Estimation of the Effect of Temperature Change on Rice Yield

Abstract

How the yields of 36 rice varieties are affected by temperature change caused by abnormal climate will be estimated. For high thermo-sensitive varieties cultivated in the Hokkaido and Tohoku regions, if there is a substantial change in temperature, a significant yield variation in the current cropping season is predicted.

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Background and Purpose

In the wake of Japan's recent weather, as manifested by the cold weather damage in 1993, it has been noted that the temperature variability is getting significant. So it is extremely important to assess how much agricultural output is affected by temperature change. Therefore, we selected 36 rice varieties, assumed the current cropping period, and predicted the yield variation when temperature changed.

Application and Notes

1. With a growth and yield prognosis model (Yajima, 1996) which considers the sterile phenomenon caused by low temperature, the temperature fluctuations are considered for -2, 0, +2, +4℃ from current mesh climatic data. Regarding the rice variety, 1~3 rice varieties at the top of the crop statistics in each prefecture were considered and 36 varieties across Japan were selected (Table1). In addition, for the transplanting date and heading date, the dates of the current cropping season were used.
2. The yield will maximize in many areas with the current temperature condition (Figure 1). When the temperature drops 2℃ and increases 2℃ all over the country, the yield will increase by 14% and 5% respectively. However, the yield will decrease by 12% when the temperature increase 4℃. The yield all over the country is predicted to decrease when the temperature drops 2℃. On the other hand, because of the short growth period and low absorption of solar radiation when the temperature rises, the yield in areas except the Hokkaido and Tohoku region will decrease (Figure 2). The yield increment is expected in Hokkaido only when the temperature is 2℃ higher (Figure 3).
3. Because major rice varieties in Hokkaido belong to the high thermo-sensitive

varieties such as Kirara and Yukihikari, the growth period will be greatly shortened when the temperature rises. However, because low thermo-sensitive and high photosensitivity varieties such as Hinohikari are introduced in Kyushu and Shikoku, the range of yield variation is small in terms of temperature change.

Application and Notes

Based on the prediction results gained from this study, we suggest the following countermeasures against temperature change:

1. From central Japan to the south, the transplanting date can be hastened when the temperature rises and can be delayed when the temperature drops.
2. Rice varieties need to be changed when temperature varies. In particular for southwest Japan, the indica variety, which is resistant to the sterile phenomenon caused by high temperature is recommended when the temperature rises.
3. If there is a decline in temperature, unless epoch-making varieties are introduced, the yield north of Japan will inevitably decrease. Switching to other crops is necessary.

Please remember that this result is based on the assumption of current agricultural cropping system.

Table 1. Major rice varieties for different regions

Region	Current Varieties
Hokkaido	Kirara, Yukihikari
Tohoku	Sasanishiki, Akitakomachi, Mutsuhomare
Kanto-Tosan	Koshihikari, Asanohikari, Getsunohikari
Hokuriku	Koshihikari
Kinki-Tokai	Nipponbare, Koshihikari, Koganebare
Chugoku	Koshihikari, Akebono, Yamahikari
Shigoku	Koshihikari, Koganemasari
Kyushu	Hinohikari, Minamihikari

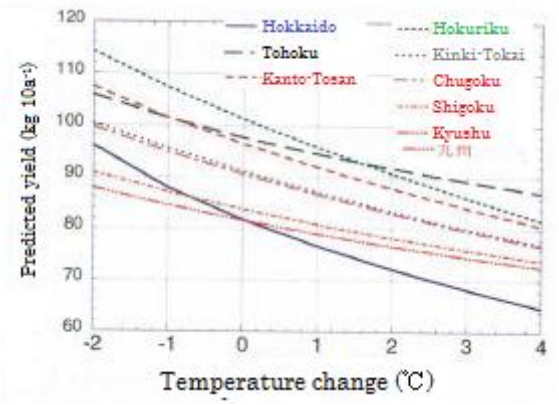


Figure 1 Predicted yield change due to temperature change

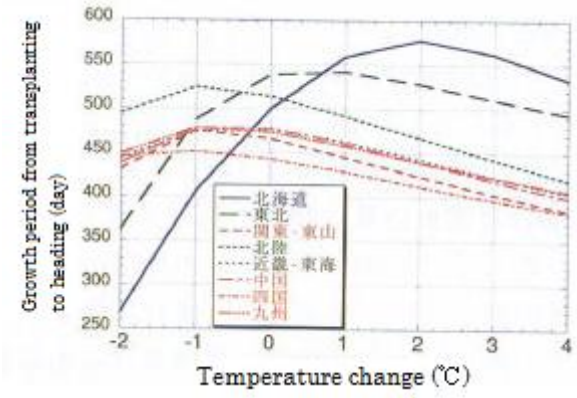


Figure 2. Growth period change due to temperature change

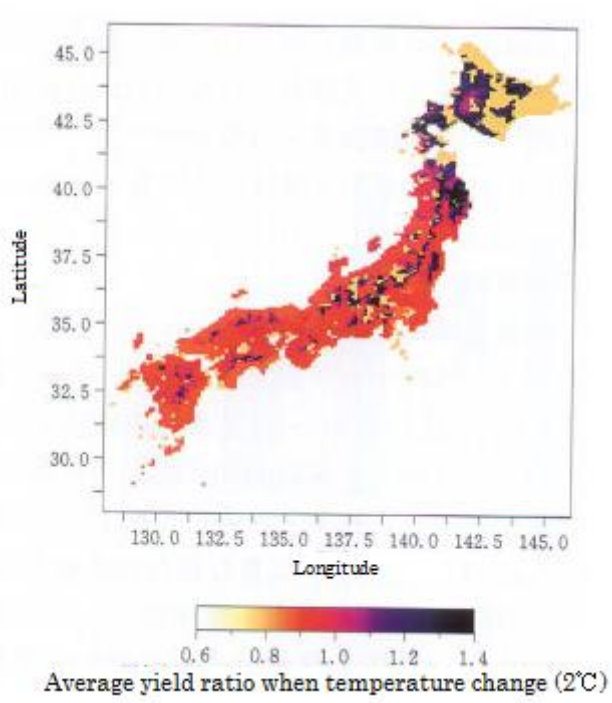


Figure 3. Predicted yield when the temperature rises 2℃ (Compared to normal yield)