

Botanical Studies in the Genus *Oryza*

VII. Germination Behaviour of Seeds Stored for Six and Half Years

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Seed-longevity prevents the grain from death in several environmental conditions, so it is looked upon as an agriculturally and botanically useful character. Moreover, it may be of some advantage to the preservation and continuous methods of plant breeding, in which it is necessary to occur intermittently. The main purpose of the present investigation is to study the longevity of seeds belonging to *Oryza* species with a view of developing a practical method for extending the period of longevity for use in the objects mentioned above.

In the previous papers (4 and 6), using 1,789 strains of 20 species of the genus *Oryza*, the germination behaviours were studied. Most of the cultivated species germinated within 1–2 days after sowing and the percentage increased within 9 days. Wild species could be classified into five groups with respect to the respective germination-behaviours. The materials used in these experiments were tested a half year after harvesting, when the dormancy was completely finished. In the present experiment, the germination-behaviours were studied using the materials, which were stored for six and half years in the uniform condition, in the hope of obtaining useful informations on the germiability, longevity of the seeds belonging to genus *Oryza* and the phylogenetic differentiation of the genus.

Materials and Method

One hundred and ninety two strains belonging to 20 species of the genus *Oryza*, including 1 cultivated- and 19 wild-species, were used in the present investigation. Most of them were collected by the members of the National Institute of Genetics and some were obtained from foreign workers.

Enumeration of the species, number of strains used and their original localities were given in Table 1. The plants used were grown in the greenhouse of National Institute of Genetics in 1964, and the seeds were harvested during the term from September to November in 1964. After harvesting, they were dried up in the room-condition and preserved in desiccator at an electric refrigerator, keeping at $0^{\circ}\text{C} \pm 1^{\circ}\text{C}$. In April 1971, they were taken out from the refrigerator and transferred to Kagoshima University and also preserved in the same condition. On May 20 in 1971, six and half years after harvesting, they were taken-out out of the refrigerator and used for the experiment.

Seeds of wild- and cultivated-species were all husked in order to get uniform germination and were sterilized with 0.1 % Uspulun solution, hydroxymercurichlorophenol, for 5 hours. Then, they were washed twice in sterilized water and incubated at 30°C in Petri-dishes on

Table 1. Enumeration of *Oryza* species used, number of strains and their original localities.

Species	No. of strains used	Locality
<i>O. sativa</i> L.	14	Japan, Formosa, India, Celebes
<i>O. sativa</i> var. <i>spontanea</i> ROSCHEV.	48	India, Nepal, Ceylon, Burma, China, Thailand, Malaya, New Guinea, Brazil
<i>O. perennis</i> MOENCH	28	India, Burma, Thailand, Philippines, Java, Kalimantan, New Guinea, Australia, Brazil, Suriname, Colombia, Cuba
<i>O. barthii</i> CHEV. et ROEHR.	5	Africa
<i>O. stapfii</i> ROSCHEV.	3	Africa
<i>O. breviligulata</i> CHEV. et ROEHR.	15	Africa
<i>O. officinalis</i> WALL.	41	India, Thailand, Malaya, Philippines, Sarawak, Brunei, North Borneo, Kalimantan, Java, Africa
<i>O. minuta</i> PRESL	5	Philippines
<i>O. eichingeri</i> PETER	1	Africa
<i>O. latifolia</i> DESV.	7	Mexico, Guatemala, Costa Rica, Panama, Colombia
<i>O. alta</i> SWALLEN	2	British Guiana
<i>O. grandiglumis</i> PROD.	2	Brazil
<i>O. punctata</i> KOTSCHY	2	Kenya, Tanganyika
<i>O. australiensis</i> DOMIN	1	Australia
<i>O. meyeriana</i> subsp. <i>granulata</i> TATEOKA	3	India, Burma, Thailand
<i>O. meyeriana</i> subsp. <i>meyeriana</i> TATEOKA	7	North Borneo
<i>O. longiglumis</i> JANSEN	5	New Guinea
<i>O. brachyantha</i> CHEV. et ROEHR.	1	Africa
<i>O. tisseranti</i> CHEV.	1	Guinea
<i>O. subulata</i> NEES	1	Argentina
Total	192	—

filter-papers. When the coleoptile broke out through the seed-coat, the seed was considered to be germinated. One to 97 seeds of each strain were used for the experiment. The experiment was started on May 28, 1971. Observations were made every day and continued till June 17, with 20 days duration.

Results

1. Germination behaviours at the strain-level

i: *O. sativa* L.

Germination started within 2 to 3 days after sowing in most of the strains (Table 2). In *japonica* varieties, 3 strains belonging to "Mochi" (= glutinous), germination started peculiarly within 3 days after sowing. Afterwards the percentage rapidly increased within 3 days. In *indica* varieties, germination started within 2 days, and afterwards the percentage rapidly increased within 3 days. In general, *indica* varieties germinated earlier than the *japonica* varieties. All of strains used germinated at more than 92 % to the whole grains used.

Table 2. Germination behaviour of cultivated and wild *Oryza* species showing in strain level. One to 97 seeds of each strain were used. The figures of the table show the accumulative percentages.

Species and strain	No. of seeds sown	No. of days after sowing																			
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
<i>O. sativa japonica</i>																					
Kyoto Asahi	33	33	85		88	91	97														
Norin No. 8	32		9		50	75	88	97		100											
" " 20	31	55	97																		
" Mochi No. 24	20		65	80	90	95															
" Mochi No. 26	21		76	86	91	95															
Kinoshita Mochi	17		88	100																	
Tangin Bōzu	24		63	83		92															
Daikoku	36	36	100																		
<i>indica</i>																					
108	43		93	95	98																
124	29	72	100																		
230	24	88	100																		
414	41	63	100																		
421	97	14	96	100																	
647	25		92																		
<i>O. sativa</i> var. <i>spontanea</i>																					
W0102	12	8		33	42							58	83	92						100	
W0105	10	60	80	100																	
W0106	15		7	47			60			73		80	93						100		
W0107	15			27	40		53					67	73								
W0122	21			10	14		33	43	48					52					57	62	
W0124	47			11	34		55	60	64					70	75				79		
W0125	36			11	19			22	25					44	53			64	69		
W0126	33			70	91		94					97		100							
W0139	7	71	100																		
W0141	25	88	92	100																	
W0157	37	35		51	100																
W0173	57	53	58	70	95																
W0179	34	35		50	68	71	74														
W0552	30	53	93		100																
W0574	23	70	83	87	96																
W0576	61	16	38	62	84																
W0587	59	14	24	41	78	80		81	86	90											
W0589	10	80								100											
W0593	31	19		52	58	65	68		71						87	90					
W0595	19	26	42	58		63							84								

(Table 2. Continued) (2)

Species and strain	No. of seeds sown	No. of days after sowing																						
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20				
W0596	33	30	39	73	91	94																		
W0598	7	100																						
W0605	7	29	100																					
W0606	23	35	65	83	91															100				
W0610	15	53	80	93																100				
W0622	1	100																						
W0623	35	34	69	71	100	86					89	93												
W0625	28	36	61	68	79																			
W0629	32	56	75	91	94																			
W0631	32	75	94	100																				
W1099	32	84	100																					
W1101	11				55	73	82					100												
W1104	16	88	94	100																				
W1105	42	38	62	71	100																			
W1107	30	67	83	97	100																			
W1108	14	86	100																					
W1111	28	79	82	86	96																			
W1115	23	65	91	100																				
W1116	65	34	66	97	99																			
W1117	34	56	79	82	97																			
W1121	6	17	83																					
W1122	1	100																						
W1161	16	6	63	69	88																			
W1235	39	39	64	100																				
W1238	9	67	89			100																		
W1239	18	44	50	100																				
W1241	28	82	96	100																				
W1244	11	82	100																					
<i>O. perennis</i>																								
W0031	29	59	72	100																				
W0036	37	11	30	76	95	97																		
W0120	30	23	50	87	90	93					100													
W0121	7	14			29	57	71	100					86					100						
W0149	44	68	82	98																				
W0162	17	77	100																					
W0612	19	16	53	95																				
W0624	9	33	100																					
W0630	16	6	44	63	69	100																		
W0633	21	19	52	100																				
W0634	13	54	85	100																				
W0635	18	61	78	89																				
W1185	28	18	68	89	96	100																		
W1186	25	32	60	84	88																			
W1191	21	62	100																					
W1192	18	11			94	100																		
W1193	12						8	17																
W1196	18																							
W1214	6	83			100																			
W1236	28	64	68	75	86																			
W1246	28	43	46	100																				
W1288	9	33	100																					
W1292	22	68	96	100																				
W1294	28	50	71	93	96																			
W1297	28	21	57																					
W1298	39	39			62	95																		
W1299	10	80			100																			
W1300	23	22	70	87			96	100																

(Table 2. Continued) (5)

Species and strain	No. of seeds sown	No. of days after sowing																			
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
<i>O. meyeriana</i> subsp. <i>meyeriana</i>																					
W1265	23				13	35	52														
W1348	3																				
W1349	4																				
W1352	2			50																	
W1354	8					13															
W1356	4																				
W1358	1																				
<i>O. longiglumis</i>																					
W1219	10		60	80	100																
W1222	17		24	53	88	100															
W1224	55		22	38	69	80	87	91	93												
W1228	47	2	13	49	64		72	79	85	87											
W1229	25		20	60	84		92	96					100						94		
<i>O. brachyantha</i>																					
W0023	7																				
<i>O. tisseranti</i>																					
W1345	27	26	67	78	82					85											
<i>O. subulata</i>																					
W0510	19	11	42	47	79																

ii: *O. sativa* var. *spontanea* ROSCHEV.

Germination started within 2 to 3 days after sowing in most of the strains. Afterwards the percentage rapidly or gradually increased within 20 days. They were roughly divided into several groups. In the strains originated from low altitude of India (W0102 - W0126), the percentage gradually increased within 20 days. It may be looked upon as a peculiar phenomenon. On the contrary, in the strains originated from high altitude of India (W1099 - W1117), the percentage rapidly increased within 4 to 12 days. In the strains originated from China (W0552), Ceylon (W1161), Brazil (W1241) and Nepal (W1244), the percentage rapidly increased within only 5 days. In the strains originated from Malaya (W0574 - W0606), the percentage gradually increased within 14 days. In their strains, the increasing processes may be regarded as belonging to the middle phenomenon between the two extreme processes mentioned above. Nearly three fourth strains used germinated at more than 90 % to the whole grains used.

iii: *O. perennis* MOENCH

In most of the strains used, germination started within 2 to 3 days after sowing. Afterwards the percentage gradually or rapidly increased within 4 to 15 days. In the strains originated from India, the percentage gradually increased within 7 to 15 days. In most of the other strains, however, the percentage increased within 3 to 7 days. Nearly four fifth

of the strains used germinated at more than 90 % to the whole grains used.

iv: *O. barthii* CHEV. et ROEHR. and *O. stapfii* ROSCHEV.

Germination started within 2 to 4 days after sowing. Afterwards the percentage rapidly increased within 3 to 4 days. It is an exceptional phenomenon that the germination of three strains, i.e., two of *O. barthii*, W0721 and W1061, and one of *O. stapfii*, W0608, started within 2 days after sowing, the percentage attaining 100 within the same day. Whole strains of *O. barthii* and two third of *O. stapfii* germinated wholly.

v: *O. breviligulata* CHEV. et ROEHR.

Germination started within 2 to 5 days after sowing. Afterwards the percentage rapidly or gradually increased within 4 to 20 days. It was ascertained that the earlier is the starting, the later is the increasing processes. Thirteen fifteenth of whole strains used, germinated at more than 90 % to the whole grains used.

vi: *O. officinalis* WALL.

Germination started within 2 to 4 days after sowing. In only 2 strains of 41 strains used, germination started within 2 days after sowing. Afterwards the percentage gradually increased within 3 to 10 days, excepting for one strain, W1278, which originated from Sarawak, Borneo. Germination finished within 3 days in 2 strains, within 4 days in 2 strains, within 5 days in 14 strains, within 6 days in 3 strains, within 7 days in 7 strains, within 9 days in 1 strain, within 10 days in 10 strains, and 14 days in 1 strain, respectively. One strain, W1302, which originated from Philippines, did not germinate at all. This phenomenon showed the existence of wide intra-specific variation. No clear tendency was recognized in locality-relationships. It was a peculiar tendency that only 2.4 % to the total strains used, germinated at more than 90 % to the whole grains sown.

vii: *O. minuta* PRESL and *O. eichingeri* PETER

Germination started within 3 days after sowing. Afterwards the percentage gradually increased within 4 to 7 days. Only one third strains of the whole strains used, germinated at more than 90 % to the whole grains sown.

viii: *O. latifolia* DESV.

Germination started within 2 to 3 days after sowing. Afterwards the percentage gradually increased within 4 to 7 days. Only 14.3 % strains of the whole, germinated at more than 90 % to the whole grains sown.

ix: *O. alta* SWALLEN, *O. grandiglumis* PROD., *O. punctata* KOTSCHY and *O. australiensis* DOMIN

Germination started within 2 to 3 days after sowing. Afterwards the percentage rapidly increased within 3 to 4 days. Three seventh strains germinated at more than 90 % to the whole grains sown.

x: *O. meyeriana* subsp. *granulata* TATEOKA and *O. brachyantha* CHEV. et ROEHR.

None of the grains used germinated during this experimental term. They have completely lost the germiability.

xi: *O. meyeriana* subsp. *meyeriana* TATEOKA

Germination started within 4 to 6 days after sowing in three seventh strains used, afterwards gradually increasing within 5 to 7 days. However, it is peculiar that only 52 % grains to the whole grains sown germinated in maximum.

xii: *O. longiglumis* JANSEN

Germination started within 2 to 3 days after sowing. Afterwards the percentage gradually or rapidly increased within 4 to 14 days. Whole of the strains used germinated at more than 90 % to the whole grains sown.

xiii: *O. tisseranti* CHEV.

Germination started within 2 days after sowing. Afterwards the percentage gradually increased and 85 % of grains to the whole grains sown germinated.

xiv: *O. subulata* NEES

Germination started within 2 days after sowing. Afterwards the percentage increased within 5 days. Finally, 79 % of grains out of the whole grains sown germinated.

2. Germination behaviours at the species-level

Germination behaviours at the species-level were shown in the upper parts of the Table 3 and Figure 1. In this table, the number of grains sown and the accumulative percentage of germinated grains to the whole grains sown were shown. In the upper part of the Figure 1, germination behaviours of 6 species from the 20 species used, were picked up and shown. In the figure, code-numbers used were corresponding with the species-number used in Table 3. As the table and figure show, most species used were capable of germinating at no less than hundred per cent of all the sown grains within 20 days after sowing.

i: *O. sativa* L.

Germination started in 2 days after sowing and rapidly increased within 3 to 4 days. In 3 days after sowing, more than 50 % of all the sown grains germinated. Afterwards the percentage gradually increased within 5 to 10 days. Finally, 98.1 % of seeds used germinated (1 in Fig. 1).

ii: *O. sativa* var. *spontanea* ROSCHEV., *O. perennis* MOENCH and *O. breviligulata* CHEV. et ROEHR.

Germination started in 2 days after sowing and rapidly increased within 3 to 5 days. In 3 days after sowing, more than 50 % of all sown grains germinated. Afterwards the percentage gradually increased within 6 to 20 days. Finally, 93.3 % of seeds used germinated in *O. sativa* var. *spontanea*, 91.2 % in *O. perennis*, and 92.2 % in *O. breviligulata*, respectively (*O. sativa* var. *spontanea* and *O. perennis*, 2 and 3 in Fig. 1, respectively).

iii: *O. barthii* CHEV. et ROEHR. and *O. stapfii* ROSCHEV.

Germination started in 2 days after sowing and about half of the grains germinated on the same day. Afterwards the percentage rapidly increased within 3 to 4 days. Finally, 100.0 % of the whole grains in *O. barthii* and 91.2 % in *O. stapfii* germinated, respectively.

iv: *O. officinalis* WALL.

Germination started slightly in 2 days after sowing. Afterwards the percentage gradually

Table 3. Germination behaviour of cultivated and wild *Oryza* species, showing in the species level. One to 97 seeds of each strain were used. The figures of the table show the accumulative percentages.

No.	Species	No. of seeds used	No. of days after sowing																				
			2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
1.	<i>O. sativa</i>	473	26.0	85.5	89.4	93.2	96.0	97.3	97.9	98.1													
2.	<i>O. sativa</i> var. <i>spontanea</i>	1,218	40.1	54.8	71.9	84.2	84.8	86.8	87.4	88.1	88.7	88.8	89.7	91.5	92.2	92.5	93.0	93.1	93.3				
3.	<i>O. perennis</i>	603	32.0	57.7	81.9	87.6	89.4	89.7	90.1	90.6													
4.	<i>O. barthii</i>	65	58.5	90.8	100.0																		
5.	<i>O. stapfi</i>	34	47.1	64.7	91.2																		
6.	<i>O. breviligulata</i>	346	25.1	54.9	79.2	84.1	84.7	86.1														92.2	
7.	<i>O. officinalis</i>	809	0.8	13.8	37.9	51.9	53.4	55.4	55.6	55.7	57.6	57.7	57.9										
8.	<i>O. minuta</i>	65	14.3	39.3	53.6																		
9.	<i>O. eichingeri</i>	48	2.1	18.8	33.3																		
10.	<i>O. latifolia</i>	132	12.1	25.8	40.9	56.1	57.6																
11.	<i>O. alta</i>	39	5.1	23.1	48.7	66.7																	
12.	<i>O. grandiglumis</i>	45	46.7	73.3	88.9	97.8																	
13.	<i>O. punctata</i>	25	20.0	44.0	72.0	92.0																	
14.	<i>O. australiensis</i>	21	33.3	61.9	71.4	76.2																	
15.	<i>O. meyeriana</i>	43																					
16.	subsp. <i>granulata</i>	45			2.2	8.9	22.2	31.1															
17.	subsp. <i>meyeriana</i>	154	0.7	21.4	49.4	74.0	79.2	85.7	89.6	92.2	92.9												
18.	<i>O. longiglumis</i>	7	25.9	66.7	77.8	81.5																	
19.	<i>O. trichyantha</i>	27	10.5	42.1	47.4	79.0																	
20.	<i>O. subulata</i>	19																					
No. 1		473	26.0	85.5	89.4	93.2	96.0	97.3	97.9	98.1													
Nos. 2-6		2,266	34.5	56.8	76.8	85.6	86.5	87.9	88.4	88.7	89.1	89.2	90.1	91.3	91.8	92.0	92.1	92.3	92.4	92.7			
Nos. 7-14		1,184	5.7	20.0	41.8	55.3	56.4	58.0	58.1	58.2	59.5	59.5	59.6	59.6	59.6	59.6	59.6	59.6	59.6	59.6			
Nos. 15-20		295	3.4	20.0	36.3	52.5	57.3	62.0	64.1	65.4	66.1	66.4	66.4	67.5	67.5	67.5	67.5	67.5	67.5	67.5			
Total and Average		4,218	24.0	46.8	65.4	75.6	77.1	78.8	79.2	79.5	80.2	80.2	80.8	81.4	81.8	81.8	81.9	82.1	82.1	82.3			

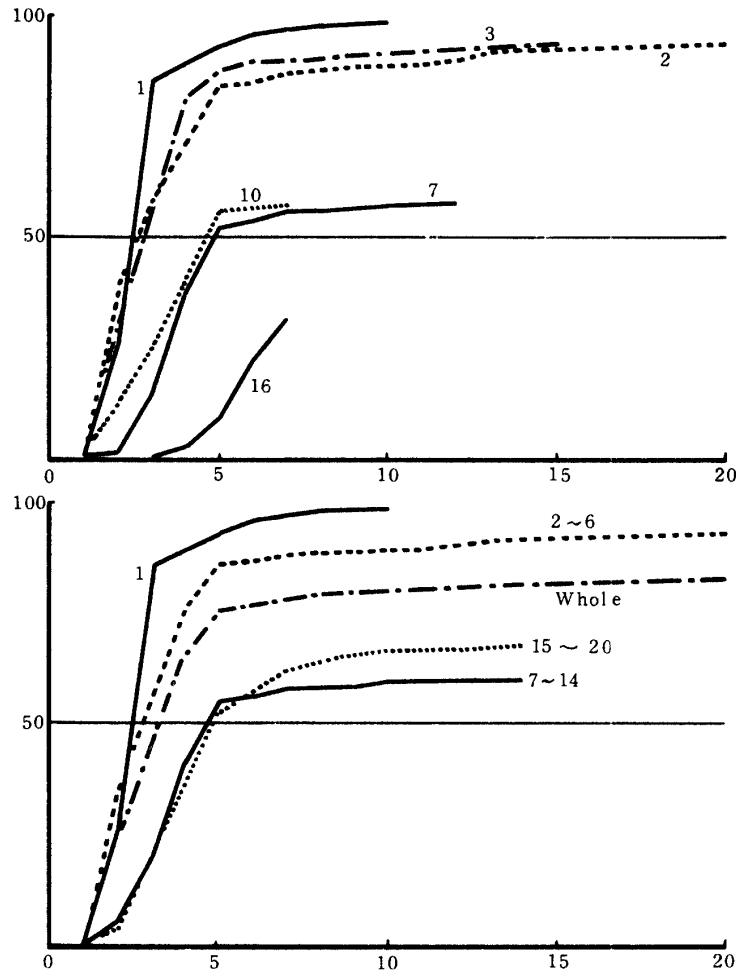


Fig. 1. Germinating processes of *Oryza* species. Code numbers used in the figure are corresponding to the species number which was used in Tables of 3, 4 and 5. Vertical axis: accumulative germinating percentage to the total seeds used. Abscissa: number of days after sowing. Upper: species-level. Lower: group-level.

increased within 3 to 5 days and more slightly increased within 6 to 14 days. In 5 days after sowing, more than 50 % of all the sown grains germinated. The final percentage was 57.9 % of all the sown grains (7 in Fig. 1).

v: *O. minuta* PRESL

Germination started within 3 days after sowing. Afterwards the percentage gradually increased within 4 to 7 days. In 5 days after sowing, more than 50 % of all the sown grains germinated. The final percentage was 57.1 % of all the sown grains.

vi: *O. eichingeri* PETER

Germination started within 3 days after sowing. Afterwards the percentage slightly in-

creased within 4 to 5 days. The final percentage was only 33.3 % of all the sown grains.

vii: *O. latifolia* DESV. and *O. alta* SWALLEN

Germination started within 2 days after sowing. Afterwards the percentage gradually increased within 3 to 7 days. In 5 days after sowing, more than 50 % of all the sown grains germinated in both species (*O. latifolia*, 10 in Fig. 1). The final percentages were 57.6 % of all the sown grains in *O. latifolia* and 66.7 % in *O. alta*, respectively.

viii: *O. grandiglumis* PROD. and *O. australiensis* DOMIN

Germination started within 2 days after sowing. Afterwards the percentage rapidly increased within 3 to 5 days. In 3 days after sowing, more than 50 % of all the sown grains germinated. The final percentages were 97.8 % of all the sown grains in *O. grandiglumis* and 76.2 % in *O. australiensis*, respectively.

ix: *O. punctata* KOTSCHY

Germination started within 2 days after sowing. Afterwards the percentage rapidly increased within 3 to 5 days. In 4 days after sowing, more than 50 % of all the sown grains germinated. The final percentage was 92.0 % of all the sown grains.

x: *O. meyeriana* subsp. *meyeriana* TATEOKA

Germination started within 4 days after sowing. Afterwards the percentage gradually increased within 5 to 7 days. The final percentage was only 31.1 (16 in Fig. 1).

xi: *O. longiglumis* JANSEN

Germination started slightly within 2 days after sowing. Afterwards the percentage rapidly increased within 3 to 5 days, and gradually increased within 6 to 14 days. In 5 days after sowing, more than 50 % of all the sown grains germinated. The final percentage was 95.5 % of all the sown grains.

xii: *O. tisseranti* CHEV.

Germination started within 2 days after sowing. Afterwards the percentage rapidly increased within 3 to 5 days and gradually increased within 6 to 10 days. In 3 days after sowing, more than 50 % of all the sown grains germinated. The final percentage was 85.2 % of all the sown grains.

xiii: *O. subulata* NEES

Germination started within 2 days after sowing. Afterwards the percentage gradually increased within 3 to 5 days. In 5 days after sowing, more than 50 % of all the sown grains germinated. The final percentage was 79.0 % of all the sown grains.

3. Germination behaviours at the group-level

Germination behaviours at the group-level in the average value were shown in the lower parts of the Table 3 and Figure 1.

Whole species used were divided into four groups; *i.e.*, i) *O. sativa*, ii) the species having AA genome excepting for the cultivated species, iii) the species having the genomes other than AA genome belonging to *Section Sativae*, and iv) the species belonging to the *Sections Granulatae, Coarctatae* and *Rhynchoryza*. In this figure, code-numbers used were corresponding to the species-numbers used in Table 3.

i: *O. sativa* (1 in Table 3 and Fig. 1)

Germination behaviour was quite the same as the data mentioned in the species-level.

ii: *Average processes in the species having AA genome excepting for the cultivated species* (2–6 in Table 3 and Fig. 1)

Germination started within 2 days after sowing. Afterwards the percentage rapidly increased within 3 to 5 days. Afterwards the percentage gradually increased within 6 to 20 days. In 3 days after sowing, more than 50 % of all the sown grains germinated. The final percentage was 92.7 %. In only 2 days after sowing, the percentage was larger than that of *O. sativa*.

iii: *Average processes in the species belonging to the Section Sativae having the genomes other than AA genome* (7–14 in Table 3 and Fig. 1)

Germination slightly started within 2 days after sowing. Afterwards the percentage gradually increased within 3 to 5 days. Afterwards the percentage more gradually increased within 6 to 14 days. In 5 days after sowing, more than 50 % of all the sown grains germinated. The final percentage was 59.6 %.

iv: *Average processes in the species belonging to the Sections Granulatae, Coarctatae and Rhynchoryza* (15–20 in Table 3 and Fig. 1)

Germination slightly started within 2 days after sowing. Afterwards the percentage gradually increased within 3 to 5 days, afterwards more gradually increasing within 6 to 14 days. In 5 days after sowing, more than 50 % of all the sown grains germinated. The final percentage was 67.5 %. The average germination pattern of this group was quite similar to that of the third group.

v: *Average processes in the whole species used* (Average in Table 3 and Whole in Fig. 1)

Germination started within 2 days after sowing. Afterwards the percentage rapidly increased within 3 to 5 days. Afterwards the percentage gradually increased within 6 to 20 days. In 4 days after sowing, more than 50 % of all the sown grains germinated. The final percentage was 82.3.

vi: *Comparisons of the germination processes in each group*

Whole species having AA genome (1–6 in Table 3 and Fig. 1) showed earlier and more rapid germination-pattern than that of the average whole species. This pattern was recognized in species-level and also in group-level.

In the third group, the different pattern was found, at the time when the germination percentages of each species were compared with the average of the whole species in the respective days. In comparison with group-level, the percentages were lower in this group than in that of the average of the whole species used in the whole days during the experiment. In comparison with species-level, two species of the former, germinated earlier than that of the latter within 2 and 3 days after sowing, 3 species in 4 and 5 days, 2 species within 6 to 14 days, respectively. In other words, about three fourth species of this group showed lower germination-percentage in comparison with that of the average percentage of the whole species used.

In the fourth group, also the different pattern was found. In comparison with group-level,

the percentages were lower in this group than that of the average of the whole species used in whole days during the experiment. In comparison with species-level, one species of the former germinated more than that of the latter within 2 to 4 days; two species within 5 days and within 9 to 14 days, and three species within 6 to 8 days, respectively. In other words, about half species of this group showed lower germination-percentage in comparison with that of the average percentage of the whole species used.

4. *Germination behaviours in which the final germination-percentage in individual species was converted to 100 %*

Practically at the beginning of the experiment, it is looked upon as desirable that the germination could be brought forth to the finish after which no grain germinates, and that the germination-percentage could reach 50 % of the whole grains germinated. So, the germination behaviours were illustrated in which the final germinated percentages in strain, species and group were converted to 100 %. The first one was omitted here. In this chapter, the second one was shown in upper parts of the Table 4 and Figure 2. In Fig. 2, the code-numbers used were corresponding to the species-number used in Table 4.

It is clear that the differences in germination behaviour were found in the species-level, but this differences were clearly smaller than those found in the previous chapter, in which the germination-percentage was shown in practical values.

i: *O. sativa* L.

Germination-percentage reached 26.5 within 2 days. Afterwards the percentage rapidly increased within 3 to 4 days after sowing. Afterwards the percentage gradually increased within 5 to 10 days. In 3 days after sowing, more than 50 % of all the germinating grains germinated (1 in Fig. 2).

ii: *O. sativa* var. *spontanea* ROSCHEV., *O. perennis* MOENCH and *O. breviligulata* CHEV. et ROEHR.

Germination percentages reached about 30 % within 2 days. Afterwards the percentages rapidly increased within 3 to 5 days. Afterwards the percentages gradually increased within 6 to 20 days. In 3 days after sowing, more than 50 % of all the germinating grains germinated (*O. sativa* var. *spontanea* and *O. perennis*, 2 and 3 in Fig. 2, respectively).

iii: *O. barthii* CHEV. et ROEHR. and *O. stapfii* ROSCHEV.

Germination percentages reached about 55 % within 2 days. Afterwards the percentages rapidly increased within 3 to 4 days.

iv: *O. officinalis* WALL.

Germination percentage reached only 1.3 % within 2 days. Afterwards the percentage rapidly increased within 3 to 5 days. Afterwards the percentage gradually increased within 6 to 14 days. In 4 days after sowing, more than 50 % of all the germinating grains germinated (7 in Fig. 2).

v: *O. minuta* PRESL

Germination-percentage reached 25 % within 3 days after sowing. Afterwards the percentage rapidly increased within 4 to 7 days. In 4 days after sowing, more than 50 % of all the germinating grains germinated.

Table 4. Germination behaviour of cultivated and wild *Oryza* species in view of the final data. The figures of the table show the accumulative percentages.

No. Species	No. of seeds germinated	No. of days after sowing																		
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. <i>O. sativa</i>	464	26.5	87.5	93.1	95.0	97.8	99.1	99.8	100.0											
2. <i>O. sativa</i> var. <i>spontanea</i>	1,136	39.4	58.8	77.1	90.2	90.9	93.1	93.8	94.5	95.1	95.2	96.2	98.2	98.9	99.2	99.7	99.8	100.0		
3. <i>O. perennis</i>	550	35.1	63.3	89.8	96.0	98.0	98.4	98.7	99.3	99.6	99.8	100.0								
4. <i>O. barthii</i>	65	58.5	90.8	100.0																
5. <i>O. stapfi</i>	31	51.6	71.0	100.0																
6. <i>O. brevitigulata</i>	319	27.3	59.6	85.9	91.2	91.9	93.4													100.0
7. <i>O. officinalis</i>	457	1.3	23.9	65.4	89.7	92.1	95.8	96.1	96.3	99.6	99.8	100.0								
8. <i>O. minuta</i>	48	25.0	68.8	93.8		95.8	100.0													
9. <i>O. eichingeri</i>	16	6.3	56.3	100.0																
10. <i>O. latifolia</i>	76	21.1	46.0	71.1	97.4	100.0														
11. <i>O. alta</i>	26	7.7	34.6	73.1	100.0															
12. <i>O. grandiglumis</i>	44	47.7	75.0	90.9	100.0															
13. <i>O. punctata</i>	23	21.7	47.8	78.3	100.0															
14. <i>O. australiensis</i>	16	43.8	81.3	93.8	100.0															
15. <i>O. meyeriana</i>	0																			
subsp. <i>granulata</i>	14			7.1	28.6	71.4	100.0													
16. <i>O. meyeriana</i>	147	0.7	22.5	51.7	77.6	83.0	89.8	93.9	96.6	97.3	98.0	100.0								
subsp. <i>meyeriana</i>	0																			
17. <i>O. longiglumis</i>	23	30.4	78.3	91.3	95.7	100.0														
18. <i>O. brachyantha</i>	15	13.3	53.3	60.0	100.0															
19. <i>O. tisseranti</i>	464	26.5	87.5	93.1	95.0	97.8	99.1	99.8	100.0											
20. <i>O. subulata</i>	2,101	37.2	61.3	82.8	92.3	93.3	94.8	95.3	95.7	96.1	96.2	97.2	98.4	99.1	99.1	99.6	99.6	100.0		
Nos. 2-6	706	8.1	31.4	69.1	92.6	94.3	97.3	97.5	97.6	99.7	99.9	100.0								
Nos. 7-14	199	5.0	29.7	53.8	77.9	84.9	92.0	95.0	97.0	98.0	98.5	100.0								
Nos. 15-20																				
Total and Average	3,470	29.1	56.9	79.5	89.1	93.7	95.7	96.3	96.7	97.5	97.5	98.2	98.9	99.4	99.5	99.6	99.7	99.8	100.0	

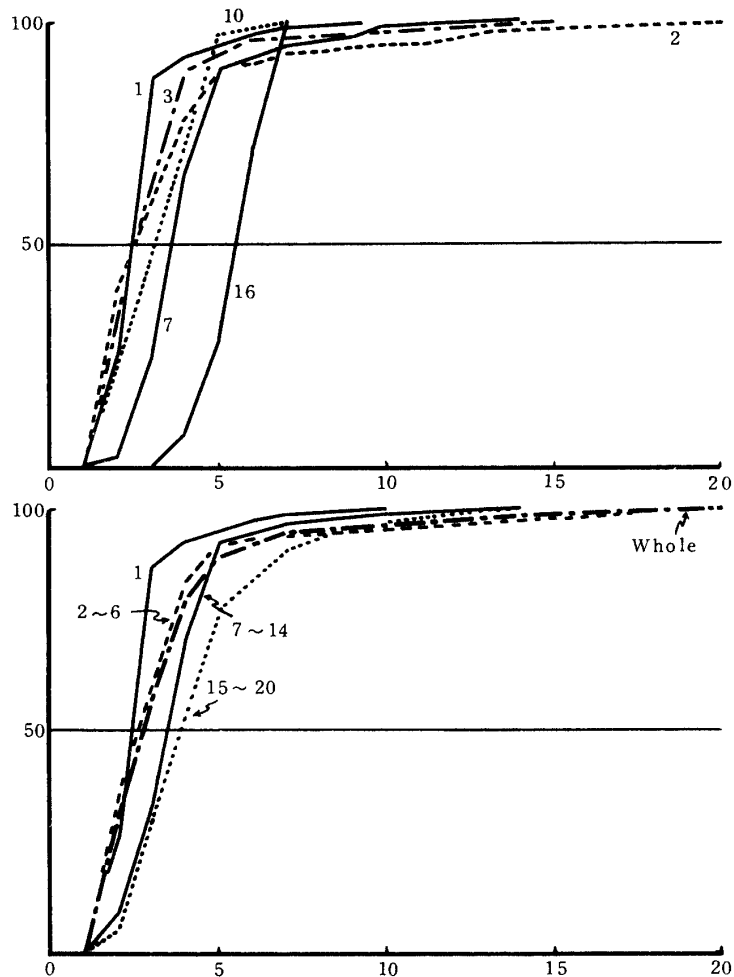


Fig. 2. Germinating processes of *Oryza* species. Code numbers used in the figure are corresponding to the species-number which was used in Tables of 3, 4 and 5. Vertical axis: accumulative germinating percentage to the final number seeds germinated. Abscissa: number of days after sowing. Upper: species-level. Lower: group-level.

vi: *O. eichingeri* PETER

Germination-percentage reached only 6.3 % within 3 days after sowing. Afterwards the percentage rapidly increased within 4 to 5 days. In 4 days after sowing, more than 50 % of all the germinating grains germinated.

vii: *O. latifolia* DESV. and *O. alta* SWALLEN

Germination-percentages reached about 15 % within 2 days after sowing. Afterwards the percentages rapidly increased within 3 to 7 days. In 4 days after sowing, more than 50 % of all the germinating grains germinated (*O. latifolia*, 10 in Fig. 2).

viii: *O. grandiglumis* PROD. and *O. australiensis* DOMIN

Germination-percentages reached about 45 % within 2 days after sowing. Afterwards the percentages rapidly increased within 3 to 5 days. In 3 days after sowing, more than 50 % of all the germinating grains germinated.

ix: *O. punctata* KOTSCHY

Germination percentage reached 21.7 % within 2 days after sowing. Afterwards the percentage rapidly increased within 3 to 5 days. In 4 days after sowing, more than 50 % of all the germinating grains germinated.

x: *O. meyeriana* subsp. *meyeriana* TATEOKA

Germination percentage reached only 7.1 % within 4 days after sowing. Afterwards the percentage rapidly increased within 5 to 7 days. In 6 days after sowing, more than 50 % of all the germinating grains germinated (16 in Fig. 2).

xi: *O. longiglumis* JANSEN

Germination percentage reached only 0.7 % within 2 days after sowing. Afterwards the percentage rapidly increased within 3 to 5 days. Afterwards the percentage gradually increased within 6 to 14 days. In 4 days after sowing, more than 50 % of all the germinating grains germinated.

xii: *O. tisseranti* CHEV.

Germination-percentage reached 30.4 % within 2 days after sowing. Afterwards the percentage rapidly increased within 3 to 5 days. Afterwards the percentage gradually increased within 6 to 10 days. In 3 days after sowing, more than 50 % of all the germinating grains germinated.

xiii: *O. subulata* NEES

Germination-percentage reached 13.3 % within 2 days after sowing. Afterwards the percentage rapidly increased within 3 to 5 days. In 3 days after sowing, more than 50 % of all the germinating grains germinated.

5. Germination behaviours in which the final germination percentage in individual group was converted to 100 %

This behaviours at the group-level in the average value were shown in the lower parts of the Table 4 and Figure 2. Grouping was quite the same as the groups mentioned in chapter 3.

i: *O. sativa* L. (1 in Table 4 and Fig. 2)

Germination behaviour was quite the same as the data mentioned in the species-level.

ii: *Average processes in the species having AA genome excepting for the cultivated species* (2-6 in Table 4 and Fig. 2)

Germination-percentage reached 37.2 % within 2 days after sowing. Afterwards the percentage rapidly increased within 3 to 5 days. Afterwards the percentage gradually increased within 6 to 20 days. In 3 days after sowing, more than 50 % of all the germinating grains germinated.

iii: *Average processes in the species belonging to the Section Sativae having the genomes other than AA genome* (7-14 in Table 4 and Fig. 2)

Germination-percentage reached only 8.1 % within 2 days after sowing. Afterwards the percentage rapidly increased within 3 to 5 days. Afterwards the percentage gradually increased within 6 to 14 days. In 4 days after sowing, more than 50 % of all the germinating grains germinated.

iv: *Average processes in the species belonging to the Sections Granulatae, Coarctatae and Rhynchoryza (15-20 in Table 4 and Fig. 2)*

Germination-percentage reached only 5.0 % within 2 days after sowing. Afterwards the percentage rapidly increased within 3 to 5 days. Afterwards the percentage gradually increased within 6 to 7 days. Afterwards the percentage more gradually increased within 8 to 14 days. In 4 days after sowing, more than 50 % of all the germinating grains germinated.

v: *Average processes in the whole species used (Average in Table 4 and Whole in Fig. 2)*

Germination percentage reached 29.1 % within 2 days after sowing. Afterwards the percentage rapidly increased within 3 to 5 days. Afterwards the percentage gradually increased within 6 to 7 days. Afterwards the percentage more gradually increased within 8 to 20 days. In 3 days after sowing, more than 50 % of all the germinating grains germinated.

vi: *Comparison of the germination processes in each group*

O. sativa germinated earlier than the average of the whole species during the experiment, excepting for the 2 days after sowing.

In comparison with the second group and the average of the whole species, it was clear that the former germinated earlier than the latter during early 2 to 5 days. Afterwards the former germinated later than the latter, but the differences between them were quite small. In other words, the processes of both of them were quite similar during the experiment. In comparison with species-level, one species of the former germinated later than that of the latter within 2, 4 and 17 days, two species within 6 to 16 days, respectively.

In comparison with the third group and the average of the whole species, a different pattern was found. The former germinated later than the latter during early 2 to 4 days after sowing. Afterwards the former germinated earlier than the latter, but the difference of the latter case was quite small. In comparison with the species-level, 6 species of the former germinated later than those of the latter within 2, 3 and 4 days after sowing; one species within 6, 8 and 9 days after sowing, respectively.

In comparison with the fourth group and the average of the whole species, some different pattern was found too. The former germinated later than the latter during early 2 to 8 days after sowing. Afterwards both of them germinated in quite the same pattern. In comparison with the species-level, one species of the former germinated earlier than that of the latter within 2, 3, 4, 8 and 9 days after sowing, 2 species within 5 to 7 and 10 to 13 days, 3 species within 14 days, respectively.

6. *Classification of the germination pattern in view of the final germination-percentage in species-level*

The classification of the germination-pattern in view of the final germination percentage in species-level was shown in the upper part of Table 5. In this table, number of strains used and the final percentages were shown. The figure in the table showed the respective percentage of the strains to the whole strains used. The final percentages were divided into 10 groups

Table 5. The classification of the germination pattern in view of the final germination percentages. The figures of the table show the respective percentage.

No.	Species	No. of strains used	The final percentage									
			0	11	21	31	41	51	61	71	81	91
			10	20	30	40	50	60	70	80	90	100
1.	<i>O. sativa</i>	14										100.0
2.	<i>O. sativa</i> var. <i>spontanea</i>	48						4.2	6.3	12.5	77.1	
3.	<i>O. perennis</i>	28	3.6	3.6				3.6		10.7	78.6	
4.	<i>O. barthii</i>	5									100.0	
5.	<i>O. stapfii</i>	3			33.3						66.7	
6.	<i>O. breviligulata</i>	15			6.7			6.7			86.7	
7.	<i>O. officinalis</i>	41	2.4	2.4	7.3	12.2	24.4	17.1	12.2	14.6	4.9	2.4
8.	<i>O. minuta</i>	5				40.0	20.0				20.0	20.0
9.	<i>O. eichingeri</i>	1			100.0							
10.	<i>O. latifolia</i>	7		14.3				42.9		14.3	14.3	14.3
11.	<i>O. alta</i>	2					50.0		50.0			
12.	<i>O. grandiglumis</i>	2										100.0
13.	<i>O. punctata</i>	2								50.0		50.0
14.	<i>O. australiensis</i>	1							100.0			
15.	<i>O. meyeriana</i> subsp. <i>granulata</i>	3	100.0									
16.	<i>O. meyeriana</i> subsp. <i>meyeriana</i>	7	57.1	14.3		14.3		14.3				
17.	<i>O. longiglumis</i>	5										100.0
18.	<i>O. brachyantha</i>	1	100.0									
19.	<i>O. tisseranti</i>	1									100.0	
20.	<i>O. subulata</i>	1							100.0			
No. 1		14										100.0
Nos. 2-6		99	1.0	1.0	2.0			1.0	3.0	3.0	9.1	79.8
Nos. 7-14		61	1.6	3.3	4.9	9.8	19.7	19.7	8.2	16.4	6.6	9.8
Nos. 15-20		18	44.4	5.6			5.6	5.6		5.6	5.6	27.8
Total and Average		192	5.2	2.1	2.6	3.1	6.8	7.3	4.2	7.3	7.3	54.2

with 10 % intervals. In this illustrations, species were arranged in order, as to the final percentage, in disregard of the species order of Table 5.

i: *O. sativa* L., *O. barthii* CHEV. et ROEHR., *O. grandiglumis* PROD. and *O. longiglumis* JANSEN

All of the strains belonging to their species germinated at more than 90 % in the respective final date. Twenty six strains, i.e., 14 strains of *O. sativa*, 5 of *O. barthii*, 2 of *O. grandiglumis* and 5 of *O. longiglumis*, were used in this group, and 16 strains of them germinated at 100 % in the respective final date.

ii: *O. tisseranti* CHEV.

One strain of *O. tisseranti* was used, and germinated at 85 % in the final date.

iii: *O. australiensis* DOMIN and *O. subulata* NEES

One strain of each of *O. australiensis* and *O. subulata* were used, and they germinated at

76 % and 79 % in each final date, respectively.

iv: *O. eichingeri* PETER

One strain of *O. eichingeri* was used, and it germinated at 33 % in the final date.

v: *O. meyeriana* subsp. *granulata* TATEOKA and *O. brachyantha* CHEV. et ROEHR.

Three strains of *O. meyeriana* subsp. *granulata* and 1 strain of *O. brachyantha* were used, and they were ascertained to have completely lost the germiability.

vi: *O. sativa* var. *spontanea* ROSCHEV., *O. perennis* MOENCH, *O. stapfii* ROSCHEV. and *O. breviligulata* CHEV. et ROEHR.

Ninety four strains, i.e., 48 strains of *O. sativa* var. *spontanea*, 28 of *O. perennis*, 3 of *O. stapfii* and 15 of *O. breviligulata*, were used. Seventy four strains of them germinated at more than 90 % in the final date. Number of strains gradually decreased to the lower germination percentage groups.

vii: *O. officinalis* WALL.

Fourty one strains of *O. officinalis* were used. In this species, intra-specific variation was peculiarly recognized. Only one strain germinated at more than 90 % in the final date. Mode was found within 41 to 50 % in the final date. The number of strains gradually decreased toward the both sides from this group. The distribution-pattern showed the normal curve.

viii: *O. minuta* PRESL

Five strains were used. Only one strain germinated at more than 90 % in the final date. This species were distributed between 41 and 100 % in the final date.

ix: *O. latifolia* DESV.

Seven strains were used. Only one strain germinated at more than 90 % in the final date. Mode was found within 51 to 60 % in the final date. Others were distributed between 11 and 100 %.

x: *O. alta* SWALLEN

Two strains were used. One germinated at 56 % and another germinated at 74 % in the final date.

xi: *O. punctata* KOTSCHY

Two strains were used. One germinated at 71 % and another germinated at 100 % in the final date.

xii: *O. meyeriana* subsp. *meyeriana* TATEOKA

Seven strains were used. No seed of four strains germinated at all. One strain germinated at 13 %, another germinated at 50 % and last one germinated at 52 % in the final date. It is also a peculiar pattern in the germination behaviour in the view point of the final percentages.

7. Classification of the germination pattern in the view point of the final germination-percentage in group-level

The classification of the germination pattern in the view point of the final germination-percentage in group-level was shown in the lower part of the Table 5. Grouping was quite the same as the mentioned in chapters 3 and 5.

i: *O. sativa* L. (No. 1 in Table 5)

Fourteen strains were used. All of the strains germinated at more than 90 % in the final date. Six of them germinated at 100 %.

ii: *Average of the species having AA genome excepting for the cultivated species* (Nos. 2-6 in Table 5)

Ninety nine strains were used. Seventy nine strains germinated at more than 90 % in the final date. Sixty five strains of them germinated at 100 %. Number of strains gradually decreased to the groups of the lower germination-percentage.

iii: *Average of the species belonging to the Section Sativae having the genomes other than AA genome* (Nos. 7-14 in Table 5)

Sixty one strains were used. Twelve strains belonged to the group between 41 and 50, 12 strains to 51 and 60, and 10 strains to 71 and 80, respectively. Their three groups were relatively large group. And other groups had relatively few strains. In other words, mode was found in the middle portion, and strains gradually decreased towards both sides. Three strains germinated at 100 % in the final date.

iv: *Average of the species belonging to the Sections Granulatae, Coarctatae and Rynchoryza* (Nos. 15-20 in Table 5)

Eighteen strains were used. Eight strains germinated at less than 10 % in the final date. Five strains germinated at more than 90 %. Three strains of them germinated at 100 %. In other groups, each one strain belonged. Then, in this group, two peaks were found.

v: *Average of the whole species used* (Total and Average in Table 5)

One hundred and ninety two strains were used. One hundred and four strains germinated at more than 90 % in the final date. Seventy six strains of them germinated at 100 %. In other groups, relatively smaller number of strains belonged. No seed germinated in 10 strains. About three fourth strains germinated at more than 61 % in the final date.

Discussion

1. Object

Data concerning the viability of seeds after very long periods, where the conditions of storage can be defined, are rare; but a particularly interesting case was reported in 1957 (1). In 1955 some samples of various cereal species were found sealed in glass-tubes within the foundation stone of the Nuremberg City Theatre. A document in the Nuremberg City Archives states that the seeds had been placed there in 1832. When the seeds were removed after 123 years of storage, moisture-contents were determined and germination tests were carried out within 9 days. According to these data, the seeds of wheat did not germinate at all, but the seeds of oats germinated at 21.9 % and the seeds of barley germinated at 12.0 % during the experiment. Using some equation it was ascertained that the germination would drop to 25 % at 9 % moisture content at 0°C after 938.5 years (12). KASAHARA *et al.* (3) studied on the germination of the seeds of rush and weed buried for more than fifty years, and reported that the seeds were capable of germinating from 1.4 to 19.5 % according to the plant species. However, datum concerning the viability of seeds of *Oryza* species after very long periods was very rare.

The writer studied the germination-behaviour, including the number of days from sowing to germinations, germination processes, duration and germiability and germination-percentage, in the hope of obtaining a useful information on the phylogenetic differentiation of the genus *Oryza* (4, 6). In these reports, the following phenomena were clarified. Most of the cultivated species germinated within 1–2 days after sowing and the percentage increased within 9 days. Wild species could be classified into five groups with respect to the germination behaviour. Most of the wild species used could germinate at no less than hundred percentage during 9 days after sowing. Some strains could germinate even 334 days after sowing in the long term experiments. It was concluded that complete and rapid germination is a general characteristics of the cultivated strains and those taxonomically related to them.

However, these experiments were done using the seeds, which were harvested about half year before the starting of the experiments. As mentioned in the introduction, it is important to detect the changes of germiability and germination-behaviour in the respective period, when the seeds were preserved in the long period longer than one year.

2. Method

Oryza cubensis EKMAN was included in *O. perennis* MOENCH in the present investigation, because the former was seen as synonymous to the latter by many taxonomists.

Seeds of wild and cultivated species were all husked in order to get uniform germination, though such condition is clearly different from the natural one. The removal of the husk allows the germination of some seeds and dehusks to be effective in the germination (11). Unhusked grains germinated clearly later than the husked grains, but germination behaviours, including germination curve, final date, final percentage, are quite the same as those from husked grains (6, 11).

It is clear that the lower was the temperature during the seed preservation, the longer was the seed longevity, and the lower was the water contents in seed during the preservation, the longer was the seed longevity (12). Then, in the present experiment, the seeds were stored in the desiccator at 0°C.

The seeds were incubated at 30°C in Petri-dishes on filter paper in the present experiment. It is clear that strains originated from the northern part germinated earlier than the strains originated from the southern part, if the seeds were set in the relatively lower temperature, for example 20°C. On the other hand, the former germinated later than the latter, if the seeds were set in the relatively high temperature, for example 30°C. However in the present experiment, observations were done during 20 days after sowing. Then the germination-behaviour could be seen as species-specific pattern.

The description of "standard germination test" differed from each other, according to the respective author. In the present investigation, the term "standard germination test" has been retained, because it is believed that it is in much confusion. In the previous paper (6), observations were continued until 365 days after sowing, and it was recognized that some strain could germinate even 334 days after sowing in the long term experiments. In the present experiment, the observations were cut at 20 days after sowing. If the observation had been continued, the similar phenomenon would have been recognized. It will be left as the future problem.

OKA *et al.* (8) preserved the *Oryza* seeds at 30°C for seven months. TAKAHASHI and OKA (9)

preserved the *Oryza* seeds at 20°C for one month. MATUMURA and HIRAYOSHI (7) preserved the *Digitaria* seeds at the room temperature for three and half years. The seeds used by them were ascertained to have had the germiability during the respective periods.

The materials used in the present experiment have been preserved at 0°C in the desiccator. In the previous paper (6), it was concluded that half year storage under such conditions is suitable for the sake of convenience and does not impair germiability except for *O. coarctata*. Because, however, the experiments have been done in the relatively short period, it is not clear, whether such preserving conditions mentioned above can keep the germiability for longer period than that in the present experiment.

How long the germiability lasts was examined by ROBERTS (12), TAKAHASHI (10), and the writer is under way in testing it under 0°C, -12°C and -24°C, keeping the seeds in desiccators to make clear how long a seed of cultivated and wild species, belonging to the genus *Oryza*, can keep germiability under those temperatures. In 1965, it was confirmed that the seeds kept in desiccators at 0°C during five years, had germinated at 85 % within 4 days after sowing (6). In the present experiments, it was clear that the seeds, kept in desiccators at 0°C during six and half years, had 82.3 % germination capability. Then, it may be concluded that preservation under such condition is suitable for the sake of convenience and does not, in general, impair germiability.

The number of living plant was not recorded in the present paper, because it is expected that some one can out-live and others can not live during the long period. Now, attention was paid to the keeping of suitable environmental conditions, which were ascertained for the individual species for healthy and normal growth with regard to their natural habitats.

3. Results

In the new seeds, germination started within one day after sowing in *O. sativa*, *O. sativa* var. *spontanea*, *O. australiensis* and *O. latifolia* (6). In the most of the species used, germination started within 2 days after sowing, excepting for *O. meyeriana* subsp. *granulata*. However, in the present investigation, germination started within 2 days after sowing, even in *O. sativa japonica*, excepting for *O. minuta* and *O. meyeriana* subsp. *meyeriana*. Two species, i.e., *O. meyeriana* subsp. *granulata* and *O. brachyantha*, were found to have lost completely the viability.

Comparing the data obtained in the previous paper and the present investigation of *O. meyeriana* subsp. *granulata*, *O. meyeriana* subsp. *meyeriana* and *O. brachyantha*, it became clear that the slower and the lower were the germinations in the new seeds, the shorter and smaller were the longevity and germination behaviour in the seeds stored for the long period. Then, the attention should be paid at the beginning of the preservation. That is, the strain, which germinated smaller percentage and slower processes at the germination experiments using the new seeds, must be reproduced at the earlier period of the preservation than the species, which germinated larger percentage and more rapid processes at the germination experiments using the new seeds.

As shown in Table 6, germination behaviours of the species were studied in the view point of days, when the seeds germinated more than at 50 % to the whole seeds used. The seeds of *O. sativa* germinated within 2 days after sowing. The seeds of the species, having AA genome excepting for *O. sativa* (corresponding to Nos. 2-6 in Tables 3, 4 and 6) germinated at more

Table 6. Distribution of the species in view of the number of days in which the seeds germinated at more than 50% to the whole seeds used.

Species	No. of days after sowing				Not reach to 50 %
	2	3	4	5	
No. 1	1				
Nos. 2 - 6	1	4			
Nos. 7 - 14		2	1	4	1
Nos. 15 - 20		1		2	1

Code No. of the species corresponding to that used in Tables 3 and 4.

than 50 % to the whole seeds used within 2 days after sowing in the one species, within 3 days in the 4 species, respectively. The seeds of the species which belonged to *Section Sativae* having genomes other than AA (corresponding to Nos. 7-14 in Tables 3, 4 and 6) germinated within 3 days after sowing in 2 species more than at 50 % to the whole seeds used, within 4. days in one species, within 5 days in 4 species, respectively, and less than at 50 % at all in one species. The seeds of the species belonging to *Sections Granulatae*, *Coarctatae* and *Rhynchoryza* (corresponding to Nos. 15-20 in Tables 3, 4 and 6) germinated at more than 50 % to the whole seeds used within 3 days in 1 species, within 5 days in 2 species, respectively, at less than 50 % at all in 1 species. It is clear that group specific characteristics were found. This phenomena were recognized when the experiments were done using the seeds stored only for a half-year (6).

As shown in Table 7, germination behaviours of the species were studied in the view point of days when the seeds germinated more than at 50 % to the whole seeds germinated in the final date. Concerning this data, the similar tendency was recognized. It may be concluded that species specific characters will become clear in accordance with the long preservation period in the view point of such tendency.

In the previous paper (6), it was concluded that ungerminated grains within 9 days after sowing might be considered, in the case of cultivated species, to have lost germiability. The

Table 7. Distribution of the species in view of the number of days in which the seeds germinated at more than 50% to the whole seeds germinated.

Species	No. of days after sowing				
	2	3	4	5	6
No. 1		1			
Nos. 2 - 6	2	3			
Nos. 7 - 14		2	6		
Nos. 15 - 20		2	1		1

Code No. of the species corresponding to that used in Tables 3 and 4.

present observations, shown in Tables 1, 2, 3, Figs. 1 and 2, supported the previous conclusion. Moreover, it was ascertained that the germination behaviour of *O. sativa* did not remarkably change during the preservation of six and half years.

From the data obtained in the present experiment, it may be said that germination behaviour changes with the time of preservation according to the species, *i.e.*, the species having AA genome becomes to be later, other species becomes to be later and smaller, especially the species belonging to Groups Granulata, and Brachyantha become extremely to be later and smaller. This is a quite serious problem for seed-preservation.

It is also clear that the older was the seed age, the greater was the intra-specific and inter-specific variations.

Data of 123 years storage showed that retention of viability in temperate cereal seed is greater than that which might be expected from the results obtained over a few week- or years of storage (12). Although further results might be necessary to confirm this conclusion, these data obtained here indicate that techniques of storage condition and germination experiment with several years intervals can be used with confidence in designing condition for long period of storage, as they tend to under-estimate the retention of viability over very long periods.

GOSS (2) reported that the longevity of seeds buried in wet condition was larger than that buried in dry condition. In the present investigation, it became clear that the viability of seeds of *O. meyeriana* subsp. *granulata* and *O. meyeriana* subsp. *meyeriana* are relatively short. They are growing in dry soil (5). These data obtained here may fit for his findings.

Germination behaviour of *O. officinalis* showed very large intra-specific variations (Tables 2, 3, 4, and 5). This species showed also remarkable intra-specific variations for photo-periodical, morphological and ecological characters (5). So, it might be concluded that these remarkable variations can be seen as the species' specific-characters.

Summary

Using 192 strains belonging to 20 species of the genus *Oryza*, including 1 cultivated- and 19 wild-species, which have been preserved for six and half years in desiccators at 0°C, germination behaviours, including days from sowing to germination, germination process, germination duration, final germination percentage, and biological significances of these characters, were studied.

One hundred and four strains germinated at more than 90 % in the final date. Seventy six strains of them germinated at 100 %. About three fourth strains germinated at more than 61 % in the final date.

Two species, *i.e.*, *O. meyeriana* subsp. *granulata* and *O. brachyantha*, were ascertained to have completely lost viability. Germination started within 2 days after sowing, excepting for *O. minuta* and *O. meyeriana* subsp. *meyeriana*. Afterwards the percentage rapidly increased within 6 to 20 days. In 4 days after sowing, more than 50 % of all the sown grains germinated. The final percentage was 82.3 %.

The slower and the lower were the germination in the new seeds, the shorter and smaller were the longevity and germination-processes in the seeds, which have been stored for a long period. Then, the attention should be paid to the preservation-planning.

It may be concluded that species' specific characteristics are to be made clear in accordance with the length of the preservation period in view of several germination characters. That is, the germination behaviours change with the time of preservation according to the variations in the species, *i.e.*, the species having AA genome become to be later, other species become to be later and smaller. It is a serious problem for species and strain preservation. Moreover, the older was the seed-age, the greater was the intra-specific and inter-specific variations. Especially, *O. officinalis* showed such remarkable variation as those found in photoperiodical, morphological and ecological characters.

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