that starch in leaf sheath is resolved by amylase and then being used in the rooting of seedlings.

The present study was therefore undertaken to make clear the growth pattern of rice seedlings under different conditions, especially under different seeding rate, shading, soil moisture, nitrogen fertilizer dose and temperature. We investigated the morphological characteristics, chemical components and rooting activity of rice seedlings, and analyzed the relation between rooting activity and amylase activity.

Materials and Methods

The study was conducted at the Faculty of Agriculture, Kobe University from 1986 to

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1987. Variety Nipponbare was grown in seedling cases. The experimental design in shown in Table 1. On the 14th and 28th day after seeding, leaf age, plant length, leaf sheath length, leaf sheath diameter, dry weight of leaves and roots, rooting activity, total nitrogen content and amylase activity were measured at 10 a.m.. The nitrogen content was measured by the Kjeldahl method and the starch content by the Somogi-Nelson method. Rooting activity and amylase activity were measured by the same method described previously[8,9].

Results

1. Seedlings on 14 days after seeding

The average morphological characteristics of rice seedlings measured on the 14th day after seeding are presented in Table 2. During the first 14 days from the seeding, rice seedlings showed the most vigorous growth in the high temperature plot, having the greatest value in plant length, leaf sheath length, leaf sheath diameter, dry weight of leaves, leaf sheath and roots, while rice seedlings in the shaded plot were spindly and poor. In the upland, lowland, 1/2N and 3/2N plots, rice seedlings showed the same morphological characteristics as in the control plot. However, in the high density plot, plant length and dry weight of each organs tended to grow less than those in the control one.

The total nitrogen content of the whole plant measured on the 14th day after seeding is presented in Table 2. The nitrogen content of the whole plant was significantly different under different growth conditions. A higher content of nitrogen was observed in the low density, 3/2N and high temperature plots than in the control plot. In the low temperature plot, it was the same as that in the control one, while a lower nitrogen content than that in the control was observed in the shaded, high density, upland, lowland and 1/2N plots.

The starch content of leaf sheath measured on the 14th day after seeding is shown in Table 2. The higher starch content of leaf sheath than that in the control plot was observed in the low density, 1/2N and low temperature plots. In the high density, upland, lowland, 3/2N and high temperature plots, the starch content was nearly the same as thet in the control plot, and the lowest content was observed in the shaded plot.

The effect of different growth conditions on the rooting activity on the 14th day after seeding, are shown in Table 2. In the low density, upland, 3/2N and high temperature plots, the rooting activity was higher than that in the control plot. However, in the shaded, high density, lowland, 1/2N and low temperature plots, the rooting activity was lower than that in the control one.

Fig. 1 showed the relationship between rooting activity and amylase activity of leaf sheath. The rooting activity clearly increased with the increase in amylase activity, resulting in a high, significant correlation coefficient ($r=0.650^*$).

Table 1. Experimental design.

Experimental plot	Seeding density	Fertilizer N	Fertilizer P_2O_5	Fertilizer K_2O	Soil moisture	Shading rate
1. control	120(g)	1.50(g)	1.0(g)	0.75(g)	90(%)	0(%)
2. shaded	120	1.50	1.0	0.75	90	70
3. low dens.	80	1.00	1.0	0.75	90	0
4. high dens.	160	2.00	1.0	0.75	90	0
5. upland	120	1.50	1.0	0.75	70	0
6. lowland	120	1.50	1.0	0.75	120	0
7. 1/2N	120	0.75	1.0	0.75	90	0
8. 3/2N	120	2.25	1.0	0.75	90	0
9. low temp.	120	1.50	1.0	0.75	90	0
10. high temp.	120	1.50	1.0	0.75	90	0

1. High and low temperature plots were controled at 25/25°C and at 25/15°C (day/night) between 6.00 to 18.00 under natural daylight, respectively.
2. Seeding density and fertilizer show the rate per nursely box (60×30cm 3cm in depth).
3. As for soil moisture conditions refer previous report[8].

Table 2. Effects of different growth conditions on the growth characteristics at 14 days after seeding.

Experimental plot	Leaf age	Plant length (cm)	Leaf sheath length (mm)	Leaf sheath diameter (mm)	Dry weight (mg)			Nitrogen content (mg)	Starch content (mg)	Rooting activity
					L.B.	leaf sheath	root			
1. control	3.6	15.4	7.1	2.5	8.0	6.2	3.2	0.62	0.94	6.1
2. shaded	3.0	17.9	10.2	1.4	4.0	5.7	1.9	0.53	0.37	1.8
3. low dens.	3.9	17.3	6.3	2.9	9.4	5.2	2.9	0.73	1.22	7.8
4. high dens.	3.2	11.0	4.5	2.5	5.5	6.6	4.5	0.53	0.76	2.6
5. upland	3.3	12.0	4.8	2.5	6.1	6.6	3.4	0.58	0.84	7.4
6. lowland	3.5	13.7	5.1	2.5	6.7	6.9	3.7	0.54	0.68	4.0
7. 1/2N	3.5	14.0	5.7	2.9	6.3	6.1	7.3	0.57	1.10	5.6
8. 3/2N	3.8	19.3	7.2	3.0	9.4	7.3	8.0	0.67	0.71	7.8
9. low temp.	3.1	13.2	5.2	2.5	5.6	6.4	4.1	0.62	1.74	5.2
10. high temp.	4.3	12.8	12.9	3.0	10.4	8.4	8.3	0.82	0.94	9.9

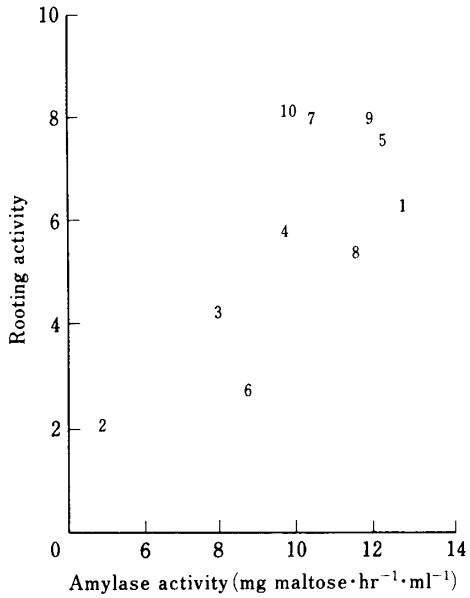

Fig. 1. Relation between rooting activity and amylase activity at 14 days after seeding. Experimental plot numbers are the same as those in Table1.

Table 3. Simple correlation coefficient between rooting activity and characteristics of rice seedlings at 14 days after seeding.

Characteristics of seedlings	Correlation coefficient
leaf age	0.834**
plant length	0.797*
leaf sheath length	n.s
leaf sheath diameter	0.797*
leaf blade D.W.	0.934**
leaf sheath D.W.	n.s
root D.W.	0.928**
nitrogen cont.	-0.589*
starch cont.	n.s
amylase act.	0.650*

*, ** : significant at 1% and 5% levels, respectively.
n.s : not significant.

Table 3 shows the simple correlation coefficient between the rooting activity and characteristics of rice seedlings at the 14th day after seeding. The rooting activity was highly correlated with leaf age, plant length, leaf sheath diameter, dry weight of leaves and roots and amylase activity. However, the nitrogen content clearly increased with the decrease in rooting activity.

2. Seedling on 28 days after seeding

The average morphological characteristics of rice seedlings measured on the 28th day after seeding are presented in Table 4. On 28 days after seeding, rice seedlings in the high temperature plot were most vigorous; this result shows about the same tendency as that on the 14th day after seeding. In the shaded plot, rice seedlings were spindly and poor, showing a lower value in plant length and dry weight of leaves and roots. The high density plot showed about the same tendency as shaded plot. In the upland and low temperature plots, plant length was lower than that in the control plot, but root dry weight a greater value than in the control showed. In the lowland, low density and 3/2N plot growth was vigorous, showing a greater value than that in the control plot.

The total nitrogen content of the whole plant, measured on the 28th day after seeding, is presented in Table 4. The nitrogen content of the whole plant was larger and different in different growth conditions and growth stages.

Table 4. Effects of different condition on the growth characteristics at 28 days after seeding.

Experimental plot	Leaf age	Plant length (cm)	leaf sheath length (cm)	leaf sheath diameter (mm)	Dry weight (mg) LB.	leaf sheath	root	Nitrogen content (mg)	Starch content (mg)	Rooting activity
1. control	5.0	29.1	10.1	3.4	25.5	27.6	8.0	1.78	5.19	11.9
2. shaded	3.7	19.9	10.1	1.6	6.1	7.5	2.1	0.49	0.32	1.3
3. low dens.	4.8	28.7	10.1	3.6	25.9	31.6	10.8	2.07	5.78	15.7
4. high dens.	4.8	28.7	10.2	2.5	19.1	13.9	5.6	1.56	2.31	7.6
5. upland	5.4	27.2	10.2	3.7	27.3	20.1	11.3	1.70	3.69	20.2
6. lowland	5.6	30.2	11.4	5.4	39.3	37.8	18.1	1.73	4.99	9.2
7. 1/2N	4.8	25.4	9.7	2.4	18.1	29.6	7.1	0.97	5.80	6.7
8. 3/2N	5.2	30.6	11.3	3.5	27.8	27.3	7.2	1.92	4.56	18.8
9. low temp.	5.0	24.8	8.7	3.8	26.7	19.8	7.8	1.69	4.51	18.2
10. high temp.	6.0	38.8	14.6	6.2	44.5	58.6	22.7	1.91	6.21	11.4

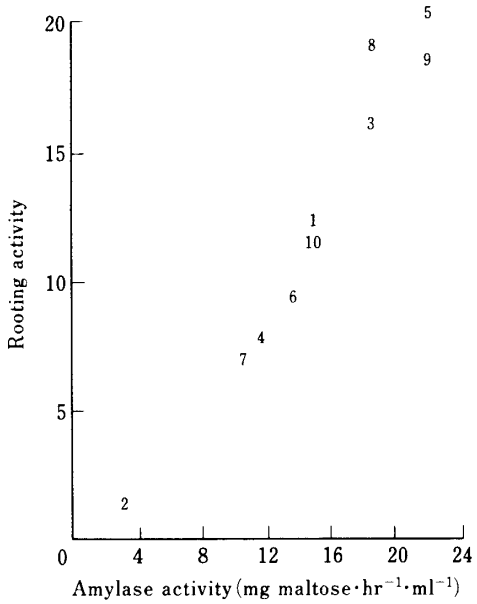

Fig. 2. Relation between rooting activity and amylase activity at 28 days after seeding. Experimental plot numbers are the same as those in Table 1.

Table 5. Simple correlation coefficient between rooting activity and characteristics of rice seedlings at 28 days sfter seeding.

Charcteristics of seedlings	Correlation coefficient
leaf age	0.686*
plant length	n.s
leaf sheath length	n.s
leaf sheath diameter	n.s
leaf blade D.W.	n.s
leaf sheath D.W.	n.s
root D.W.	n.s
nitrogen cont.	0.782**
starch cont.	0.686*
amylase act.	0.974**

*, ** : significant at 1% and 5% levels, respectively.
n.s : not signdificant.

The high content of nitrogen was observed in the low density and low temperature plots where the nitrogen content was higher than that in the control plot. The shaded plots showed a lower nitrogen content than that in the control one. Other plots showed nearly the same content as that in the control one.

The starch content of leaf-sheath measured on the 28th day after seeding is shown in Table 4. The starch content of leaf-sheath in the density, upland lowland, 3/2N and low temperature plots the starch content was less than that in the control one ; especially in the shaded plot there was almost no starch contents.

The effects of different growth conditions on the rooting activity on the 28th day after seeding are shown in Table 4. A higher rooting activity was observed in the low density, upland, 3/2N and low terperature plots than that in the control plot. However, in the shaded, high density, lowland and 1/2N plots, a lower rooting activity than that in the control one was observed. In the high temperature plot, the rooting activity was the same as that in the control one.

Fig. 2 shows the relationship between rooting activity and amylase activity of leaf-sheath. The rooting activity clearly increased with the increase in the amylase activity,

giving a higher, significant correlation coefficient ($r=0.974^{**}$).

Table 5. shows the simple correlation coefficient between the rooting activity and characteristics of rice seedlings on the 28th day after seeding. The rooting activity was not correlated with plant length, leaf-sheath diameter, dry weight of leaves and roots, but highly correlated with amylase activity.

Discussion

Rice seedlings grown under different growth conditions showed a higher rooting activity on 14 days after seeding thas that on 28 days after seeding. Sato[7] had shown that rooting activity increased with the growth of rice seedlings for 30 days after seeding, and then rapidly decreased with the passage of time. Those results suggested that the increase in dry weight causes an increase in starch accumulation. The present study showed the same tendency, since the rooting activity was higher on 14 days after seedings than on 28 days after seedings. Honda and Usuda[3] reported that the rooting activity of seedlings was intensified by the increase in the sum of the total sugar, starch and nitrogen compounds. In this paper, rice seedlings showed high starch and nitrogen contents in 28 days after seedings.

Therefore, rooting activity on 14 days after seedings was correlated with leaf age, leaf-sheath diameter, dry weights of leaves and roots, starch content and amylase activity, However, on 28 days after seeding, rice seedlings were not correlated with morphologica characteristics.

The nitrogen and starch content and amylase activity, showed a higher significant correlation coefficient with rooting activity. Thus, the result suggested that good rece seedlings are characrerized by morphological characteristics in early growth stage and chemical compounds (nitrogen and starch) in later growth stage. On the other hand, the amylase activity has a higher significant correlation coefficient in goth growth stages with the rooting activity. Therefore, it was suggested that the rooting activity tended to increase with increasing the amylase activity and that a certain relationship existed between good seedlings and starch accumulation ability. The questions related to these points are pending for future studies.

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* In Japanese with English summary.

** In Japanese, the title was tentatively translated by the present authors.