

A New Estimating Method for Normal Yield of Rice

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ABSTRACT: Rice is a staple foodstuff in Japan, and its cultivation and production is highly affected by weather conditions. An alternative method for forecasting rice yields using weather and damage data is presented.

1. Significance of the Normal Yield of Rice in Japan

Rice is the staple foodstuff in Japan. Normal yield per 10 ares for the coming crop year has been calculated in March as a basic figure used for various administrative purposes. The normal yield means expected level of yield in the case weather and damage for the year is assumed to be normal.

2. Problem and Basic Idea of the New Model

The normal yield Y has been estimated so far using the multiple regression model expressed as:

$$Y = a + b\sqrt{X} + cZ \quad (1)$$

where \sqrt{X} signifies the annual trend of increase in yield taking into account the improvement of cultivation, etc., and Z is the damage rate caused mainly by weather conditions. However, yield has not always increased annually in recent years, which reflects alterations in the way of cultivation by the producers' intention to seek more quality than quantity of products. Therefore, the models were required to be modified to eliminate this hurdle.

In the new model, the value is also obtained by the factors of Y_t accounting for annual trend and ΔY relating to the weather:

$$Y = Y_t + \Delta Y. \quad (2)$$

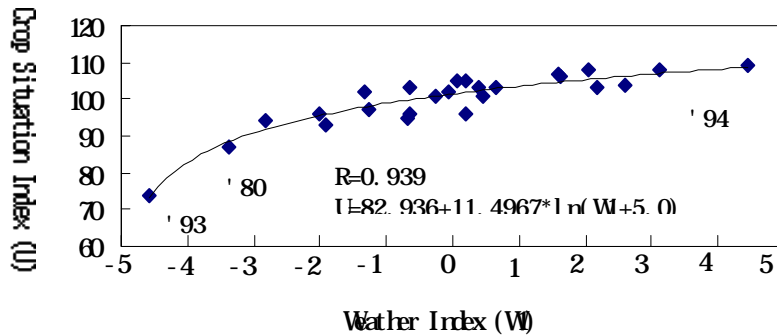
In this formula, for Y_t , the smoothing spline method is applied under the assumption that Y_t would be shifting smoothly because of difficulty in fixing the functions determined by the effects of various factors such as progress of cultivating technology, change of rice variety, and level of rice prices. To calculate ΔY , a multiple regression model is adopted because it is closely correlated with the weather conditions (see Figure 1). Accordingly, this method is to solve the formula which consists of the smoothing spline and multiple regression. It also concerns the problem of how to apply the method of Partial Thin Plate Smoothing Spline (PTPSS).

3. Modeling of the Weather Effect

In Japan, yield of rice is highly affected by the weather. There is strong correlation between the Crop Situation Index U (actual yield/normal yield \times 100) and Weather Index W_t which represents weather conditions (temperature, rainfall, sunshine hours, wind) during the growing period of rice and a first component to be figured out through principal component analysis (Figure 1).

Figure 1.

Correlation between the Weather Index and the Crop Situation Index



In the new method, this correlation is applied to the estimation model of ΔY . In the actual calculation, it is expressed as a cubic polynomial formula including the second and the third components which have effectiveness as weather indices collected from the data of AMeDAS (Automated Meteorological Data Acquisition System) of the Meteorological Agency:

$$\Delta Y = aW_1^3 + bW_1^2 + cW_1 + dW_2^2 + eW_2 + \dots + fW_3. \quad (3)$$

4. Result of the Model

Then, PTPSS is adopted to formula (2) using the ΔY expressed above. In this process, selection of explanatory variables in formula (3) and evaluation in accordance with the smoothing spline curve are conducted by using GCV(Generalized Cross Validation) as an indicator. Figure 2 shows the result of the calculation based on rice yield data from 1970 and the weather data of 50 meteorological stations in Japan. The new method better reflects the current situation of rice production and is a more rational way for estimating normal yield.

Figure 2.

Estimation of the normal yield using the smoothing spline in the case that W_1 , W_1^2 and W_1^3 are adopted

