Similarity in Regional Distribution of Cool Summer Events between Korea and Japan

Y. Hayashi[1)], H. Toritani[1)], S. Goto[1)], H. Kanno[2)],
Y.S. Jung[3)], S.J. Hwang[4)], H.D. Kim[5)], J.T. Lee[6)] and J.I. Yun[7)]

1) National Institute for Agro-Environmental Sciences, Tsukuba, Japan
2) National Agricultural Center for Tohoku Region, Morioka, Japan
3) Kangwon National University, Chunchon, Korea
4) Pusan National University, Pusan, Korea
5) Keimyung University, Taegu, Korea
6) Rural Development Administration, Suwon, Korea
7) Kyung Hee University, Suwon, Korea

1. Introduction

There is general agreement that the mean land-surface air temperature of the Earth has increased by about 0.6℃ over the past century (Vinnikov et al., 1990; Jones, 1994). However, IPCC concluded in 1996 that the observed warming was "broadly consistent with predictions of climate models, but it was also the same magnitude as natural climate variability". Additionally, the Meteorological Agency of Japan (1995) reported that each region shared inherent temperature rise and precipitation anomaly over the past 100 years. It thus confirmed that the magnitudes of warming and precipitation anomaly were different from one region to another.

In North Asia, which includes the Japanese Islands and the Korean Peninsula, a maximum warming of 1.0/100-years was recorded (MAJ, 1995). It was the largest warming recorded over the earth. Regarding the anomaly ratio of precipitation, the largest increment was also observed in the same extent. It could be that the region might be subject to the largest climatic variation within the next 100 years. Agriculture around our countries might be most vulnerable to such climatic variations if the ongoing trends should continue in the near future. This is the reason why the IPCC Regional Reports of 1998 pointed out that the regional trends in global change would be a problem of one of the most important issues.

2. Climate system in East Asia

As for the synoptic aspects, high over the Sea of Okhotsk and its surrounding regions cool northeastelies blow towards the polar frontal zone along the south coast of the Japanese Islands and the Korean Peninsula. As the cool northeasterlies are regarded as important air currents during the summer season, when the high develops intensively, they often cause extensive crop damage in Japan and Korea. A typical synoptic situation in cool summers is illustrated in Fig. 1. The cool northeasterlies approach the east areas of the Tohoku region in Japan and the eastern part of Korea. As a result, both areas suffer damage from the cool airflow and the crop productivity in those areas drops significantly.

On the contrary, when the North Pacific high performs strongly or shifts slightly to the north of its usual location in the northwest Pacific Ocean, the polar frontal zone moves northward along

thesoutherncoastoftheJapaneseIslandsanddiminishesquickly(UedaandYasunari,1998;Yoshino, 1998). This regime leads to intensely hot summer weather, especially in the southern areas in Japan and Korea, and reveal that paddy rice yield is enhanced under hot, dry weather because high temperatures promote vegetative growth when coupled with established irrigation systems.

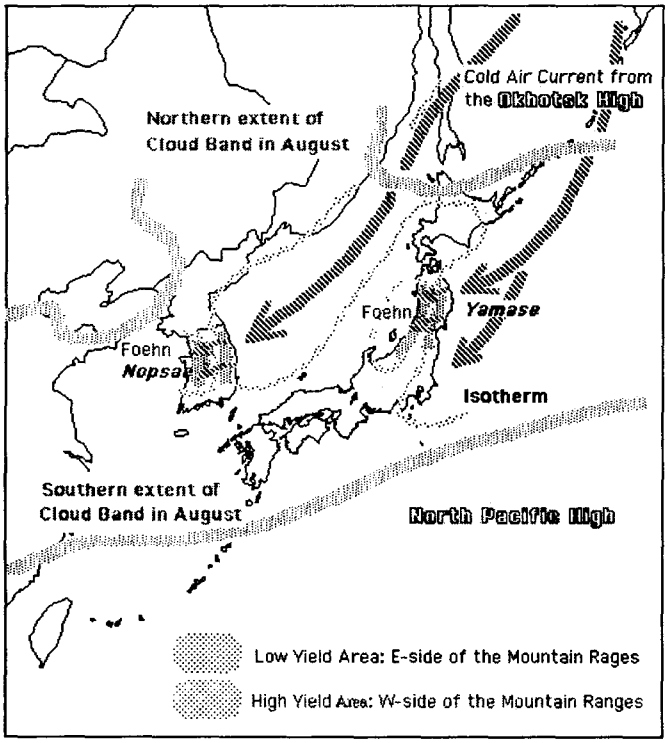

Fig. 1 Regional Climate System of cool summer conditions dominating in East Asia.

3. Yearly change in yield of paddy rice

Rice yields in Japan and South Korea have steadily increased from a level around 3.5 t/ha in the 1970s to 5 t/ha in the 1990s. Year to year changes of the yield of the neighboring countries are shown in Fig. 2 from 1969 to around 1999. A linear trend analysis discloses almost 2.4% and 4.9% yearly increases for Japan and Korea, respectively. Despite the advances, considerable yearly fluctuations are still evident. The linear trends are most likely due to improved management and development of new varieties of the crop. The weather effects on yield can be revealed by subtracting the linear trend from the original sequence.

Rice growth, especially in the middle latitudinal zone of Japan and South Korea, shows a remarkable relationship to low temperatures accompanying insufficient solar radiation. In 1980 and 1993, the cold air mass over the Okhotsk Sea lasted unusually long during the growing season of paddy rice. Rice growth showed a strong relationship to low temperatures accompanying insufficient solar radiation. As a result, as unusually cool summers prevailed over the Japanese Islands and the Korean Peninsula, the crops under such weather conditions suffered severely, producing heavily reduced yields. In 1994, the opposite occurred: a stable pacific high covered the areas and sustained a definitely improved yield over 1993.

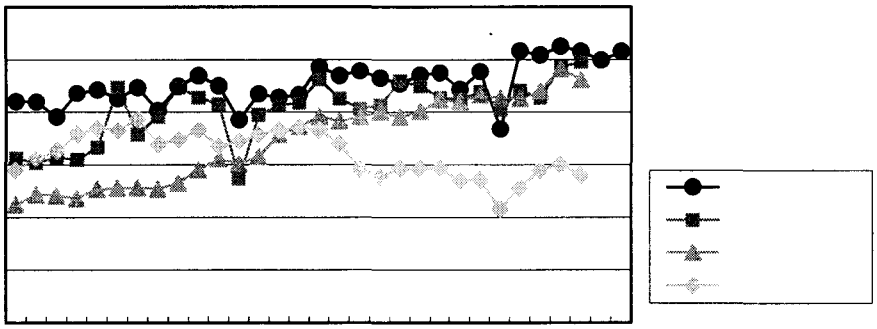

Fig. 2 Yearly variations of paddy rice yield in East Asian countries.

4. Projection of rice production of Japan and South Korea

Throughout the Japanese Islands and the Korean Peninsula, which are almost near the northern limit for rice cultivation, year-to-year fluctuations of rice yield depend on temperature more sensitively than the other lower latitude areas. To project production of paddy rice under the possible temperature fluctuations, an average temperature during July and August is chosen in most cases because the reproductive development stage of rice growth, when the crop is most sensitive to temperature, normally occurs in this period in East Asia (Horie et al., 1995).

The authors have analyzed the relationship between temperature fluctuations and variations in paddy rice yield on a regional scale. The result is tabulated in Table 1 which shows changes in gross rice production obtained by use of an equation, $Y = -0.074\ T + 0.319\ T + 0.117$. Here T is the averaged temperature anomaly in July and August of the Tohoku region of Japan, and Y the yield anomaly for both countries. The correlation coefficient corrsponds $r = 0.685$.

Table 1 Estimated changes in paddy rice production in Japan and South Korea.

Anomaly of Temperature()	-3	-2	-1	+1	+2	+3
Changes in Rice Production () Case / Area						
A / The Tohoku region + South Korea	-37	-21	-9	6	8	7
B / Japan + South Korea	-17	-10	-4	3	4	3

Case A: Total area of the Tohoku region of and South Korea.
Case B: The whole area of Japan and South Korea.

In the last 30 years, the standard deviation () of the average temperature for July through August in the Tohoku region has been around 0.9. If a 10 % reduction in the yield should occur in the extent of Japan and South Korea (Table 1, Case B), the temperature deviation from normal would have to be about 2. Similar situations have occurred twice since 1964. It can be estimated that, significantly large depressions in rice production may be encountered although global warming proceeds.

5. Conclusive Remarks

Agricultural production can be largely affected when the climate varies significantly from the normal. Consequently, in the present study, one of the most prominent aspects required is on understanding of the fluctuation of climatic elements in regional scale. Namely, Fig. 1 discloses local winds "Yamase" on the east side of the northern Japan and "Nopsae" on the west side of the Korean Peninsula (Kanno, 1997; Choi et al., 1997). The former signifies a cool and foggy northeasterly and the latter represents a kind of foehn wind originated in NE airflow as the dominant direction. They activate much under abnormal situations of the regional climate systems and bring severe impact on the agricultural productions.

We can also estimate that magnitudes of the temperature rises by the global warming at 2060s, i.e. doubled CO_2 condition, and the abnormal climate are about 3°.5 for warm 6 months average and 3°.9 for monthly average respectively. The fact that these are lying in the almost same ranges attracts our attention to a discussion on vulnerability evaluation of future agriculture problems.

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