Studies on the Classification and the Geographical Distribution of the Japanese Barley Varieties. I.

Significance of the Bimodal Curve of the Coleoptile Length.

By

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[Received on April 21, 1942.]

Introduction.

Having conducted some works on the characteristics of seedling with various Japanese barley varieties, the author found that those varieties showed a typical bimodal frequency curve in regard to the length of the coleoptile. The discontinuity of variation observed in the length of the coleoptile is of great interest, because this suggests the possibility of dividing those varieties distinctly into two groups which are of genetically different constitutions, the same as DE VRIES had done with *Chrysanthemum segetum*. Therefore, comparative studies on the two varietal groups derived from the discontinuous variation curve of the coleoptile lengths were made statistically with regard to important characters of young and adult plants, and also to their geopraphical distribution.

As the results of this study it was confirmed that the two varietal groups differed distinctly in the various morphological characters tested, the cause of which might be due to the presence or the absence of "Uzu" gene, a kind of brachytic, affecting on them pleiotropically. It was also found that there exist regularities in the geographical distribution of the two groups in the hulled and the naked barley, and it suggests us that there are marked ecological differences among them.

In this paper the author will state the results briefly.

Material.

As the materials for this study more than 300 varieties of barley were collected from various districts of Japan, namely, Saghalein, Hokkaido, all of the prefectures of Japan proper, Korea, Formosa and also Manchukuo, where they are cultivated nowadays. Beside these, local forms and preserved varieties of this Institute were also used.

Results.

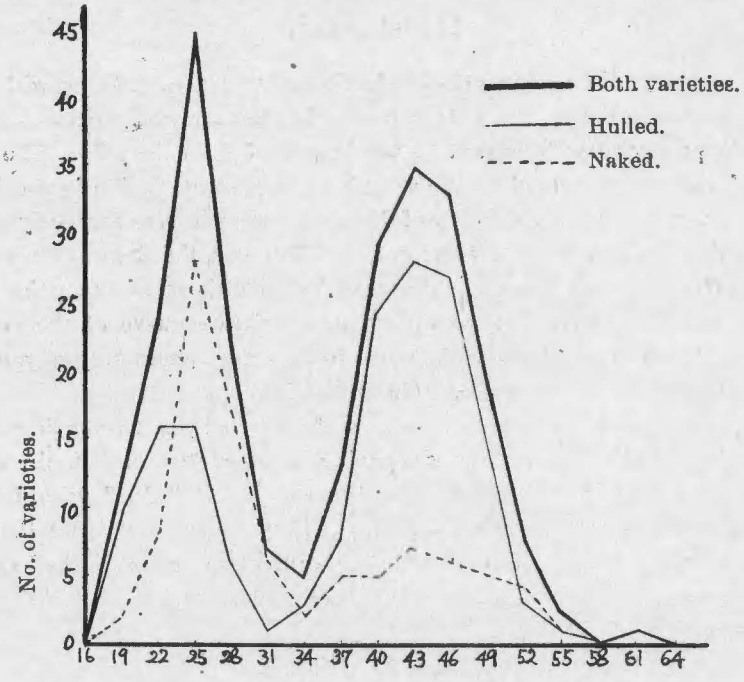
1. Grouping the barley varieties according to the characteristics of the coleoptile.

The author has already confirmed, in the results reported in other paper, that the length of the coleoptile is a character peculiar to a variety and shows a considerably stable value, if the seeds are well chosen and the growing of the seedlings done under a constant condition, while on the other hand, he found that there exist marked differences in the coleoptile lengths among varieties.

In this experiment several parallel tests[1] were carried out under different conditions using more than 300 barley varieties in order to know the varietal differences of the coleoptile lengths. One of the results is graphically shown in Fig. 1.

Fig. 1.

Frequency curve of Japanese barley varieties with respect to the length of coleoptile.



1) In determining the length of the coleoptile of each variety, 34 seeds of uniform size were sown in a Petri-dish containing sterilized sand saturated with tap water. Seedlings were grown under continuous illumination of 120 Lux in an incubator kept at 20 °C. with more or less saturated atmosphere.

After a week, when the coleoptile had completely elongated, 20–30 of uniform individuals were used for the measurement. Mean value of them was adopted as the length of a variety.

Similar tests were made under different conditions, such as in the darkness and outdoors.

At a glance of Figure 1, it can be easily noticed that these varieties of barley show a typical bimodal curve in regard to their coleoptile lengths; that is, one mode is found at the class of 25 mm., and the other at 43 – 46 mm., and the curve is divided into two normal ones at the class of 34 mm., which is the central bottom of the bimodal curve.

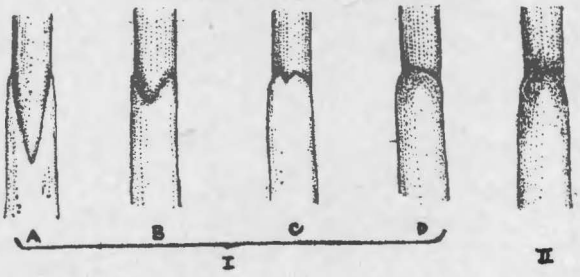
Quite similar results were obtained from other tests, for instance, the result of the test done under a condition of almost darkness was such that two modes were seen at 25 – 30 mm. and 49 – 52 mm., respectively, and that the curve was divided into two at the class of 37 mm. Moreover, this result of grouping held true for other tests performed under different external conditions.

Here, the author assumes the group of varieties belonging to the lower mode as "*The short type*", and the other group in the higher mode as "*The long type*", respectively.

To endorse the propriety of this grouping, some facts are presented below.

Fig. 2.

Showing several notches at the apex of the coleoptiles of the short type variety (I) as compared with that of the long type (II).



The coleoptile of the short type varieties often reveals a prominent projection at the portion near the apex. The Projection is hollow cylindrical, and is formed of tissue layers as similar to those of the coleoptile. As in Plate XI and XII it always stands facing to the embryo-end and at the lowest end of the cleavage, through which first leaf emerges. The projection may be regarded as a ligule of the coleoptile, assuming the coleoptile to be a leaf sheath without a blade.

Aside from this, at the apex and on the opposite side of the projection there can be often observed a Y-shaped notch. (Fig. 2.) Therefore, the apex of the coleoptile has two notches, one on each sides in this case.

However, in the coleoptile of the long type varieties, neither the projection nor the notch can be found.

2. *Comparative gross morphology.*

A. On the seedlings.

For the comparison of the morphological features of young plants, about 160 varieties of barley consisting of almost equal numbers of both types were grown in wooden cases compacted with fine soil sufficiently mixed. In each

wooden cases ten varieties of 35 seeds each were sown. The growing was begun simultaneously on August 28 th 1941, and continued till the third leaf began to appear. The seedlings were measured immediately after collecting.

Comparative ovservations informed us that there were marked differences between the two types in their young stage, as is shown in Plate XIII and XIV ; the young plant of the short type was of thickset stature with deeper green leaves, and often revealed in the leaf blades such peculiarities as projections on the both surfaces, a V-shaped notch at the apex, and a counter-clock-wise twist at the middle portion. Those of the long type, on the contrary, were generally of long and slender appearance with pale green leaves and the above peculiarities were entirely absent.

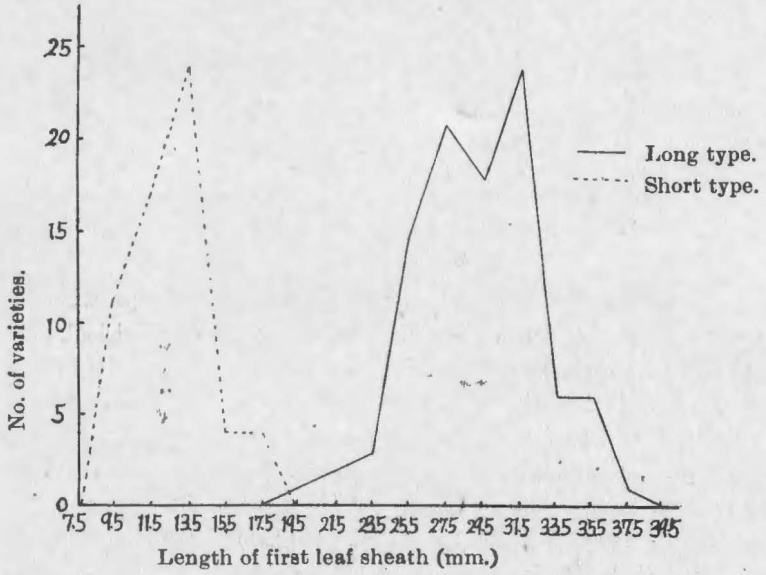
Results of the measurement on the length of the sheath and the blade, and the width of the first leaf showed these relationship more precisely.

a) Length of first leaf sheath.[2)]

The results are graphically shown in Fig. 3.

Fig. 3.

Variation curves of the long and the short types with respect to the length of first leaf sheath.



The values of the varieties of the long type fluctuate from 19 mm. to 37 mm., the modal point being at 28 mm. Those of a short type give the breadth of variation of 9 mm.-18 mm., the mode being at 14 mm. Therefore, it may be said that the length of the first leaf sheath differs clearly between the two types without exception.

2) The length of the first leaf-sheath was measured from the joint of the blade and the sheath to the embryo. The first internode was included in this measurement, but it was negligibly short in this culture.

b) Shape of first foliage leaf.

Similar relationship was observed in the length of the first leaf,[3] but the variation curves of the two types crossed each other in some degree at the lower and the higher ends owing to the high fluctuation of their values. On the other hand, quite reverse relationship was seen regarding the width of the first leaf-blade[4]; the short type being generally wider than that of the long type. (Fig. 4.)

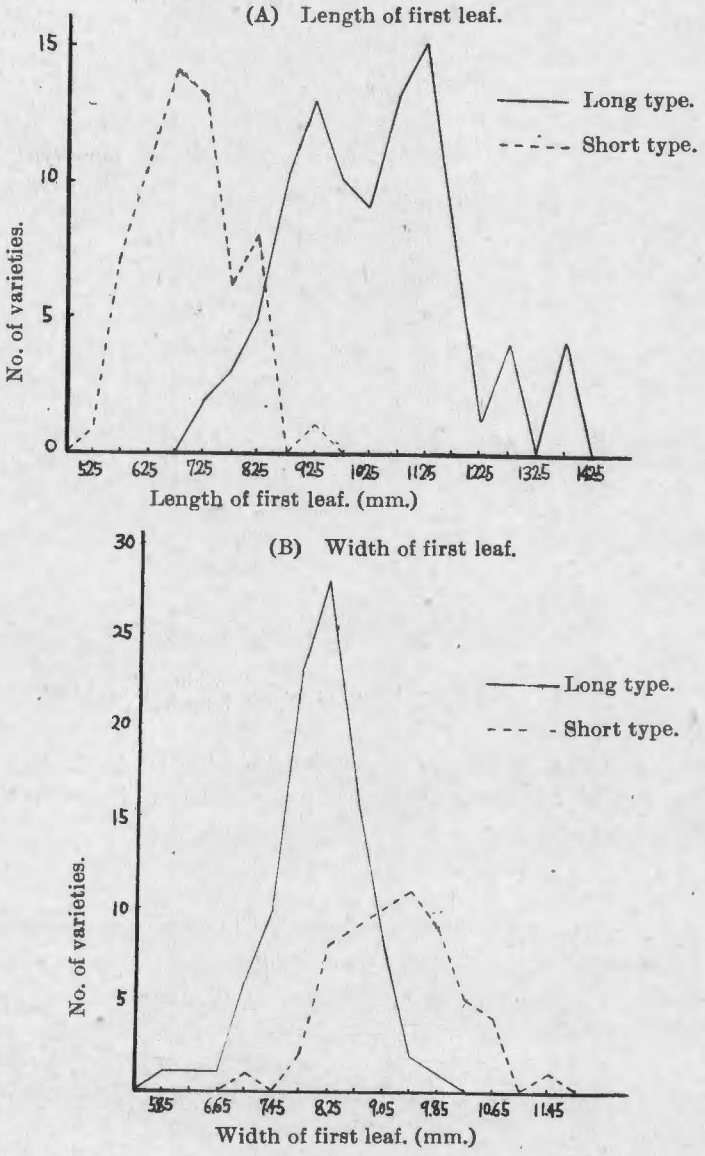


Fig. 4. Variation curves of the long and the short type with respect to the length and the width of the first leaf-blade.

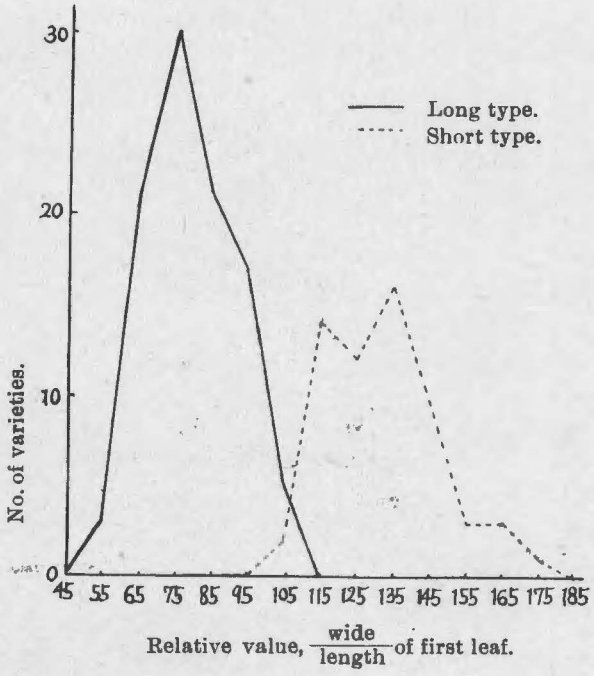
3) The length of the leaf-blade was defined as that from the joint of the blade and sheath to its apex.

4) The widest portion was measured and it was represented as the width of the leaf

In order to show the shape of the blade, the relative values of the width against the length, or leaf-shape indices, were calculated. Graphical representation of the results is given in Fig. 5.

Fig. 5.

Comparison of the variation curves of the long and the short type with respect to the relative value, the width against the length of first leaf.



From this, it may be recognized that the blade of the first leaf of the long type varieties is generally longer and slender, while that of the short type relatively thickset.

B. On the adult plants.

Comparative studies were conducted further regarding various characteristics of matured plants, namely, halm length, main characteristics of ear, size and weight of grains, and date of earing, all of which are important not only for the classification, but also for the breeding.

As to the grain characters, samples were taken from materials representing varieties most commonly cultivated which were gathered from Agricultural Experiment Station of respective districts.

a) Appearance of the adult plants.

Field observations informed us that the same relationship as found in the young stage was equally maintained until their maturity.

The general appearance of the adult plants of the two types may be briefly explained as below.

The short type varieties are generally thickset: halms are thick and short; leaf-blades are also short, straight, thick, wide with deep green colour, and standing at an acute angle to the halm; and ears and awns are short, coarse, and considerably fragile.

On the contrary, the long type varieties show slender appearance: halm are generally fine; the blades are long and pale green, the apex of which are more pointed, standing at somewhat obtuse angle to the halm and sometimes drooping downward from the middle portion; and ears and awns are generally long. Concerning the awn, two types are distinguished in this group: one is long and tough, the other somewhat shorter and more flexible.

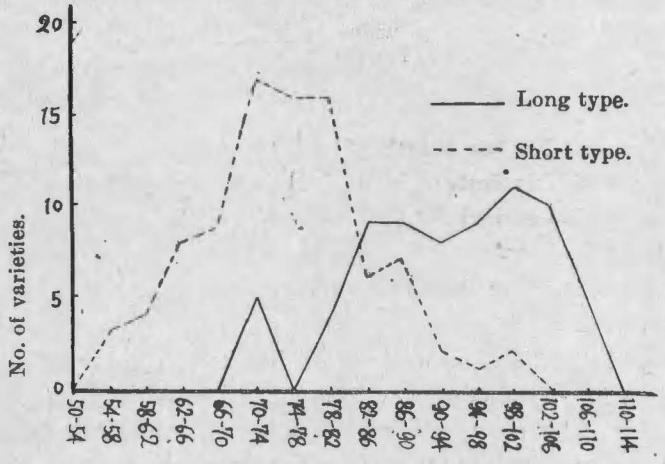
b) Length of halm.

Japanese barley varieties show considerably wide variation as to their lengths of halm; the shortest being about 50 cm., and the longest about 110 cm.

Comparative curve of the two varietal groups is drawn in Fig. 6.

Fig. 6.

Variation curves of the long and the short types with respect to the lengths of halm.



The result shows that there exists the same relationship as found in other characters mensioned above between the two types in their lengths of halm. The fluctuation of their values in both types seems to be somewhat wider, which may be caused by internal and external conditions.

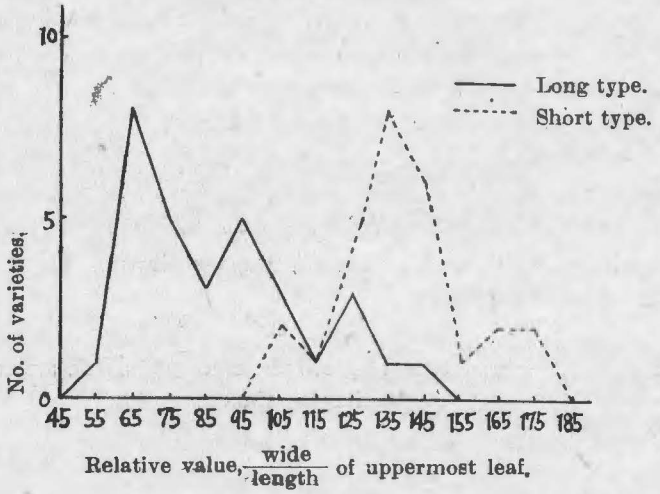
c) Shape of uppermost leaf.

The uppermost leaf was taken as a representative of the foliage leaves. The method of measurement was similar to that used for the first leaf, and almost the same result was obtained.

Fig. 7, which is the variation curves of leaf-indices of the uppermost leaves, shows that the leaf-shape of the short type is short and wide in general, while that of the long type is long and slender.

Fig. 7.

Comparison of the variation curves of the long and the short type with respect to the relative value, the width against the length of uppermost leaf.



d) Length of ear.[5]

It is well known that ear length of barley is peculiar to variety, but differs among varieties, and this feature is utilized in the classification of varieties. Japanese barley varieties used for this study also show immense diversity in regard to their lengths of ear.

In Fig. 8 are compared the variation curves of the ear lengths of the two varietal groups.

It may be said that the length of ear of the short type are generally short, while those of the long type vary in wide range; that is, the long type consists of many varieties of long ears which are not found in the short type, although both the long and the short types reveal some irregularities in their dispersion which may be due to the internal as well as the external influences.

e) Length of awn.[6]

Form and length of awns vary widely among different varieties, and this variation is used as one of the most important characteristics in the classification of cereals.

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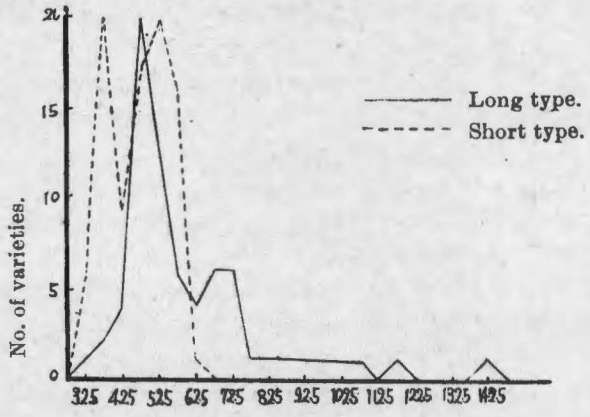
5) In each variety, 10 or more standard ears were measured and averaged to represent the varietal ear length.

6) For the determination of the awn length, samples were taken from 10 or more standard ears and each awn of central spikelet of medial row was measured.

Fig. 8.

Variation curves of the long and the short types with respect to the lengths of ear.



Materials used for this work consisted of following awn-types:

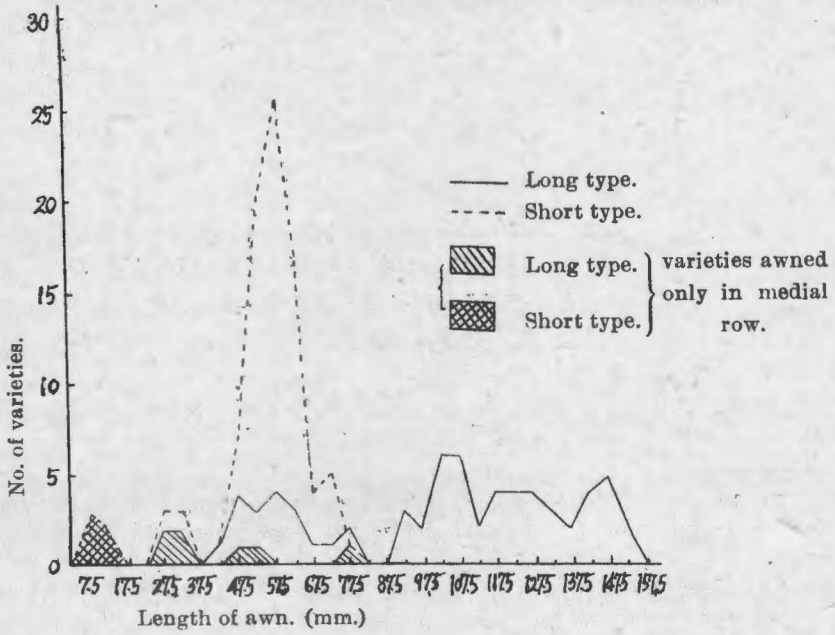
1. Both the main and the lateral florets fully awned.
2. Only the main floret awned — corresponding to var. *japonicum* Vav.

Among these varieties of the both awn-types, there are remarkable variation in the awn length of medial row which may be caused by some genetical factors.

The results of measurement on awn lengths of the short and the long types are shown graphically in Fig. 9.

Fig. 9.

Variation curves of the long and the short types with respect to the lengths of awn.



The lengths of awn of the short type varieties vary from 10 mm. to 80 mm., and those of the long type from 30 mm. to 155 mm., though there can be seen several peaks in the variation curves of both types. It arrests our attention that all of the varieties which have awns of longer than 80 mm. are confined to the long type. With respect to the varieties awned only in medial row, quite similar relation was observed; all varieties of the short type have awns of about 10 mm. long, and those of the long type of 30 – 80 mm.

f) Length of axis of basal bristle.[7]

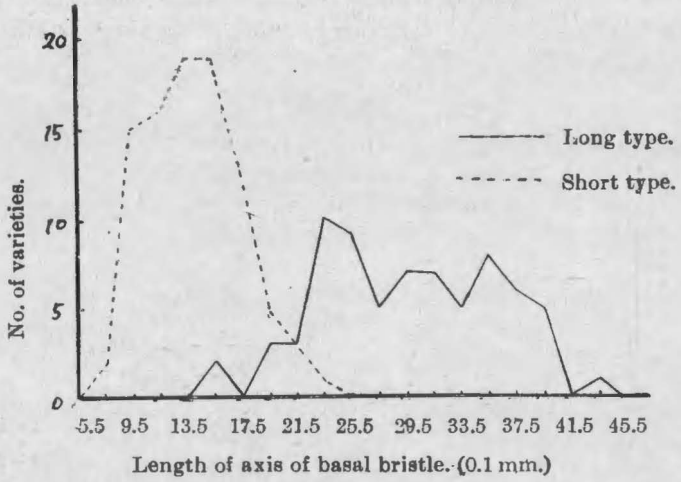
The basal bristle, which is regarded as a rachilla of secondary floret, also is a character useful for the classification of barley.

Between the two varietal groups can be seen marked difference as to the several characters of basal bristle, especially in their length of axis.

The results shown in Fig. 10 regarding the length of the axis of basal bristle indicate that the short type is generally shorter than the long type. In oder to make this relation easily understood, some samples of A-type and of C-type were separately photographed and are shown in Plate XIII, Fig. 5.

Fig. 10.

Variation curves of the long and the short types with respect to the length of axis of basal bristle.



g) Length of empty glume.[8]

Empty glumes of Japanese barley varieties are linear lanceolate with little variation in their shape, but with marked differences in their length.

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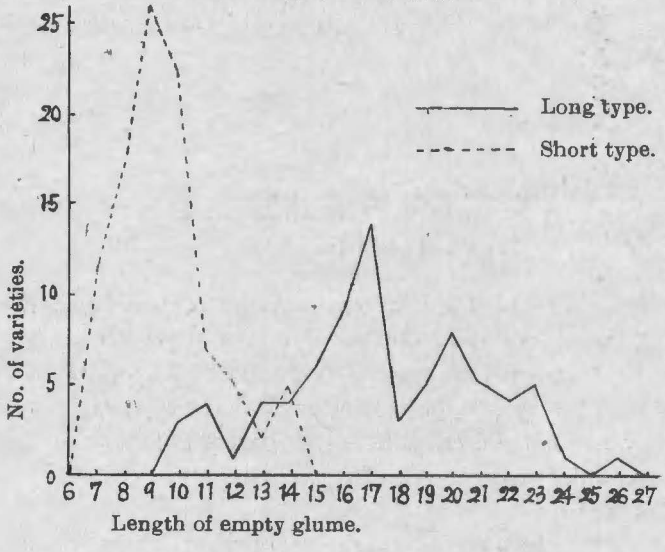
7) 10 or more samples of basal bristles were carefully picked out with a needle from central portion of two standard ears and were measured under biocular microscope.

8) Simultaneously, samples of empty glumes were taken from the same portion of the ears and were measured by placing between two slide glasses.

The results of measurement on this character are graphically given in Fig. 11, in which, differences of the two varietal groups can be easily recognized. A photograph of several empty glumes of the both types are inserted by way of example. (Plate XI, Fig. 2.)

Fig. 11.

Variation curves of the long and the short types with respect to the length of empty glume.

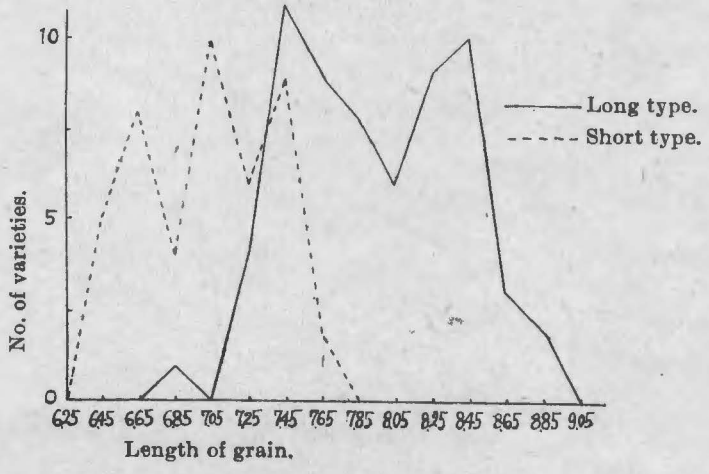


h) Size of grain.[9]

Fig. 12.

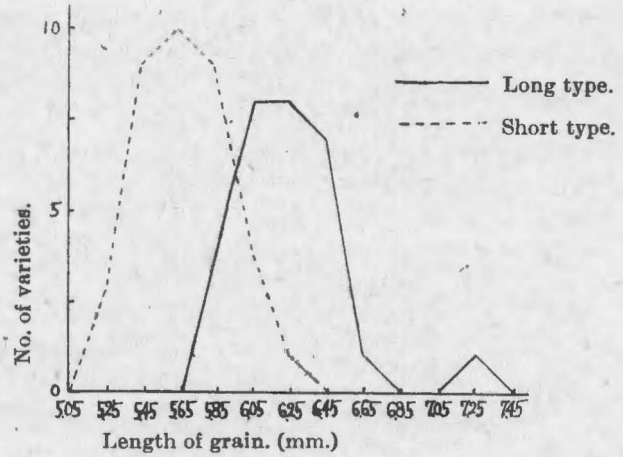
Comparison of the variation curves of the long and the short types with respect to the length of grain.

(A) Hulled.



9) About 100 grains of modal size, which were selected by passing through sieve, used for the measurement.

(B) Naked.



Apparently, grains of the long type varieties seem to be larger and longer than those of the short type. Comparative measurement on grain lengths of hulled and naked varieties are separately presented in Fig. 12, A and B. The results show that the short type is shorter than the long type in the length of grains. However, no significant differences were recognized in the width and thickness between the two groups. (The results omitted.)

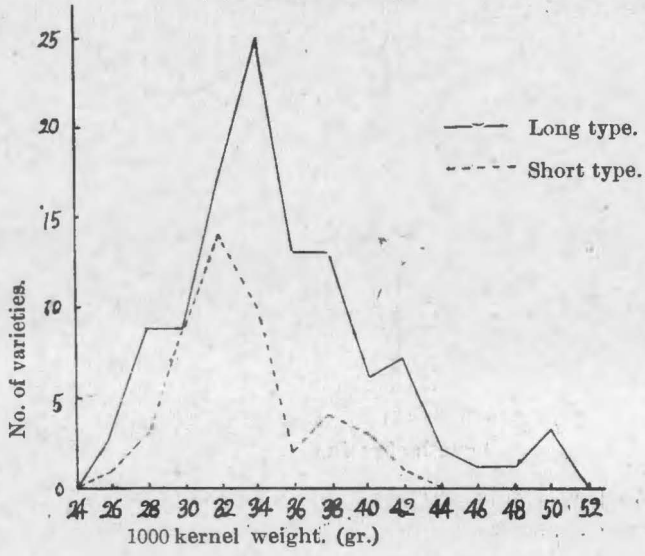
i) Weight of kernels.

The character of 1000 kernel weight was compared between the two groups. The results are shown in Fig. 13. It shows the difference being so slight that it is almost insignificant.

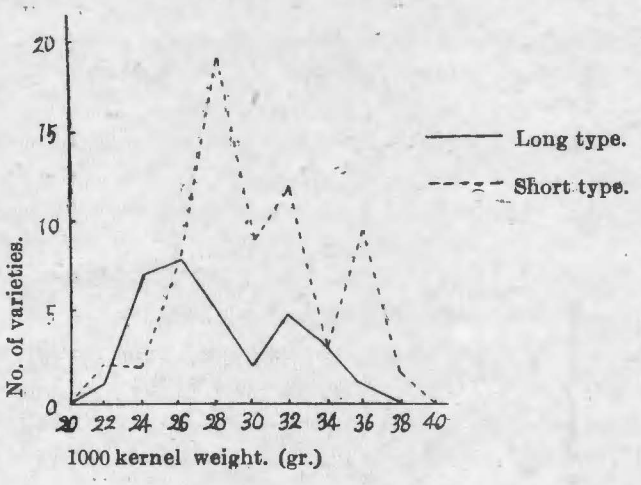
Fig. 13.

Variation curves of the long and the short types with respect to 1000 kernel weight.

(A) Hulled variety.



(B) Naked variety.

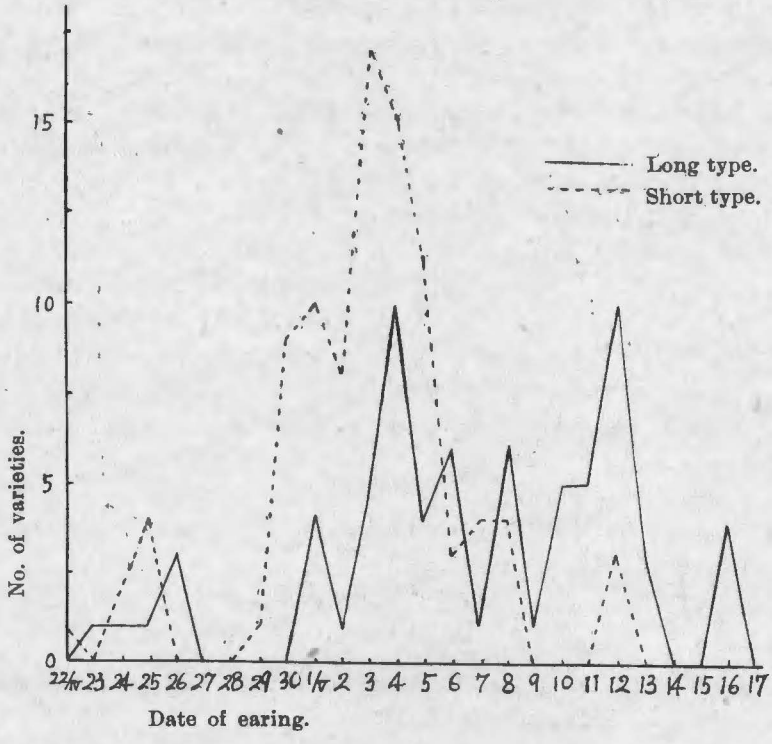


j) Date of earing.

Observations were made on the date of earing in the two varietal groups. The result presented in Fig. 14, shows that there is no difference between them in this character.

Fig. 14.

Variation curves of the long and the short types with respect to the date of earing.



3. Geographical distribution of barley varieties in Japan.

Having recognized marked differences existing between the two types in regard to their various morphological characters, it was further supposed for the possible differences in their physiological behaviours. In order to find a clue to this subject, the geographical distribution of varieties was studied.

For this purpose, area occupied by barley in each of the prefectures of Japan was calculated as proportion of the whole country, in the first place; then the percentages of areas occupied by the long type and of the short type were investigated for each prefectures by referring to the statistics published in 1933 by the Japanese Department of Agriculture and Forestry.

From the above culculation, the cultivated areas occupied by the varieties of the long type and of the short type for each of the prefecture can be culculated as percentage of the total areas under barley cultivation in Japan.

Similar calculations were simultaneously carried out with respect to hulled and naked barley.

Summarizing the results, a comprehensive distribution map of barley varieties of Japan was obtained and is shown in Fig. 15.

The map shows clearly that the varieties of the long type and the short type as well as their hulled and naked ones are distributed in regular manner in Japan.

The northern-most part of Japan as Saghalein and Hokkaido is occupied with the naked-long type, which is sown in spring time in generals; and Tohoku, Hokuriku and San-in districts by the hulled-long type of winter habit.

Descending southward, the middle and southern part of Japan proper are wholely covered with the short type varieties. Here, it must be noted that the relative position of the hulled and the naked is quite reversed in this region, the hulled in the north (Kwanto and Tokai districts) and the naked in the south (Kinki, Sanyo, Shikoku and northern part of Kyusyu).

Then, the long type appears again in the southern-most part of Japan. A tendency of naked barley spreading in the north (southern coastal region of Shikoku and Kyusyu), and the hulled in the south (Ryukyu and Formosa) may be recognizable, though it is not so distinct as in the other parts, as the comparative cultivated area of barley crop is less.

From these results, it may be assumed to be present such boundarys in the distribution as given in Fig. 15.

In Korea and Manchukuo, almost all parts are occupied by varieties of the long type, though several short type varieties are found in southern coastal region of Korea with warm climate.

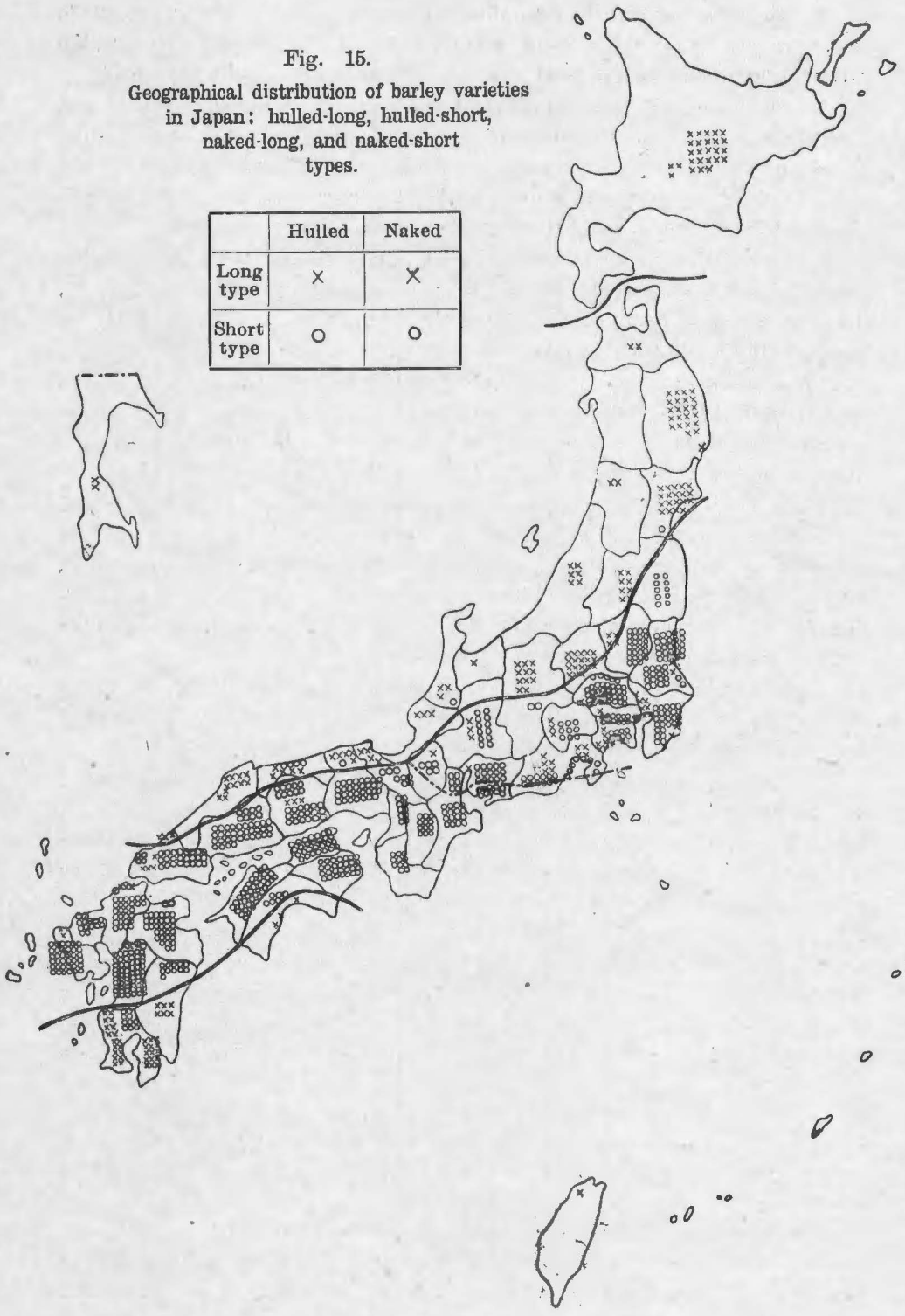
Discussion.

The results of studies on the characteristics of the coleoptile obtained hitherto by the author may be summarized as follows:

Fig. 15.

Geographical distribution of barley varieties in Japan: hulled-long, hulled-short, naked-long, and naked-short types.

	Hulled	Naked
Long type	×	×
Short type	○	○



1. The mean value of the coleoptile lengths of a certain variety was so stable that, as proved by the coefficient of variability of only 3.3 per cent. in the tests, the variation curve consisting of these mean values may be taken as highly reliable.

2. The bimodal variation curve can be easily divided into two normal ones at a certain class value, and varieties of these two parts remained constant in their respective positions even when tests were made under different conditions. Further, the two varietal groups showed marked differences not only in their length of coleoptile but also in the morphological characteristics.

3. In addition to these facts, genetical study showed that the coleoptile length is controlled mainly by a single gene segregating in 3 : 1 ration in F_2, the long coleoptile being dominant over the short. (The experimental data pertaining to this subject will be reported in later paper.)

From the above facts, it may be concluded that the two varietal groups derived from the discontinuous variation curve of the coleoptile length can be considered to be of genetically different constitution, differing especially on a single main factor.

Further, comparative studies regarding various characters of young and adult stages revealed such a regularity of variation that the short type varieties are generally shorter as to the length, and wider as to the width, in comparison with the long type varieties ; and it is also note worthy that, although considerable number of varieties were used for the test, there was no exception contradicting the above mentioned regularity.

These facts may be adequately explained by the assumption of pleiotropic effect of a certain gene, the presence of which perhaps caused the diminution of the coleoptile length as well as that of various parts of growing plants.

On the other hand, it is generally recognizable that the variation curves of the two varietal groups, drawn in regard to a certain character of later developments, inter-crossed each other in some degree. This shifting or the disturbance of variation curves may be attributed to the different grade of actions of the pleiotropic gene to a certain character, or to the presence of some other intense gene besides the assumed pleiotropic gene.

SWENSON (1940) reported a result of detailed comparative studies on a normal variety of barley, Himalaya, and a branchytic mutant, which had mutated from the Himalaya. The gene for branchytic habit of growth behaves as simple Mendelian recessive to normal. There was a general diminution in size of branchytic plants and their parts as compared to those of Himalaya ; the plumules were about one half as long ; the plants as well as the leaf sheath were two-thirds as long ; and the awns were about one half as long. The seeds were only 85 per cent as heavy, and as to the number of seeds and total weight of seeds per plant there were no significant differences.

As to rice plant, similar studies were done by NAKAYAMA (1940). Three dwarf rice strains were used for the comparative materials, the genetical behaviours of which had been investigated by AKEMINE. He had observed that the action of a

dwarf gene was most remarkable at the early and the late stage of development and was weakened at the middle stage.

VAN OBERBEEK (1938) remarked that the coleoptile of some dwarf forms of *Zea mays* is shorter than that of the normal.

These authors' results explain obviously that the diminutive effects of dwarf gene displayed throughout the whole stages from earliest development to maturity with different intensity varied with parts of plant. It is reasonable to suppose, therefore, that the short type varieties have a dwarf gene in common which affect in remarkable extent on the length of coleoptile, and simultaneously, on the length of halm, ear, awn, and etc., however, these relations should be verified directly by the genetical survey.

The first worker who distinguished varieties of extremely shortness in the length of halms, ears, and awns among various barley varieties from Japan, and considered them as a *varietas* was KÖRNICKE. He designated them as *Hordeum hexastichum* var. *brachyatherum*. The general description is as follows:

Short-awned six-row barley from Japan. *Hordeum hexastichum brachyatherum* KCKE. Ear: light-yellow, short, compact; awn: short, only 4 cm., straight, light coloured; ear and awn very fragile; halm: redish yellow, 60–75 cm.; caryopsis: light yellow, small, (8 mm. in length, 3½ mm. in breadth, 3 mm. in thickness) considerably fine-coated. 241 caryopses 10 gr. Ear 4–6 cm. long with 40 grains.

The most detailed and precise classification of Japanese barley varieties was undertaken by S. TAKEDA (1917). He, in his work "Classification of wheat and barley varieties" stated that "Sobōrokkaku" or coarse-awned *hexastichyum-typus*, has the feature of coarse- and short-awn, short and compact ear, short halm, and differing also from others in empty glume, basal bristle forms and etc. Furthermore, among these varieties, he classified various kinds of "Ear type".

K. MIYAKE and Y. IMAI (1922) stated, "Uzu or a brachytic form has been unconsciously utilized by farmers owing to its high productivity and earey-ripening. The "Uzu" gene has simultaneous diminutive action on the ear-density, length of ears, glumes and halms and, especially on length of awn. The "Uzu" gene is single recessive to normal".

The characteristics of the short type of this present study is in accord with the above workers' descriptions of their brachytic forms, and they are conceivably identical. With respect to "Sobo-rokkaku" named by Takeda, it was confirmed by the reference to varietal names listed by him, and, in addition, to its physiological and morphological characteristics. As to the "Uzu" form of MIYAKE and IMAI, it was proved true by the answer received for the inquiry sent to one of the author.

Next, some considerations as to the geographical distribution of barley varieties in Japan will be stated.

As Japan extends north to south, sub-arctic, warm and subtropic regions are included, she has many varieties with respect to a certain crop plant. Here, natural as well as artificial selections affect their varietal distribution and result in

the thrival of only those varieties adapted to respective conditions of different districts. Varieties of barley may also be applicable to the case.

It was already stated that the naked-long type of spring habit was found in the extremely northern part, followed by the hulled-long type of winter habit in the lower latitude of Japan.

According to VAVILOV, N. I. and BUKINICH, D. D. (1929) and also FREISLEBEN, R. (1940), the naked barley of spring habit is cultivated in the most elevated areas of over 2500 m. above sea level, and the hulled barley of winter as well as spring habits in the lower region of less than 2500 m. in the mountaineous districts of Afghanistan. A quite same relation in the distribution of the hulled and the naked was also observed by ORLOV, A. A. (1929) in Abyssinia and Erythrea.

This relative position of the naked and the hulled barley in the vertical distribution in Afghanistan and in Abyssinia and Erythrea may be conceived to resemble that of horizontal distribution in our country. This is very interesting, but there is no satisfactory explanation for this fact.

Disregarding such cases as the presence of naked barley of spring habit in Saghalein and Hakkaido and of few hulled barley in Ryukyu and Formosa, it may be said that the hulled barley prevails in the northern part, while the naked one in the south. It is, therefore, natural to suppose the former to be more resistant to the cold- or snow-damage than the latter in generals, as in these districts barley sown in autumn and grown through cold winter is an oridinary practice. However, it is important to pay attention to possible differences between the hulled and the naked barley in some other physiological natures such as the water requirement and also to economical demands.

With respect to the distribution of the long and the short types, varieties of the short type are confined to central and southern parts of Japan, where the climate is generally mild; while those of the long type are distributed in extremely northern and southern parts of considerably severe climate, and also exceptionally in central part.

From this, it may be supposed that varieties of the short type in comparison with the long type can not adapt themselves in the extremely severe climatic conditions, especially in low and high temperatures.

As to a reason for varieties of the short type to be completely shut out from the northern districts, deficiency in the resistance to snow- or cold-damage may be conceivable. According to the results on the varietal differences in the resistance to snow-rot (Yatuyanagi unpublished), all of the varieties belonging to the short type showed remarkable low-resistance to snow-damage, while among those of the long type were seen various grades of resistance to it. Besides, it is found that the distribution of the short type shows close relation to that of snow fall, that is, the short type being distributed in areas having a short period covered by snow.

Consideration is also given as to the reason why the short type varieties had spread all over the central and southern part of Japan, expelling the long type.

It may be due to the superiority of the morphological and physiological characters of the short type as compared with the long type: its high adaptability to the climatic condition, excellent productivity, shortness in plant height and awn length, and high resistance to lodging owing to the thick straw. These characters are most required by the farmers for the cultivation of barley under warm and rainy conditions of Japan.

Summary.

1. According to the differences in some characteristics of the coleoptile, varieties of barley collected from various districts of Japan were classified into two groups, namely, the long type and the short type, and their comparative studies were statistically persued on the various important characters of young and adult plant organs. Furthermore, geographical distribution of barley varieties in Japan was also investigated.

2. From the results it was confirmed that all of the short type varieties had a gene for dwarfness ("Uzu" gene), which affected pleiotropically on coleoptile, first and uppermost leaf, ear, awn, halm, empty glume, axis of basal bristle and also grains, that is, diminutively in their length and broadly in their width in different degree with different organs. This factor, however, had no influence on the weight of grains and the date of earing.

3. It was found that the short type varieties distinguished in this test is identical with Sobō-rokkaku of TAKEDA, and "Uzu"-varieties of MIYAKE and IMAI, and includes the var. *brachyatherum* KOKE.,

4. Four types of barley: hulled-long type, hulled-short type, naked-long type and naked-short type were distributed in markedly different districts of Japan, and their ecological features were discussed.

The writer wishes to acknowledge the kind guidance of Dr. M. KONDO, the Director of this Institute during the course of this study. Acknowledgement is also due to Mr. T. NAKAYAMA for his help in the preparation of the English text of this paper.

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PLATE XI.

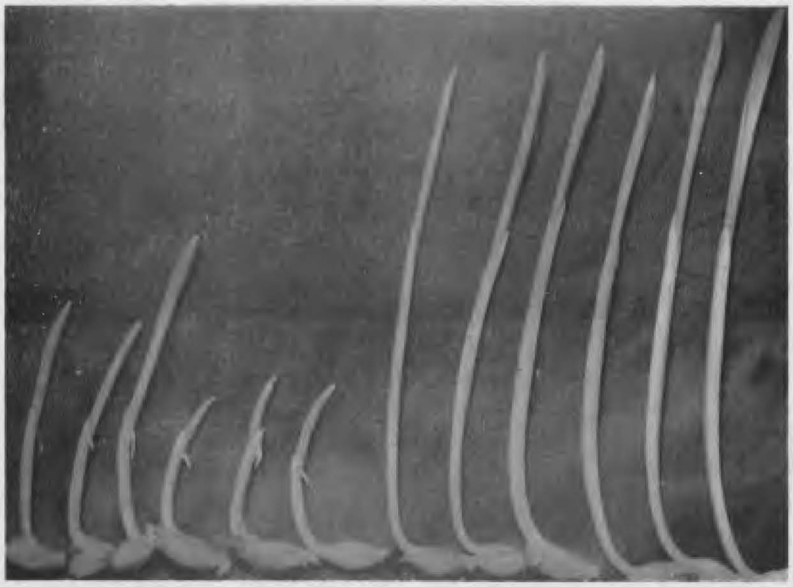
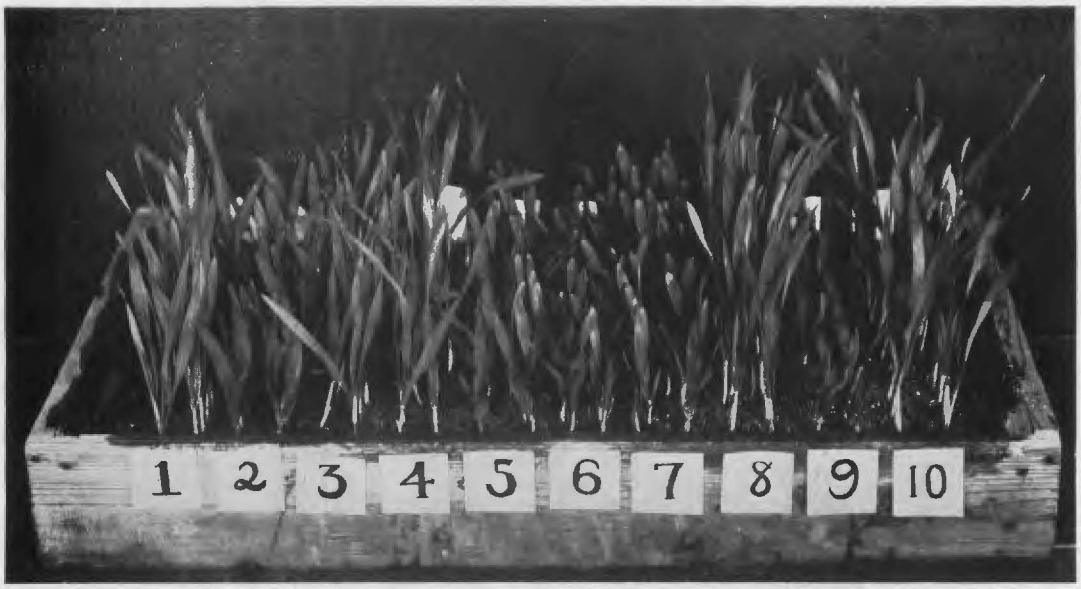


Fig. 1. Appearance of the coleoptile of the short and the long types.
Left • • • • A short type variety, Zairai Tanbo.
Right • • • A long type variety, Golden melon.

Fig. 2. Projections at the apex of the short type variety.

PLATE XII.



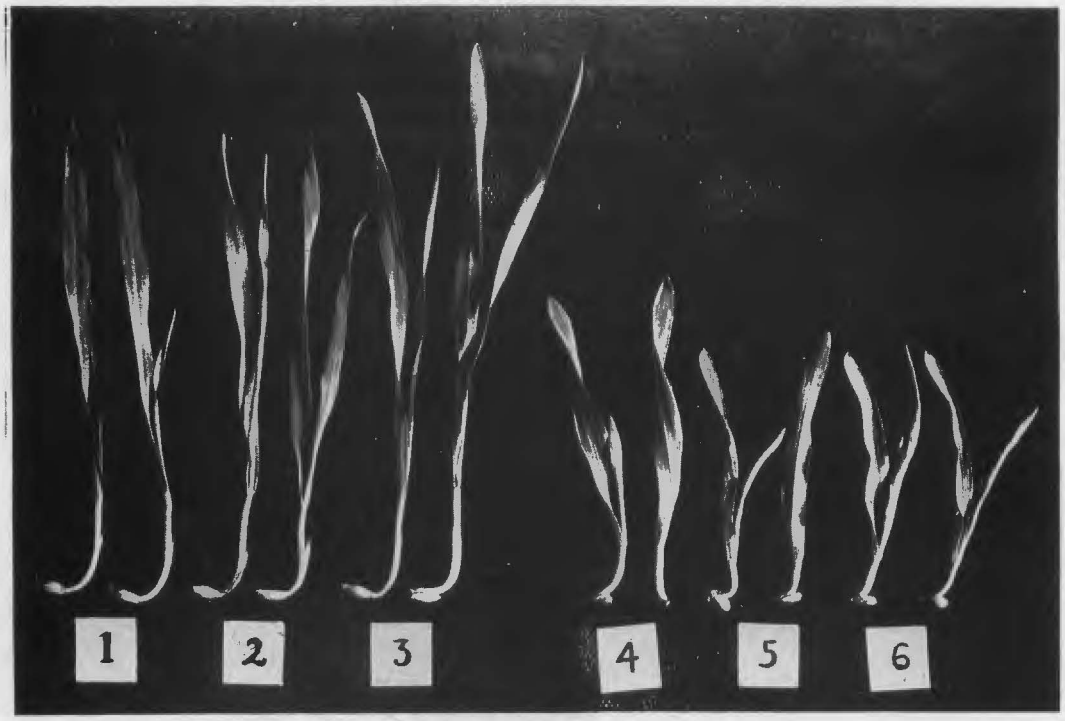


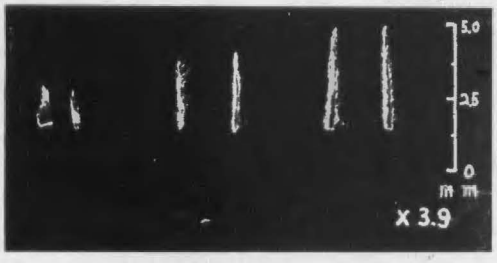
Fig. 3 and 4. Appearance of young plants of the short and the long types.

Showing in Fig. 3, Nos. 1, 3, 4, 8, and 10 · · · · · · Long type varieties,
Nos. 2, 5, 6, 7, and 9 · · · · · · Short type varieties.
„ in Fig. 4, Nos. 1, 2, 3 · · Long type; Nos. 4, 5, 6 · · Short type.

PLATE XIII.

(A) So-called A-type.

Upper . . . . . Long type.
Lower . . . . . Short type.



(B) So-called C-type.

Left . . . . . Short type.
Centre and right . . Long type.

Fig. 5. Variation in the character of the basal bristle of several varieties belonging to the long and the short type.

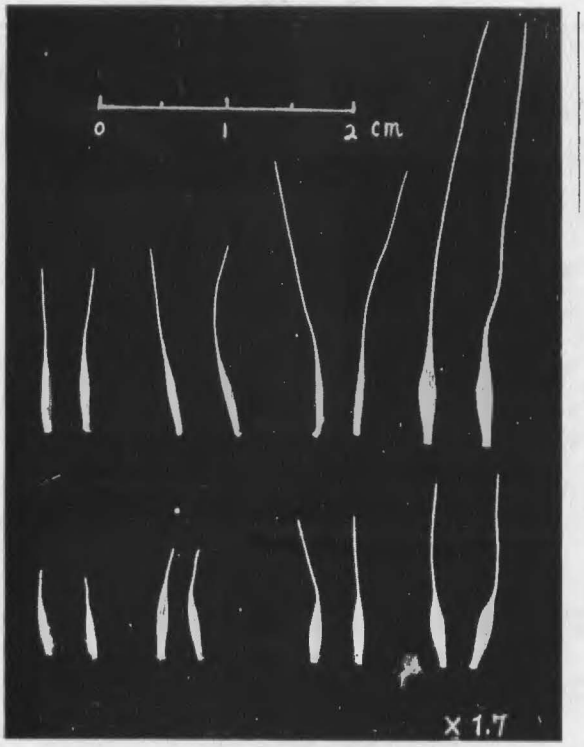


Fig. 6. Variation in the character of the empty glume of several varieties belonging to the long type (Upper) and the short type (Lower).