Studies on the Classification and the Geographical Distribution of the Japanese Barley Varieties. III
On the Linkage Relation and the Origin of the 'uzu' or Semi-Brachytic Character in Barley.

By

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Introduction

In the previous reports were presented the essential morphological features of the 'uzu' or the semi-brachytic form of cultivated barley, its geographical distribution in Japan, and the quantitative effects of the 'uzu' gene upon some plant characters in hybrids. The practical importance of the semi-brachytic character as applied to breeding and cultivation in Japan is not fully recognized and requires further researches disclosing the more detailed natures of this character. For the partial fulfilment of this purpose, studies on the linkage relation of the normal versus uzu character pair as well as on the detailed geographical distribution of uzu type of barley were made.

I. Linkage study of the normal versus uzu character.

A linkage study of the normal vs. uzu character pair was reported by MIYAKE and IMAI (1922): Correlative inheritance of this character pair (U u) with the multiple alleles, I i i', for reduced lateral florets appendages, and one of the genes for awn length, A_2a_2, were found, and concluded that Uu, A_2a_2, I i i', and also Dd, a gene for non-six-rowed vs. six-rowed were located in the same linkage group, presumably in the first linkage group of ROBERTSON *et al.* (1941). It was known in the experiment that Dd and Uu segregated independently in F_2, but they considered the discrepancy to be due to a great distance existing between the two genes under consideration, in spite that the genes I i i' and Dd were recognized to be closely or completely linked in the other section of the same report. They, moreover, neither persued further the F_3 behavior, nor investigated thoroughly the interrelationships of the U u gene pair with some of the others which are located in the other linkage groups.

1. *Materials and Methods*

Several semi-brachytic varieties were crossed with the normal varieties, in order to determine the interaction of uzn character with the other character pairs listed below, which are known to occur in their respective linkage group. The gene symbols used are as suggested by ROBERTSON *et al.* (1941).

Linkage group	Character pairs	Symbols
I	Non-six-row vs. six-row	V v
	Normal vs. ligule-and auricleless	Al al*
II	Black vs. white lemma and caryopsis	B b
III	Lax vs. dense ear	L l
	Covered vs. naked caryopsis	N n
	Long vs. short awned	Lk lk
IV	Blue vs. white aleurone	Bl bl
V	Long vs. short haired rachilla	S s
	Rough vs. smooth awned	R r
	Tough vs. fragile stem	Fs fs
VI	Green vs. white seedlings	Ac ac
	Green vs. white seedlings	An an
VII	Green vs. chlorina seedlings	Fc fc
	Green vs. virescent seedlings	Yc yc

* The linkage relation of this character pair will be reported later in other paper.

The uzu varieties used in the crosses were Kairyo-bozu, Suifu, Kogane-mugi, Yanehadaka, Yanehadaka-hen, Chōshiro-hen, and Henro-hen. They were of the same genotypic constitution regarding the genes Al, v, bl, Fs, R, uz, Ac, An, Fc and Yc, though some differed on Nn, Ll, Lklk and Ss alleles. Nine normal varieties were mated with the above so that the interrelations of uzu gene with the genes of the indicated linkage groups can be observed. The cross number with their respective varieties involved are listed below.

Cross No.	Parents ♀	×	♂	Cross No.	Parents ♀	×	♂
41-8	Six-rowed Chevalier	×	Yanehadaka	48-18	Nigrinudum	×	Oshichi-hen
47-32	Kairyo-bozu	×	Kamairazu	48-36	〃	×	Choshiro-hen
47-33	Kamairazu	×	Suifu	48-40	〃	×	Kogane-mugi
47-35	Liguleless	×	〃	48-37	Colsess I	×	Choshiro-hen
47-37	Kairyo-bozu	×	Liguleless	48-38	〃	×	Kogane-mugi
47-38	Kogane-mugi	×	Iraki black	48-39	Coast III	×	〃 〃
47-41	Russian No. 54	×	Choshiro-hen	48-34	Colsess V	×	Yanehadaka-hen
47-51	〃 〃	×	Henro-hen				

In these crosses, the records of the F_2 segregation of the first eight taken at their adult stage in the usual manner, but on the remaining seven crosses the seedling method was used. The latter method is as follows.

Since the crosses with Nigrinudum, Colsess I, Coast III and Colsess V involved chlorophyll deficient genes, an, ac, fc and yc respectively, the recessive homozygotes for some one of these genes are distinguished from the green seedlings within one or two weeks after sowing. The very favorable feature of this experiment was that all uzu segregates characterized themselves by the distinctly shorter coleoptile with a peculiar projection at the apex, which is easily discerned from the normal ones. A comparative experiment revealed that these peculiarities in the appearance of the uzu seedling were most strikingly manifested when the plant was grown in a glass-box kept at 25°C or higher, and placed in a sunny room. All of the progenies of the seven crosses were, therefore, grown and observed utilizing these features under the condition described above. The uzu segregates with or without chlorophyll were individually distinguished from the normal ones with or without chlorophyll on sixth or seventh days after sowing the seeds.

The experiment was further extended for ascertaining the accuracy of this seedling method, and to secure material for F_3 test a total of 925 F_2 green seedlings were taken separately from the crosses, No. 48-38, 48-39 and 48-40 and transplanted into the experimental field after the records were taken on their seedling characters. The two test methods checked in their results without one exception: The plant classified as normal or semi-brachytic at their seedling stage grew and exhibited the expected feasures in the adult.

Determination of the F_2 genotypes of these crosses was made by the seedling method using about 25 seeds from each the F_2 plants.

2. *Experimental Results*

A) ***Characters independently inherited:***

Various characters inherited independently of normal vs. uzu (Uz uz) are given in Table 1.

It is apparent from Table 1 that there is no linkage relation between normal vs. uzu and non-six-rowed vs. six-rowed, nor normal vs. liguleless condition of the leaves. Consequently, the gene uz should not be regarded as being located in the linkage group I. It appears also that the gene pair for normal vs. uzu (Uz uz) is inherited independently of the following gene pairs: black vs. white (Bb) located in linkage group II; covered vs. naked (Nn), lax vs. dense ear (Ll) and long vs. short awned (Lklk) in group III; blue vs. white aleurone (Blbl) already known to be in group IV; long vs. short haired rachilla (Ss), normal vs. fragile stem (Fsfs), and one of the gene pairs for rough and smooth awn (Rr) previously shown to be in group V; and green vs. chlorina seedling (Fcfc) and green vs. virescent seedling (Ycyc) in group VII. As to the green vs. virescent character pair, F_3 test was also made and obtained a result as shown in Table 2, revealing the F_2 data to be convincing. Therefore, these results permit us to suspect that the normal vs. uzu character pair is not likely to lie on the I, II, III, IV, V nor VII, but probably on group VI.

B) ***Linkage of characters:***

Since it was already indicated by ROBERTSON (1937) that ac, involved in heterozygous condition in Colsess I and an, in Nigrinudum are both located in the linkage group VI, the interaction of normal vs. uzu (Uzuz) with two different character pairs, Acac and Anan, both for green vs. white seedlings, were studied by means of the seedling method in crosses between several uzu varieties and two normal, Colsess I and Nigrinudum.

The segregation of the four phenotypes in the F_2 generations in the two crosses with Colsess I is shown in Table 3, where the F_2 segregation indicates a very poor fit to the calculated 9:3:3:1 ratio for independent inheritance of Acac and Uzuz.

Table 1. Observed F_2 phenotypes for normal vs. uzu and genes inherited independently.

Linkage group	Cross No.	Genotypes tested AaBb	F_2 Phenotypes AB	Ab	aB	ab	Total	χ^2	P
I	47-38	VvUzuz	183	58	52	20	313	1.0516	.7894
	47-35	AlalUzuz	163	63	58	15	299	1.8549	.5546
	47-37	〃 〃	173	44	63	16	296	3.9880	.2630
II	47-38	BbUzuz	169	55	66	23	313	2.0172	.5693
	47-41	〃 〃	174	50	52	22	298	1.7404	.6318
	47-51	〃 〃	271	64	92	27	454	6.8203	.0590
III	47-38	LlUzuz	179	60	56	18	313	0.3314	very large
	41- 8	NnUzuz	181	58	63	22	324	0.3676	〃
	47-37	〃 〃	170	41	66	20	297	5.9471	.1148
	47-32	〃 〃	207	63	62	20	352	0.9747	.8063
	47-32	LklkUzuz	211	63	65	20	352	1.0203	.7966
IV	47-32	BlblUzuz	203	57	65	26	351	2.0969	.5549
	47-35	〃 〃	171	58	53	15	297	1.0014	.8009
	47-37	〃 〃	167	40	46	14	267	4.6660	.2017
V	41- 8	SsUzuz	172	60	72	20	324	2.6722	.4509
	47-35	〃 〃	172	55	54	18	299	0.2075	very large
	47-33	〃 〃	165	48	52	14	279	1.4272	.7035
	47-38	〃 〃	173	56	62	22	313	1.1493	.7671
	47-32	FsfsUzuz	207	61	68	23	359	0.7368	very large
	47-33	〃 〃	172	51	45	12	280	4.1778	.2455
	47-38	RrUzuz	180	55	55	23	313	1.1553	.7659
VII	48-34	FcfcUzuz	448	131	177	47	803	7.4162	.0610
	48-39	YcycUzuz	723	258	249	72	1302	2.0881	.5565

Table 2. Observed and calculated F_2 genotypes as determined by F_3 segregating families from the green plants in F_2 of the Coast III × Kogane-mugi cross (48-39).

Items	F_2 genotypes AABB	AaBB	AABb	AaBb	aaBB	aaBb	Total	χ^2 *	P
Obsvd.	23	40	44	79	20	41	247		
Calctd.	20.58	41.17	41.17	82.33	20.58	41.17	247	0.6679	Very large

Aa = Uzuz ; Bb = Ycyc :* Compared with a calculated 1:2:2:4:1:2 ratio.

It is noted that doubly recessive individuals are very rare, while single dominant classes are more than what would be expected for independent inheritance, which apparently indicates a linkage in the repulsion phase. The recombination percentage, calculated by the IMMER's product method, was found to be 4.7, with a standard error of 1.5 per cent. The observed data afforded a good fit to the calculated segregation for 4.7 per cent of recombination.

The genotypic constitution of the green F_2 plants of the cross No. 48-38 (Colsess I × Kogane-mugi) was determined from its F_3 segregation. The result was

Table 3. F_2 segregation of normal vs. uzu and green vs. white seedlings in Colsess I × uzu varieties crosses.

Items	Number of indicated phenotypes				Total	χ^2	P
	Normal		Uzu				
	green	white	green	white			
48-37	695	327	324	1	1357		
48-38	306	151	141	0	598		
Total	1001	478	465	1	1945		
Calc. 9:3:3:1 ratio	1094.05	364.69	364.69	121.57	1945	190.3468	very small
Calc. 4.7% recombination	973.57	485.18	485.18	1.07	1945	1.7212	0.6355

Table 4. F_2 genotypes as determined by F_3 segregating families from the green plants in F_2 of the Colsess I × Koganemugi cross (No. 48-38)

Genotypes*	AABB	AaBB	AABb	AaBb	aaBB	aaBb	Total
Frequencies	6	38	20	239	114	26	443

* Aa = Uzuz, Bb = Acac

Table 5. Recombination values (P) and their total informations (I) calculated from Table 3 and 4.

Items	P	I	PI
F_2	0.0469	1955.6918	91.7219
F_3 doubly dominant	0.1240	4732.5782	586.8397
F_3 singly dominant	0.1024	2506.7140	256.6688
		SI = 9194.9840	SPI = 932.2304

shown in Table 4. From the F_3 data, the recombination values, P and their total informations, I, for doubly and the singly dominant classes were readily calculated by the formulae given by IMMER (1934). Table 5 shows their P and I values along with those for the F_2 based on the result in Table 3.

It was the desire of the authors to find the combined recombination value, rather than for each one, and for this, an applicable method is suggested by IMMER (1934). But a further attempt was made in this investigation to calculate a "combined weighted P-values", where the separate P-values were weighted. This method was first indicated by ROBERTSON *et al.* (1944). The formula is as follows:

Combined weighted $P = \frac{S\,P\,I}{S\,I}$, where S = summation, P = recombination values, and I = total informations.

The standard error for this average P-value is obtained by the formula:

$$\text{Standard error} = \sqrt{\frac{1}{S\,I}}$$

Applying the values shown in Table 5 to the formulae, a recombination value of 10.17±1.0428(%) was obtained.

By means of quite similar method as stated above, the crosses involving Nigrinudum × three different uzu varieties were studied, and the results indicated a linkage relation between Anan and Uzuz.

Table 6 shows the observed and the calculated F_2 phenotypes for normal vs. uzu

Table 6. F_2 segregation of normal vs. uzu and green vs. white seedlings in Nigrinudum X uzu varieties crosses.

Items	Number of indicated phenotypes					χ^2	P
	Normal		Uzu		Total		
	green	white	green	white			
48-18	256	109	108	5	478		
48-36	165	77	79	2	323		
48-40	423	207	213	4	847		
Total	844	393	400	11	1648		
Calc. 9:3:3:1 ratio	927	309	309	103	1648	167.91	very small
Calc. 16.6% recombination	835.35	400.65	400.65	11.35	1648	0.2469	very large

and green vs. white seedlings, which reveals a good fit of the observed count to the calculated ratio for 16.6% of recombination, but not to the 9:3:3:1 ratio for independent inheritance.

The determination of the F_2 genotypes for the cross No. 48-40 (Nigrinudum ×

Table 7. F_2 genotypes as determined by F_3 segregating families from the green plants in F_2 of the Nigrinudum X Koganemugi cross (No. 48-40).

Genotypes*	AABB	AaBB	AABb	AaBb	aaBB	aaBb	Total
Frequencies	4	15	26	112	61	17	235

* Aa = Uzuz, Bb = Anan

Kogane-mugi) was also made and the results are shown in Table 7. The recombination values and their total informations (P and I) for F_3 doubly and singly dominant classes, and likewise for F_2 calculated from data on Table 6 and 7 are given in Table

Table 8. Recombination values (P) and their total informations (I) calculated from Table 6. and 7.

Items	P	I	PI
F_2	0.166	1763.790	292.78914
F_3 doubly dominat	0.174	1588.672	276.42893
F_3 singly dominant	0.122	1156.865	141.13753
		SI=4509.327	SPI=710.35560

8. The weighted average of recombination percentage calculated from the figures in Table 8 was 15.75±1.4892(%).

A conclusion that the normal vs. uzu character pair (Uzuz) is located in the linkage group VI can apparently be drawn from the results mentioned above.

C) A consideration on the arrangement of genes, inclusive of Uzuz, on the VI chromosome.

Experiments showed that the recombination percentage of uz and ac was 10.17±1.0428(%), and that of uz and an 15.75±1.4892(%); but inasmuch as the distance between ac and an was unknown. the locus of the uz gene on the VI chromosome could not be determined. Nevertheless, an inference for this is possible, because ROBERTSON (1929, '37) succeeded in determining the order of the arrangement of and the distances between four genes, including ac and an, on the VI chromosome. This is presented in Fig. 1. In this chromosome map, the distance from ac to an

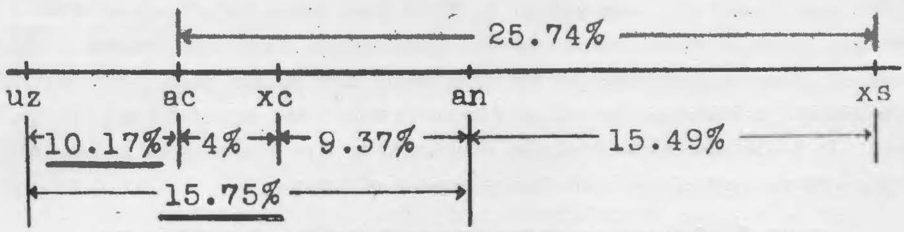

Fig 1. A chromosome map showing the order of the five genes inclusive of uz gene located in the linkage group VI, based on the results of Robertson (1937) and of the authors (underlined).

can be calculated as 4+9.37=13.37(%) or 25.74−15.49=10.25(%); and therefore, its value is expected to be 13.37% to 10.25%. The computed distance between ac and an from the data here obtained shows two values, large and small, depending upon how one assumes the locus of the uzu gene on the chromosome. The distance computed from the weighted average values is either 5.58% or 26.07%. The same computation made from the F_2 data gives the value 11.9% or 21.3%. The smaller value, which approaches that of ROBERTSON's, may be more plausible in this case, and if it is so, it may be reasonably concluded that the order of the gene arrangement is uz−ac−an, instead of ac−uz−an, although more evidences are, of course desired for the final decision. Fig. 1 is a chromosome map showing the order of the five genes located in the linkage group VI, based on the results of ROBERTSON (1937) and of the authors (underlined).

Here it is noted that the uzu is an unique non-lethal gene found in the linkage group VI, the other four genes of this group being all lethal. The results here obtained should be of some use for the genetical study of barley in the future, for the uzu character is very common in Japanese barley, and besides, is easily distinguished from the normal type in its adult as well as in the seedling stages. This experimental results may also be a distinct advantage for the Japanese barley breeders, since it was shown that the uzu character is independently inherited of the various other characters of agronomic importance chiefly located in the I to V linkage groups.

II. Geographic Distribution and Origin of the Semi-Brachytic Character.

Some evidences suggesting history and origin of the semi-brachytic character, which has hitherto been obtained, are presented below.

There is little doubt that the semi-brachytic barley has already been grown by farmers in Japan prior to the middle of the last century, although its cultivated area is surmised not to be so large as it is now. According to a statistical data, though incomplete, rapid enlargement of its acreage seems to have been brought about rather recent, perhaps since the middle of the Taisho era (1913 - 1926) when the systematic cereal breeding and agricultural extension work program were established. A tendency of steady increase of its area is apparent even at present. During the 13 years period from 1932 to 1945, total increment of its cultivated area was estimated to be more than 340,000 acres, while varieties of normal type, on the other hand, had decreased 33,000 acres during this same period. In Table 9 are given the proportion of acreage for four groups of barley, the normal and semi-brachytic forms with covered or naked grain are given as percentages of the total barley area in the years 1932 and 1945 respectively. It indicates that the semi-brachytic barley had gained 5.1 per cent in 13 years. It is also noteworthy that the semi-brachytic type predominated to the extent of some 80 per cent of the whole barley acreage of Japan.

Table 9. Comparison of the extent of acreage occupied by the normal and semi-brachytic forms with covered or naked grains in the years 1932 and 1945 in Japan.

Year	Normal form		Semi-brachytic form		Total of the semi-brachytic
	covered	naked	covered	naked	
	%	%	%	%	%
1932	17.5	7.9	25.9	48.7	74.6
1945	15.8	4.5	29.9	49.8	79.7
Difference	**−1.7**	**−3.4**	**+4.0**	**+1.1**	**+5.1**

In the first report, due to the incompleteness of the investigation, only a brief statement that the semi-brachytic barley was also found in the coastal region of southern Korea was given, but thereafter in order to accumulate further necessary informations for understanding the origin of this form, a statistical study has been advanced for the Korean barley.

For the materials of this study, 486 samples were secured by the aid of the authorities of the former Grain Conditioning House, Government of Korea, who kindly collected several samples of the most commonly cultivated barley in the vicinity of each of 156 branch houses scattered throughout Korea. The characters of these sample barley were studied for a number of years from the plants that were yearly propagated at the Institute.

By classifying them into the normal or the semi-brachytic with covered or naked grains and basing on the number of varieties falling in each of these four groups, the acreage and the proportion of occurrence in each of the prefectures as calculated from an Agricultural Statistics edited by Government of Korea in 1939 is shown in Table 10. It is apparent from Table 10 that the semi-brachytic form is confined to the warm southern coastal region, the normal varieties covering the rest of the regions of rather severe winter. The semi-brachytic-naked form occupies considerable extent of

Table 10. Cultivated area occupied by the normal and the semi-brachytic barley with covered or naked grains in different Prefectures of Korea. (Unit 100 ha.)

Prefecture	Normal		Semi-brachytic	
	covered	naked	covered	naked
N. Hamkyong	366			
S. Hamkyong	285			
N. Phyŏngan	88			
S. Phyŏngan	162	17		
Hwanghai	62	4		
Kwanwŏn	385	2	29	
Kyonkwi	911	8	28	4
N. Chungchŏng	754		84	1
S. Chungchŏng	637	104	201	82
N. Kyongsang	2235	71	69	24
S. Kyongsang	1061	69	217	335
N. Chŏlla	146	226	93	849
S. Chŏlla	244	35	8	1705
Total %	63.2	4.6	6.4	25.8

the area in North and South Chŏlla and South Kyongsang, but is very rare in the remaining parts of Korea. This form of barley is grown in general on the lowland after the rice crop or on the upland following the cotton. The semi-brachytic-covered form is also found in somewhat warmer parts of South Kyongsang, North Chŏlla and South Chungchŏng, though smaller in acreage than the naked type. The total area covered by the semi-brachytic form, inclusive of the covered and the naked varieties, amounts to about one third of the whole barley acreage of Korea.

The region of the normal-naked form is almost like that of the semi-brachytic-covered form, but extends a little farther north. The chief and representative form of barley in Korea is the normal-covered, occupying a considerable extent of area throughout the country.

The geographical regularities in the distribution of the four groups of barley in Korea stated above compare well to those in Japan Proper, suggesting a quite similar difference in the ecological requirements for the normal and semi-brachytic, as well as for the covered and the naked forms in the two countries. The reason for the semi-brachytic form being cultivated less in Korea than in Japan may be thought to be due to the differences in the prevailing climate during the barley growing period. According to Fukui (1939), southern coast of Chŏlla and Kyongsang has mild winter resembling northern Kyushu of Japan, where the growth of the semi-brachytic naked form is favored. Northward in the central parts of Korea, which is classified by Fukui as the South Korean Climatic Region, the winter cold followed by the spring drought becomes so severer that no plant of the semi-brachytic form will survive.

An important fact pertaining to the origin of the Korean semi-brachytic barley is supplied by Takeda (1929) who had long worked at the Agricultural Experiment Station of Korea. He says," the semi-brachytic (Sobo Rokkaku) barley is seldom found in South Kyongsang, but never elsewhere, and it seems probable that no variety of this type is found among those indigeneous to Korea". He emphasizes repeatedly in his book that with the exception of South Kyongsang Prefecture only the normal varieties are grown in Korea, and the semi-brachytic form is thought not to adapt well for the Korean climate.

A fact supporting his statement is that a majority of the Korean semi-brachytic naked varieties held in our stock still retain at present such Japanese names as Takeshita, Shimabara, Kumamoto, Shirodo, Nitahadaka and etc., all of which are the varieties most commonly cultivated in southern Japan. Other unnamed varieties are all morphologically akin to the barley of Japanese origin. It is said that these varieties are called as "Japanese barley" in southern Korea. The covered varieties of this type, on the other haud, involves some strains that are known to be selections from hybrids with Japanese semi-brachytic varieties made at the Suigen and other Agricultural Experiment Stations in Korea.

These informations doubtlessly support the view that the semi-brachytic barley is not indigeneous to Korea, but it has been introduced one after another perhaps from southern Japan since the time when Korea was anexed to Japan in 1910.

Another interesting fact is that according to the Agricultural Statistics cited above, the total barley area in Korea has increased steadily to 1.7 times during some 30 years from 1912 to 1939, and the increment was chiefly due to the enlargement of the naked barley acreage especially in the southern three Prefectures, North and South Chŏlla and South Kyongsang (Table 11). Successful barley growing on the lowland after the rice and also on the upland following the cotton crop since about 1932 in these regions has its chief share. The success of this introduction was owed entirely to the Japanese agronomists in Korea who recommended them to the adapted areas.

Table 11. Areas of the covered and the naked barley grown on lowland after the rice crop or upland field in 1912, 1925, 1932, and 1939 in whole Korea, together with those in southern three Prefectures (N. and S. Chŏlla and S. Kyongsang). (AfterAgricultural Statistics edited by Korean Government, unit 100 ha.)

Year	Covered barley			Naked barley		
	Lowland	Upland	Total	Lowland	Upland	Total
1912 in all	931	5293	6224	108	345	453
1925 in all	1708	6574	8282	151	398	549
1925 3 Pref.	954	2060	3014	104	230	334
1932 in all	2283	6701	8985	354	640	994
1932 3 Pref.	1231	1876	3107	293	470	763
1939 in all	2227	6073	8300	1327	1643	3014
1939 3 Pref.	899	1094	1993	1255	1469	2724

Figures in Table 10 and 11 show how rapidly such an agronomic character as semi-brachytic enlarges its area under favorable natural as well as artificial circumstances.

The semi-brachytic barley is scarcely grown outside of Japan and Korea. TAKAHASHI found a variety of this type being cultivated in a small plot in the subverbs of Shanghai, China. This was, however, proved not to be an endemic to China, as it was identified as 'Sekitori' or 'Chikurin', one of the most common covered barley in Kwanto district of Japan. Apparently, a certain Chinese farmer had gathered scattered barley grains of Japanese origin and tried to grow them, because its place was the vicinity of a harbour where Japanese supplies were being unloaded during the World War II.

FREISLEBEN (1940) found five samples of short-awned covered barley from the boundary region of Nuristan and Chitral in north-western India, and classified them as var. *brachyatherum* KCKE. But, inasmuch as these samples had very fine pointed awns and the stems of considerable length, compared to var. *brachyatherum* from Japan having very coarse awns and short stems, he correctly noticed that there probably exists no phylogenetic interrelationship between them; this is exactly the present writers' opinion.

Since a number of semi-brachytic varieties have been introduced from Japan into Germany, U. S. A. and U. S. S. R., specialists of barley in these countries are now more familiar with this form. Owing to its inadaptability, this form of barley has been utilized principally for breeding or other purposes only. No mutant resembling to this form has ever been reported to be endemic to these countries, except the brachytic mutant, which is known to have appeared by a different mutation (SWENSON 1940).

The results of investigations hitherto carried forth, though incomplete in many ways and requires further studies, lead us to a reasonable conclusion that the uzu or semi-brachytic character occurred by a mutation of a certain normal type of barley having been grown very probably in the southern parts of Japan. To the authors, the question of how the diversity in forms of the semi-brachytic barley has been brought about is another difficult problem that requires to be solved. For this, an inference may be made at present, where a repeated crossing of the mutant or its descentants with some other normal varieties is more probable than reccurrent mutations in different normal varieties.

SUMMARY

Barley having the 'uzu' or semi-brachytic habit of growth are of considerable economic importance in Japan. Some informations on the linkage relation, the geographical distribution and origin are presented here for future breeding and cultivation of this form of barley. The results are summarized below.

1. Experiments showed the gene pair for normal vs. uzu is inherited independently of the genes known to be located in the linkage groups, I, II, III, IV, V, and VII.
2. Linkage relations were found between uz and two chlorophyll deficient genes, ac and an, both having been located in group VI. The weighted average of combined F_2 and F_3 recombination percentage of uz and ac was 10.17 ± 1.0428 (%), and that of uz and an 15.75 ± 1.4892(%). The locus of the uzu gene on the VI chromosome was inferred as shown in Fig. 1.
3. The uzu type of barley in Japan is suspected to have not been so extensively grown

in Meiji era (1857 - 1912) as it is now, but it was enlarged in its acreage rather recently. A data supporting this view is given. The uzu form occupies 80 per cent of the whole barley acreage in Japan at present.

4. An investigation of the geographical distribution of the covered and naked grain characters in the normal and the uzu barley of Korea was made. In spite of the fact that the uzu type takes up about one third of the entire barley acreage in Korea at present, it is obvious that this form is not indigeneous to this country, but was introduced from Japan since its annexation to Japan.
5. The uzu form is seldom found outside of Japan and Korea. It is suspected that this form may have originated by a gene mutation occurred on a certain normal variety in Japan, most probably in the southern part.

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