Areal Difference and its Yearly Change of Cold Disaster on the Rice Cultivation of Northeast Japan (I)

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Areal Difference and its Yearly Change of Cold Disaster on the Rice Cultivation of Northeast Japan. (1)

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In this paper the author-attempts, as a premise to his areal analysis of many factors of cold disasters, to make clear how has been changing with time and localy the resistance of rice cultivation to its yearly climatic change.

By his study of areal changes of the cold disaster with time, he is going to grasp the areal significance of the climatic circumstance, and in addition the areality of rice culture in their process of development in the cold district.

The cold disaster is a phenomenon that mainly a low temperature and scanty sunshine in summer give great handicaps to the growth of crops and their yields come down. In Northeast Japan and the highland of Central Japan, the disaster has periodically taken place once every several years, and has given great damages mainly to the rice culture. In general, the degree of damages from the climatic disasters results from the interaction of the degree of climatic change and the physical and human conditions of an area where resistance is made to the climatic change. About the cold disaster, many papers have been published in many fields such as agriculture, meteorology, economics and sociology,[1] because of the severe damage being often given to the fundamental farming of Japan. Especially, the development of agriculture in Northeast Japan has been greatly influenced by counter plans against the cold disaster. However, the studies on the distribution of cold disasters are generally few, and very few especially in the field of geography.

Fig. 2 and 3 show the distribution of the cold disasters in 1934 and 1953. The distribution pattern in 1934 is most typical and has something in common with those in the past many years when the cold disaster took place. In this figure, it is recognized that the center area of the disasters is in the north-eastern part and the degree of the damages comes down rapidly westward and gradually southward, and that the distribution is greatly influenced by the mountain ranges running from north to south. K. Suda already reported in his paper these striking characteristics of the distribution[2], and T. Asai analysed the interrelation between both the distributions of the cold disasters and the air temperature at the time when

1) For example, see "Study on the literature of cold damages to rice culture, by A. J. Agricultural Meteorology, 1955".

2) K. Suda : Locality of cold disaster, Weather & Climate, Vol. 2, pp. 146-149, 1935.

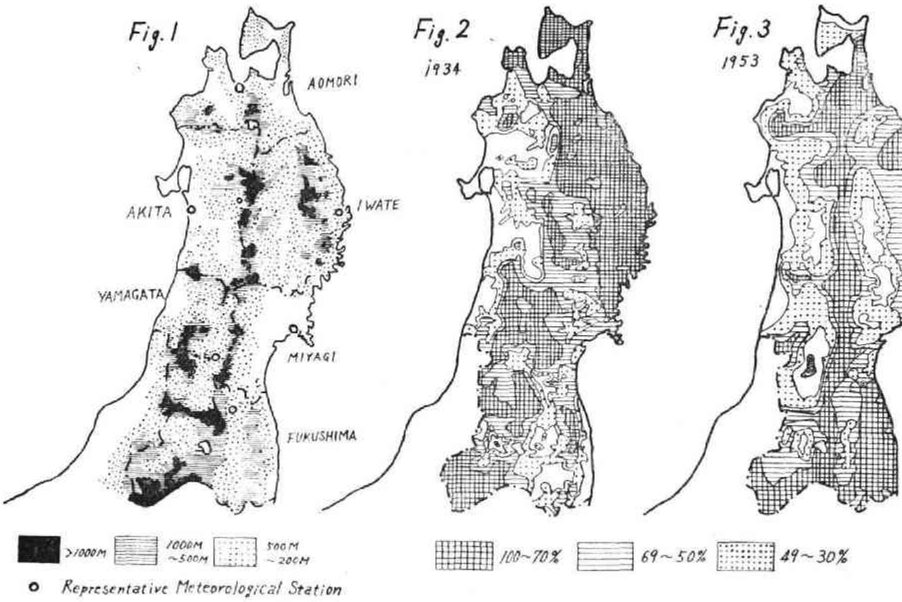

Fig. 1 Index map. (showing topographic feature, Prefectures and representative meteorological stations)

Fig. 2 and 3 Distribution maps of the rate of the yield in the year when the cold disaster took place to the mean yield in the normal years

a northeast cold wind, so called "Yamase", prevails[3]. In other words, the greatest features of the distribution as mentioned above depends mainly on a cold air mass which developes over the Ohotsk sea and is carried by the northeast wind. But, if some distribution maps of the cold disasters are compared with one another, for example the two distribution maps of Fig. 2 and 3,—it will be easily noticed that there are many differences among them. And the differences depend upon not only the yearly differences of climatic change, but those of human resistances such as the improvement in the species of rice-plant, etc.

I. Method

Generally, a plant has its own effective temperature range, and the growth of a plant and temperature are in a plus correlation in a certain limited range. If a temperature comes over or down the high or low critical temperature of its range, it stops growing. Usually, agricultural crops are cultivated under such a climatic condition that a temperature is higher than their high critical temperatures. And

3) T. Asai: On the distribution of air temperature in Tohoku district when "Yamase" cold wind prevails, Mis. Rep. Res. Inst. N.R. No. 16, 58-66, 1950.

the cold disasters can be thought to result from lower temperatures than the high critical temperatures of the crops. And it will be considered that the effective temperature ranges of crops change with the development of cultivation technic such as the improvement in the species. Therefore, in order to grasp the areal differences of the damages with time, he draws the following correlation graphs of the yearly yield per unit area and the mean air temperature of a month showing the most intimate relation to the yield. And the unit of area is divided into the following classes. 1). Prefecture unit. Correlation graphs concerning every prefecture with the yearly mean yield per unit area and the yearly mean monthly air temperature at the representative points of every prefecture. 2) Subregion unit divided by topographic or climatic features. Correlation graphs concerning every subregion with the yearly mean yield and the yearly mean monthly air temperature at the representative point of every subregion. Of course, to understand areal characteristics, a subregion unit is more preferable than a perfecture unit. But the data are too limited to serve the purpose, and the author can not but adopt the prefecture unit in this paper.

In the air temperature in the correlation graph is used the integrated value of the mean monthly maximum air temperatures in June, July and August, because the air temperatures in the months, as well as the sunshine, are regarded as the climatic element bearing the most close relation to the yield of rice plants, and because the maximum air temperture is used as a better indicater to express the weather condition in the daytime directly related to the growth of crops than the mean air temperature between the maximum and minimum air temperatures.

In the correlation graphs by the method above mentioned, trend-curves to coincide with the tendency of the distribution of coordinate points are drawn per period, and he regards maximum convex points on the curves as the high critical points of the mean effective temperature range for some species of the rice plants raised in an area.

II. On the correlation graph of the unit yield and the integrated air temperature by prefecture.

1) *Aomori* Prefecture. (Fig. 4)

In the case of *Aomori* Prefecture, two trend-curves are clearly recognized as is shown in Fig. 4. One presents the tendency between 1897 and 1927, and the other between 1928 and 1947. The maximum convex points on these curves are respectively Point A (1.53 : 72.0)[4] and Point B (2.04 : 74.3). On both of them, the

4) (*koku* per *tan* : integrated temperature °C), 1 *koku* of rice is equal to about 150 kg, 1 *tan* is equal to about 0.245 acres.

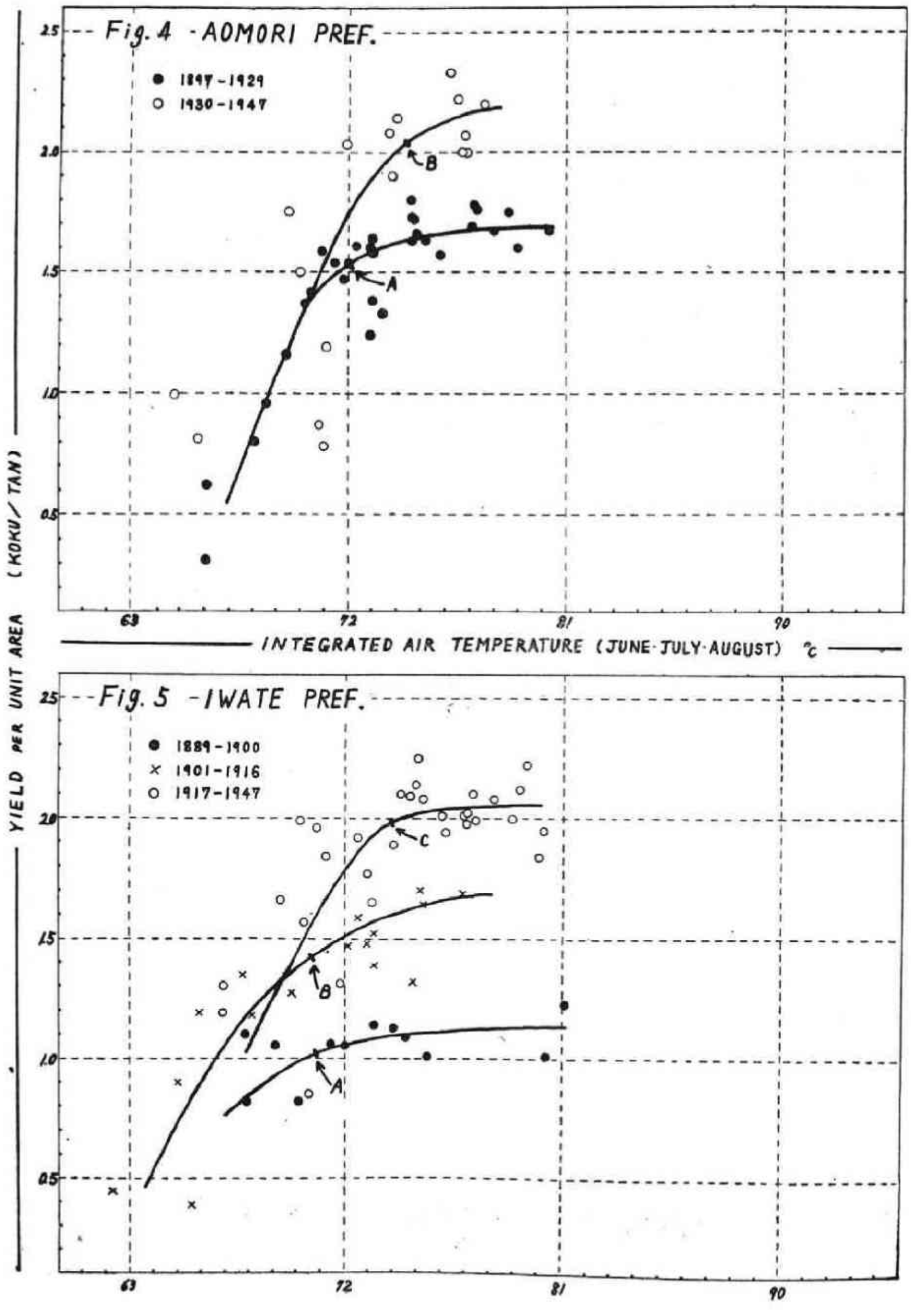
Fig. 4 - AOMORI PREF.
1897-1929
1930-1947
A
B
2.5
2.0
1.5
1.0
0.5
63
72
81
90
YIELD PER UNIT AREA (KOKU/TAN)
INTEGRATED AIR TEMPERATURE (JUNE·JULY·AUGUST) °C
Fig. 5 - IWATE PREF.
1889-1900
1901-1916
1917-1947
A
B
C
2.5
2.0
1.5
1.0
0.5
63
72
81
90

unit yield does not increase and is rather stagnant, even though the intergrated temperature becomes higher than those of Points A and B, but at the time when the temperature goes down, the unit yield also declines rapidly. As mentioned in chapter I, it can be thought that the Points A and B correspond to the mean high critical temperature of the rice plants cultivated at each period. These two curves are clearly apart from each other over 72°C in the integrated temperature, and the standard of the unit yield[5] increases from 1.65 *koku* to 2.13 *koku* between the two periods. The striking difference of the standards does not result from the climatic condition, but from the progression of cultivation technics. And the fact that Point A shows a yield of about 1.53 *koku* and Point B about 2.04 *koku* at Y axis may be regarded as the increase of the resistance of the rice plants to the climatic change. However, the temperature of the Point B is about 2.3°C higher than that of Point A. That is, the high critical temperature becomes higher with time and the resistance to the decline of the air temperature goes down.

2) *Iwate* Prefecture. (Fig. 5)

In *Iwate* Prefecture, the following three trend curves are distinguishable. They correspond to the following three periods : 1889–1900, 1901–1916, and 1917–1947, their maximum convex points being Point A (1.02 : 70.7), Point B (1.62 : 70.6) and Point C (1.98 : 73.9). As the standard of the unit yield changes with time from about 1.08 *koku* to 2.05 *koku* under the temperature condition of over 72°C, the unit yield of the maximum convex points increase from 1.02 *koku* to 1.98-*koku*. Moreover, the integrated temperature of the point comes higher from 70.7°C to 73.9°C more clearly than that in *Aomori* Prefecture.

3) *Akita* Prefecture. (Fig. 6)

In this prefecture, two trend-curves corresponding to the periods of 1897–1919 and 1920–1947 are drawn, and their maximum convex points are Point A (1.65 : 78.0) and Point B (1.95 : 78.3). Compared with those of the two prefectures, some characteristics are revealed as follows. These two trend-curves are apart and do not cross each other, and after 1920, the extremely low unit yield does not appear. The characteristic of the maximum convex point is that though the unit yield increases from 1.62 *koku* to 1.95 *koku* as is the case with the previous prefectures, the temperature little from 78.3°C to 77.8°C. That is, the resistance to the air temperature does not change here, and the standard of the unit yield under the condition of over 78°C goes up to 2.16 *koku* from 1.70 *koku* before 1920. These facts are quite different from those in *Aomori* and *Iwate* Prefectures.

4) *Yamagata* Prefecture. (Fig. 7)

5) Mean value of the unit yields under the temperature condition which is higher than the temperature of the maximum convex point.

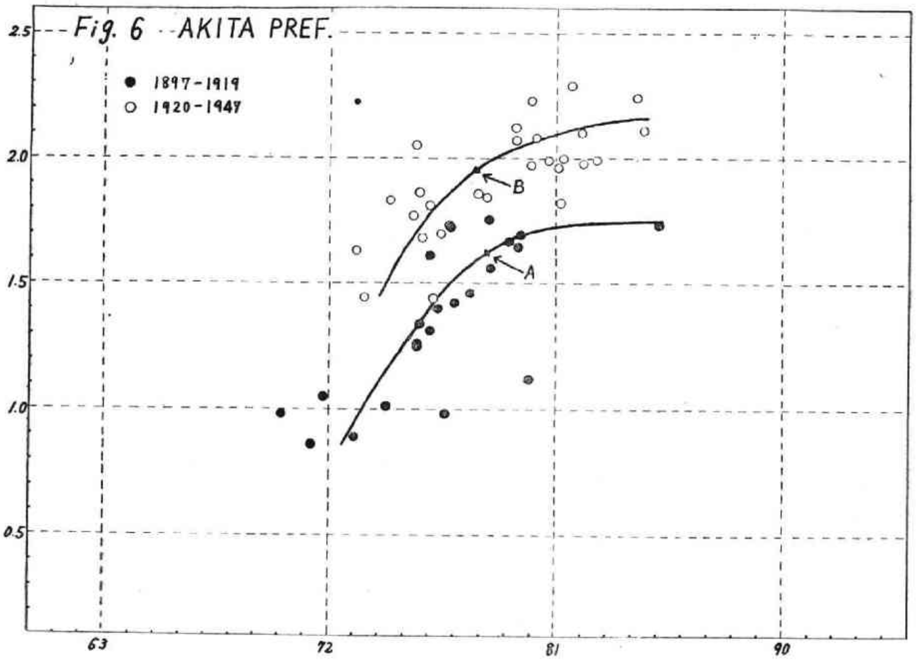
Fig. 6 AKITA PREF.
1897-1919
1920-1947
2.5
2.0
1.5
1.0
0.5
63
72
81
90
A
B

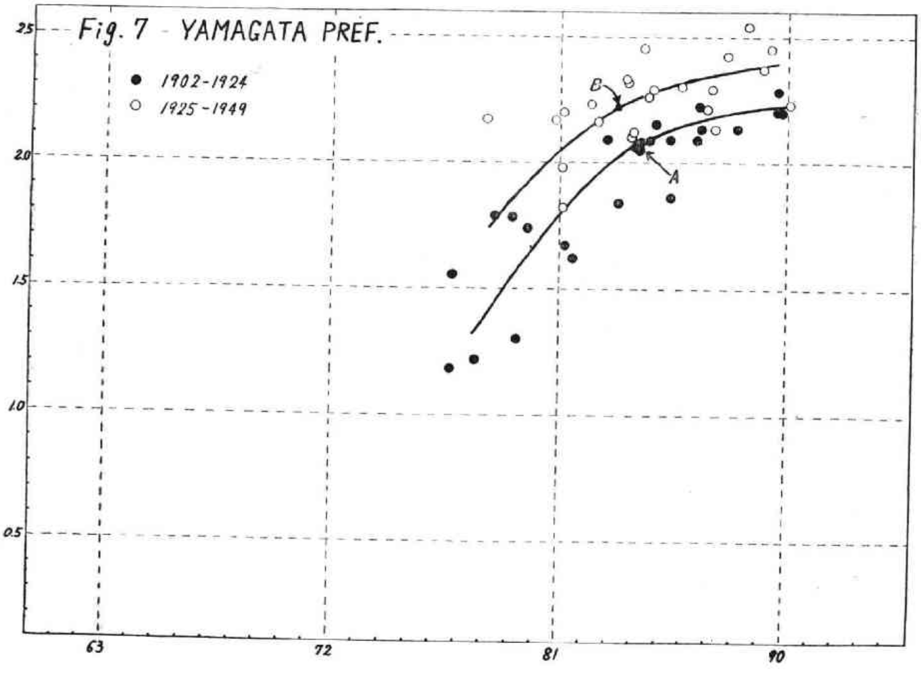
Fig. 7 YAMAGATA PREF.
1902-1924
1925-1949
2.5
2.0
1.5
1.0
0.5
63
72
81
90
A
B

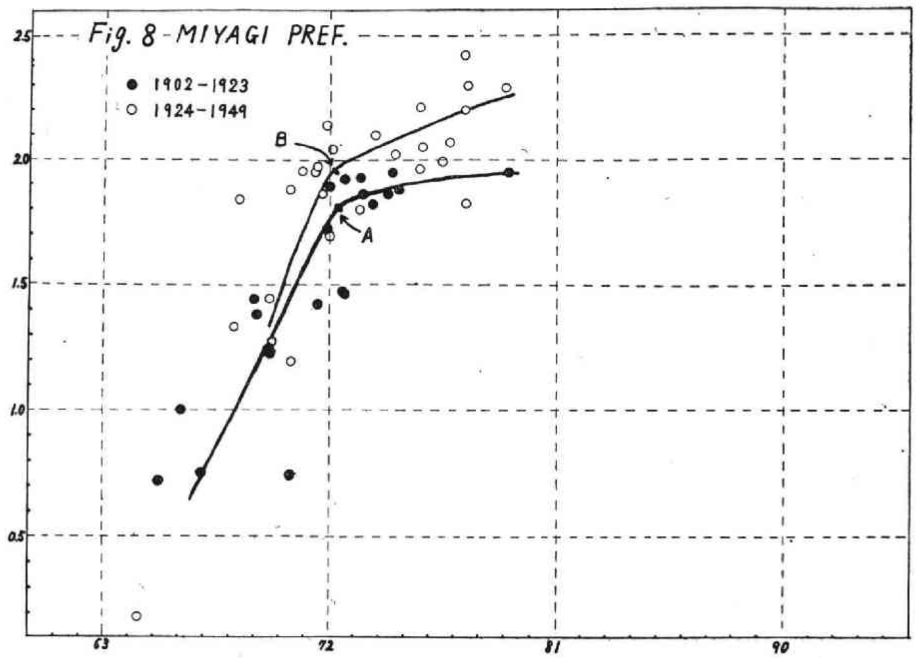

Fig. 8 - MIYAGI PREF.

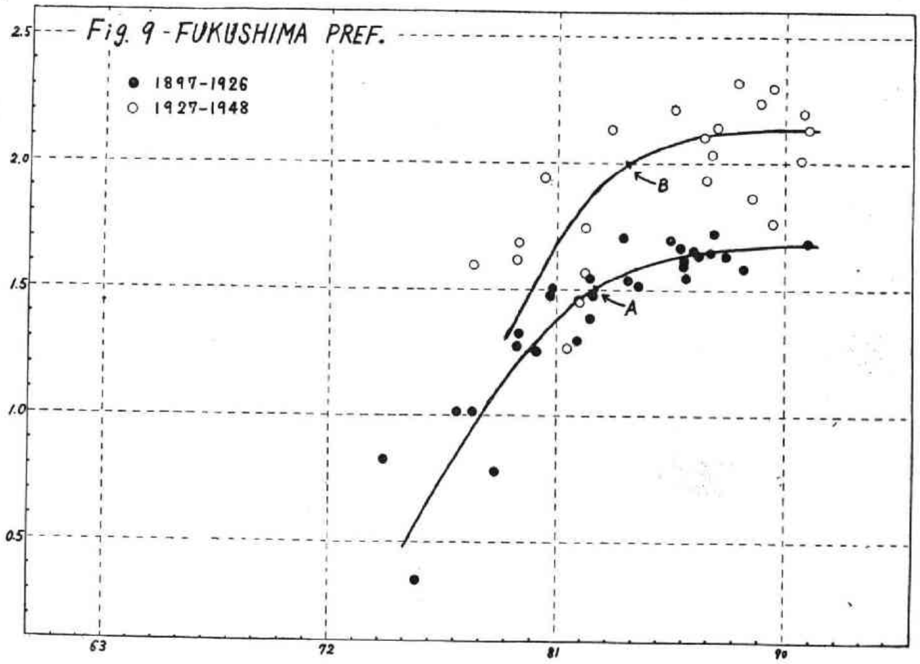

Fig. 9 - FUKUSHIMA PREF.

In *Yamagata* Prefecture, the difference of the standard of the unit yield with time is very little, representing only about 0.2 *koku*. But two trend-curves are almost in parallel, though they are adjacent to each other. The trend-curve corresponding to the period of 1902–1924 has Point A (2.07 : 84.0). That is, in *Yamagata* Prefecture, the unit yield and the temperature are generally high, and the temperature of the maximum convex point goes down from 84.0°C to 83.2°C, much more exessively than in *Akita* Prefecture.

5) *Miyagi* Prefecture. (Fig. 8)

The correlation graph of *Miyagi* Prefecture is rather similar to those of *Aomori* and *Iwate* Prefectures than those of *Akita* and *Yamagata* Prefectures. But the two-trend curves are not so distinguishably divided. They correspond to two periods of 1902–1923 and 1924–1949, and under the condition of over 72°C their standards of the unit yield are divided into two classes : about 1.90 *koku* before 1932 and about 2.12 *koku* after 1924. Their maximum convex points are A (1.81 : 72.3) and B (1.96 : 72.2). The difference of the temperatures between these two points is scarecely recognized and least in the six prefectures.

6) Fukushima Prefecture. (Fig. 9)

The two trend-curves are clearly recognized, and correspond to two periods of 1897–1926 and 1927–1948. Their maximum convex points are A (1.51 : 82.5) and B (1.99 : 83.7). and their standards of the unit yield under the temperature condition of over 83°C are about 1.65 *koku* and about 2.10 *koku*. But, though the unit yield of maximum convex point increases from about 1.51 *koku* to about 1.99 *koku*, the temperature becomes high from 82.5°C to about 83.7. This shows more rapid declination of the unit yield with the lowering of temperature at the period of 1927–1948 than at the period of 1897–1926.

III. Some condiderations and conclusion

By the aforementioned considerations, remrakable characteristics can be pointed out as follows. (Table 1 and Fig. 10). 1) In the correlation graph of the unit yield and the integrated temperature in June, July and August, can be drawn a trend-curve per period, though in *Yamagata* Prefecture it is comparatively obscure. That is, the three trend-curves in *Iwate* Pref. and the two curves in the other five prefectures can be recognized. 2) The maximum convex point corresponding to the high critical temperature exists on every trend-curve. In a word, when a temperature is higher than the high critical temperature, the unit yield does not change greatly, but when a temperature becomes lower, it rapidly decreases. 3) From this point of view, it is possible to suppose the resistance of rice plants to the climatic change, based on the fact that the temperature of the maximum convex point goes up or down compared with that of the previous periods. The fact that the temperature goes up means that the lowest limit of the temperature enough to maintain the normal standard of the unit yield becomes high, and that the resistance to the climatic change, that is, to the low temperature, becomes

Table I

Prefecture	Period	Maximum convex point (*Koku* : °C)	Difference of temperatures of maximum convex points between A and B or A and C (°C)	Normal standard of the unit yield (*Koku*)	Defference of normal standards of the unit yields between A and B or A and C (*Koku*)
Aomori	1897-1929 1930-1947	A (1.53:72.0) B (2.04:74.3)	+ 1.7	1.65 2.13	0.48
Iwate	1889-1900 1901-1916 1917-1947	A (1.02:70.7) B (1.62:70.6) C (1.98:73.9)	+ 3.2	1.08 1.55 2.05	0.97
Akita	1897-1919 1920-1947	A (1.62:78.3) B (1.95:77.8)	− 0.5	1.70 2.10	0.40
Yamagata	1902-1924 1925-1949	A (2.07:84.0) B (2.21:83.2)	− 0.8	2.10 2.30	0.20
Miyagi	1902-1923 1924-1949	A (1.81:72.3) B (1.96:72.2)	− 0.1	1.90 2.12	0.22
Fukushima	1897-1926 1927-1948	A (1.51:82.5) B (1.99:83.7)	+ 1.2	1.65 2.10	0.45

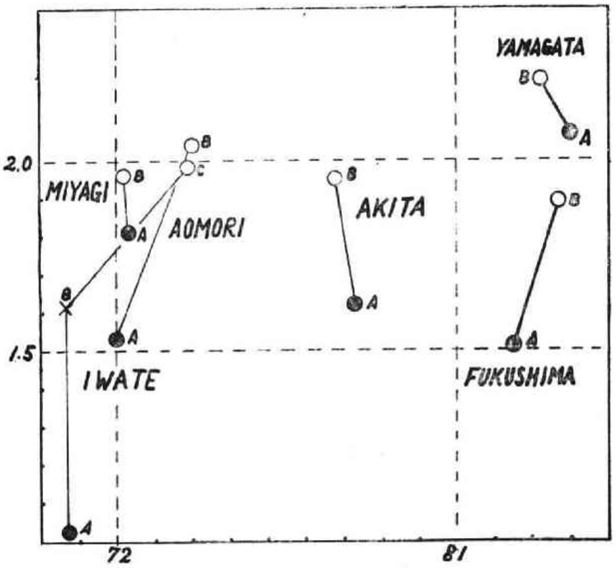

Fig. 10. Change of maximum convex points with time.

weaker than that of the previous periods. Usually, the standard of the unit yield increases with time and the unit yield of the maximum convex point comes high. But the temperature of the point does not always go down. 4) In *Akita* and *Yamagata* Prefectures facing the Japan Sea and *Miyagi* Prefecture facing the Pacific Ocean, the temperature of the point goes down (*Yamagata* and *Akita* Prefectures) or make little change (*Miyagi* Prefecture). That is, with the increase of the standard of the unit yield, the resistance to the climatic change becomes stronger or makes no change. 5) However, in two prefectures facing to the Pacific ocean and in *Aomori* Prefecture situated in the nothernmost part, the temperature goes up more or less, and its increase is most remarkable in *Iwate* Prefecture. That is, the resistance to the low temperature is weaker, though the normal standard of the unit yield shows a fairly rapid increase.

Such considerations are based upon the prefecture unit consisting of various natural and human areas. And smaller units must be adopted to grasp a more real and concrete areality as to cold disaster. The trend curve used in the paper will have to be drawn more scientifically.

However, in the paper the author has pointed out the differences of the resistance to the climatic change, with time and localy. Above all, the tendency of the declination of the resistance, in spite of the increases of the normal standard of the unit yield, is considered to show a characteristics existing in the development of the rice agriculture in the cold district.