Studies on the Haploidy in Relation to Plant Breeding

II. Offsprings from haploid individuals of rice¹

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Morinaga and Fukushima (1931) were the first to report on the occurrence of haploids in the rice plant and their later detailed study (1934) on the haploid was given with respect to cytological as well as external features. Mention should be also made in this connection to Yasui's work (1941) on the diploid-bud formation of the same.

Cultivation of many haploids from three garden varieties of the species in question, *i.e.*, Shin-ai, Saitama-mochi and Takara, by the present author afforded various types of diploid buds, and enabled him to carry out investigations into the haploids, diploid-buds and offsprings. Histogenical explanation is given in this paper to account for the formation of the diploid-buds with a view to contributing to the problem of natural doubling of chromosomes.

1. Good pollens and seed set

Since 12 univalents are present in the meiosis of haploid rice, the diploid gamete will be brought forth from random distribution of univalents as $2/2(1+1)^{12}=2/8192$. Consequently the percentage of good pollens by means of this way is very low. However we may be met with somewhat higher percentage from the result of formation of restitution nucleus and other pro-

Table 1. Pollen grains from haploid and diploid individuals (%)

	Garden var.	Plump	Imperfect	Empty	Total
<i>n</i>	Shin-ai	11(0.11)	125(1.20)	10242(98.69)	10378(100.00)
	Saitama-mochi	8(0.08)	93(0.90)	10190(99.02)	10291(100.00)
	Takara	9(0.09)	111(1.11)	9877(98.80)	9997(100.00)
<i>2n</i>	Shin-ai	6109(86.20)	759(10.71)	219(3.09)	7087(100.00)
	<i>do. n→2n*</i>	5820(86.04)	716(10.59)	228(3.37)	6764(100.00)
	Saitama-mochi	5340(84.45)	707(11.18)	276(4.37)	6323(100.00)
	Takara	5764(84.24)	814(11.90)	264(3.86)	6842(100.00)

*G₂ generation.

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cesses, depending on environmental or other causes. In 1953 an observation of good pollens, using acetocarmine or iodine-potassium iodide solution, was made on haploid and diploid individuals of 3 varieties as shown in Table 1.

From this result the haploids seem to have somewhat higher percentage of good pollens than that of theoretical number by random distribution. Although the pollens are good apparently, they are not always diploid and germinant. In my pot culture, at any rate, the haploid produced seeds naturally at the approximate ratio of one grain per two or three thousand florets.

2. Diploiding due to bud-variation

As mentioned above, the chance of production of diploid seeds is very few through the usual course. However, there were sometimes fairly obtained seeds as following cases: (a) certain branch of a panicle was fertile and the other sterile, (b) scarcely whole a panicle was remarkably fertile, (c) more or less small grains set similarly on all parts of a panicle and (d) no seeds though the size of glumes was as large as that of diploid one. Of these 4 types (Cf. Fig. 1), the total number of

Fig. 1. Various panicles from the haploid of Shin-ai. $2n$ (cont.), n and four types (A~D).

Table 2. Fertile panicles from haploids

var. \ Type*	A	B	C	D
Shin-ai	4	1	2	1
Saitama-mochi	3	1	1	2
Takara	8	2	1	1

* See the text.

panicles, obtained during from 1950 to 1952 in many stocks propagated vegetatively, is shown in Table 2.

There were two kinds of usual and small grains among seeds obtained from the haploid. But the plant from small grains bore usual grains. A generational observation, as seen in Table 3, was made on the plant (G_1) from small grains of C type (Shin-ai) comparing with the plants (G_2 and G_3) from usual grains of that progeny. That is, the total length of terrestrial part was measured in 1953 on 40~50 individuals from 3 days after germination to 80 days (before the heading). From this result G_1 is somewhat smaller, especially in the seedling stage, than control, G_2 and G_3 .

Table 3. Individuals from small and usual grains (average total length, cm)

Generation	Days after germination										
	3	5	7	10	15	30	40	50	60	70	80
Cont.	3.2	6.1	10.7	15.1	17.6	27.7	35.3	43.7	62.4	76.9	87.6
G_1	2.1	4.6	8.7	11.7	13.8	24.6	31.7	42.8	61.7	74.6	85.9
G_2	2.7	5.4	9.9	13.0	15.2	27.7	37.0	47.5	65.8	81.4	93.8
G_3	2.8	5.6	10.2	13.4	15.9	26.0	35.0	46.0	64.1	78.6	90.1

3. Histogenical explanation

Generally the rice plant is considered as of two layers consisting of endohistogen and ectohistogen (*Cf.* Imai, 1936). Thus 4 types (A~D, Fig.

Fig. 2. A diagrammatic representation of various growing points (A~D) of rice plant considered as two layers. Dotted parts are $2n$ and the other n .

2) may be expected, corresponding to 4 groups (a~d) of panicles as mentioned previously. That is, if both the layers change to diploid condition, there will be brought B type. But in C type only the endohistogen become diploid condi-

tion and the ectohistogen lies in haploid tissue. Such a variant seems to show intermediate character between diploid and haploid branches. And the fertility seems not so good due to insufficient harmony between two different tissues. In type D of which change is seen in ectohistogen, on the contrary, the external character seems to be as near to normal one, but no perfect seeds can be expected. For the gamete in two-layer plant develops usually from endohistogen. In type A it is considered that a diploid tissue derived

from type B, C or D enters the haploid tissue as a sectorial chimera in various grades. Thus the panicles of respective types will be seen in grain set as shown in Fig. 3.

Under this consideration, a factual explanation is here offered for the bud-variation of three varieties. Shin-ai showed clearly a difference in grain size between B and C types (Fig. 4),

and the latter set small grains (small: usual=1.8:2.8 grams approximately per 100 grains) and was semifertile (*ca.* 50% in 1951). Moreover, our attraction

Fig. 3. Various panicles (A~D) shown diagrammatically. Dotted grains are fertile and the other sterile.

Fig. 4. Usual and small grains of Shin-ai. Control and G_2 are usual, and G_1 small.

turned over the awn of Saitama-mochi, *viz.*, common diploid plants had characteristic awns, but the haploid had not any ones. Consequently type B bore usual awn, but C no awn and D had somewhat short one (Fig. 5). So the gene requires two doses for

Fig. 5. Different phenotypes in awns (Saitama-mochi) of $2n$ (control), n and three types (B~D).

Fig. 6. Various seeds (B~D) from different haploids.

expression of awn and one dose as haploid none occurs. Again, in Takara these relations due to type were not so remarkable as aforesaid two varieties. A comparison of seeds as above mentioned is shown in Fig. 6.

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