VARIATION IN THE RATE OF RECURRING PLASTID MUTATIONS IN HORDEUM VULGARE CAUSED BY DIFFERENCES IN THE SOWING TIMES

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In *Hordeum vulgare*, L., a strain known as "Okina-Mugi" shows variegation with white stripes on the green parts of the plant body. The genetics of the variegated barley was thoroughly studied by Sô (1921). The white stripes are due to the propagation of cells containing white plastids, which are produced by recurring exo-mutations of the green plastids. The strain carries a stimulating gene, by the action of which the plastids alter from

FIGURE 1.—Progeny of variegated barley, containing some albinotic seedlings.

green to white. The gene itself is transmitted as a recessive to the normal allele; as it has a high constancy, the survived seedlings of the variegated barley invariably grow up to be variegated plants and never mix with the self-green ones. In the progeny of the variegated barley, a small proportion of albinotic seedlings appear (figure 1). The albinotic seedlings will die two or three weeks after their germination, when the stored substances in the endosperm are exhausted.

In 1931, seeds of a pure line of the variegated barley were sown incidentally at two different times with an interval of 12 days. I found a great difference in the amount of variegation in the rosettes of the two series of cultures. Their progenies were examined at the seedling bed by counting the albinos, the data being shown in table 1.

TABLE 1

SOWING TIME	CULTURE NO.	NUMBER OF PEDIGREES	VARIEGATED	ALBINOTIC	MOSAIC	TOTAL
October 18	1	69	15370	1164	54	16588
	Percentage		92.7	7.0	0.3	100
October 30	2	124	25609	814	31	26454
	3	67	15728	593	13	16339
	4	33	7344	342	18	7704
	5	94	19663	598	21	20232
	Total	318	68344	2352	83	70779
	Percentage		96.6	3.3	0.1	100
Totals		387	83714	3516	137	87367
Percentage			95.8	4.0	0.2	100

The origin of the mosaic seedlings is believed to be due to the egg cells containing green and white plastids together (IMAI 1928). The proportion of the albinotic seedlings is 7.0 percent in No. 1, 3.1 percent in No. 2, 3.7 percent in No. 3, 4.4 percent in No. 4, and 3.0 percent in No. 5. These figures may be divided into two groups, one showing a high ratio of 7.0 percent (No. 1) and the other a low ratio of 3.3 percent (Nos. 2-5). The differences in the frequency of the albinotic seedlings is therefore due to differences in the sowing times, it being possible to predict the results from the amount of variegation in the mother plants.

In the autumn of 1932, a series of experiments were attempted by sowing at intervals of 10 days with the object of testing this point more accurately. The results are tabulated in table 2.

TABLE 2

SOWING TIME	CULTURE NO.	NUMBER OF PEDIGREES	VARIEGATED		ALBINOTIC		MOAIC		TOTAL
			NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT	
September 10	1-1	31	5381	91.8	456	7.8	23	0.4	5360
September 20	1-2	37	6660	90.0	733	9.9	11	0.1	7404
September 30	1-3	49	9252	88.3	1210	11.5	17	0.2	10479
October 10	1-4	58	10156	90.7	1013	9.1	19	0.2	11188
October 20	1-5	54	10082	92.5	804	7.4	12	0.1	10398
October 30	1-6	88	16956	94.5	967	5.4	15	0.1	17938
November 9	1-7	39	6456	97.1	184	2.8	4	0.1	6644
Total		356	64943	92.3	5367	7.6	101	0.1	70411

The rate at which the albinotic seedlings appear varies greatly according to the times of sowing. Observations of rosettes of the mother plants made last spring revealed considerable differences in the amount of variegation, especially the notable reduction in cultures Nos. 1-6 and 1-7. To assist the understanding, the variation in the frequency of the albinotic seedlings according to the different times of sowing is graphed in figure 2.

The frequency curve, as will be seen, is quite smooth, showing a gradual decrease in the frequency at both sides of the mode for class 1-3, the sowing time of which is September 30. The rate in the occurrence of the albi-

FIGURE 2.—Variation in the frequency of albinotic mutants with differences in sowing times.

notic mutants is closely related to that of the plastid mutations, seeing that the variegation exhibited on the rosettes of the mother plants differs in the amount of the white stripes. The conclusion therefore is that sowing time regulates the rate of exo-mutations of plastids. It was found on September 30, 1932, that the frequency in occurrence of the albinotic seedlings reached an average of 11.5 percent, and the percentage gradually declined, both the earlier and later sowing giving a smaller proportion than the maximum observed. The frequency, however, fluctuated considerably in the pedigrees (progeny of respective plants) sown at the same time, as shown in table 3.

TABLE 3

CULTURE NO.	FREQUENCY OF ALBINOS (PERCENT)																														TOTAL	
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29		30
1-1			2	2	1	3	6	5		3		2	3	1	1		1						1									31
1-2					1	2	8	4	2	4	1	4	1		2	2	2	2	2													37
1-3			1	3	3	1		3	6	1	4	6	2	3	1	4	4		1	1	2	1	2									49
1-4				2	4	5	9	3	3	7	3	4	5	1		4	1	1	1		1	1		1				1				58
1-5			6	7	4	4	5	3	4	1	4	2	5		2	1	2	1	2	1												54
1-6		1	10	17	13	8	5	4	9	2	8	3	2	1	1	1	1		1			1										88
1-7		5	13	5	5	2	2	2		1		1				1																39
Total	6	30	34	31	24	27	26	30	18	24	14	25	8	7	11	7	10	4	6	2	3	3	3	1				1			1	356

The deviations are considerable, the highest proportion amounting to 29.5 percent. A mathematical treatment of the table shows:

Culture No.	M	σ
1-1	8.06 ± 0.53	4.38 ± 0.37
1-2	9.95 ± 0.46	4.19 ± 0.33
1-3	11.31 ± 0.51	5.28 ± 0.36
1-4	8.97 ± 0.53	5.95 ± 0.37
1-5	7.07 ± 0.46	5.04 ± 0.33
1-6	5.24 ± 0.29	4.08 ± 0.21
1-7	2.97 ± 0.34	3.13 ± 0.24
Total	7.63 ± 0.19	5.38 ± 0.14

The respective mean values (M), however, agree very nearly with the corresponding average figures shown in table 2 and graphed in figure 2. The standard deviations are remarkable, but do not vary much for the different cultures.

The average frequency of the albinotic mutants in the pedigree cultures of the variegated barley is 5.6 percent, which was obtained from the available data shown in table 4.

TABLE 4

VARIEGATED		ALBINOTIC		MOSAIC		TOTAL
NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT	
148657	94.2	8883	5.6	238	0.2	157778

The frequency of albinos fluctuates considerably about the average value. If the plastid mutations were to occur at any stage of the plant ontogeny, the deviation would probably be so remarkable that the frequency of mutations would hardly be possible to express with a reliable figure. Since in the variegated barley promeristematic mutations do not occur, no white ears are produced. This loosely limits the extent of variation in the frequency of the albinotic mutants.

Although difference in sowing time may accompany many environmental factors which influence the mutability of the plastids, the most important of them seems to be temperature. Experimenting with a mutable gene of *Drosophila virilis*, DEMEREC (1932) came to the conclusion that "The experiment, therefore, indicates that ten degrees centigrade difference in temperature has not affected the rate of change in the unstable miniature-3 gamma gene in a detectable degree." Prior to him, EYSTER (1926), however, obtained a positive result in his experiments with the variegated pericarp of maize. He raised variegated stocks in two lo-

calities differing in climate, one, Arizona, being of "the higher and more variable temperature and greater transpiration" than California, the other. EYSTER's conclusion is that "The California-grown variegations consistently had more red markings covering one-fourth the surface of a kernel and larger areas than the Arizona-grown variegations" and that "Changes from orange to variegation, and from orange to red also occurred more frequently under the California conditions." Since variegation is manifested by the recurring exo-mutations of plastids in my experiments with barley, the stimulating gene carried by the variegated stock is susceptible to certain environmental factors, its physiological potency to change the plastids being affected. It behooves us then to establish definitely at what period of the plant ontogeny the frequency of the plastid mutations is influenced, and by what environmental factors the mutability is regulated.

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