ESTIMATION OF SUGAR BEET YIELD BRFORE HARVESTING USING METEOROLOGICAL DATA AND SPOT SATELLITE DATA

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ABSTRACT

The objective of the study is to assess the potential of development of an efficient sugar beet cultivation support system effective to reduce the cost for beet crop cultivation, sugar production and sugar material distribution using the agricultural spatial information data. For predicting the root yield of sugar beet, the analysis of the growth was conducted around the town of Memuro, Hokkaido, Japan. The cumulative temperature, cumulative precipitation and cumulative solar radiation from the end of April to the middle of July were selected as the predictors of the root yield prediction formula. The predictive error was 3.8t/ha, that was the result calculated by the farmers group, after weighted to the predicted root yield using NDVI which was derived from SPOT5 satellite data. The results suggest that it was possible to predict the root yield before three months of harvesting season.
Keywords: sugar beet, yield prediction, satellite data, meteorological data

INTRODUCTION

In Japan, sugar beet is only cultivated in Hokkaido, the northernmost island. The production of beet sugar in Hokkaido is about 640,000 tons, which is 75% of the total national production. Recently, the Japanese government is implementing a “New policy on sugar beet crops and other sweet resources” policy, through which it aims to reduce the cost of the production and manufacturing processes, because the price of domestic beet sugar is 2.8 times higher than the imported sugar. In order to assess the feasibility of developing an efficient sugar beet cultivation support system to effectively reduce the costs of beet cultivation, beet collection and sugar production using an agricultural spatial information, and also to predict the root yield of sugar beet three months before the harvesting season, an analysis of satellite data and meteorological data was carried out in this study.

METHODOLOGY

This study was conducted around the town of Memuro located in the middle west of the Tokachi plain, Hokkaido, Japan. To derive the root yield prediction equation, multiple linear regression analysis was executed using the data on cumulative

temperature, cumulative precipitation and cumulative solar radiation from the end of April to the middle of July from 1990 to 2005. The average root yields of Memuro town in 2006 and 2007 were predicted using the yield prediction equation. Secondly, the digital values of sugar beet fields derived from the satellite data were converted to surface radiance values, and the majority value of the NDVI was calculated from the radiance values of all sugar beet fields in Memuro. The predicted yield data and the majority value of NDVI are presumed to be equal, and the NDVI values of whole sugar beet fields were transformed into a absolute root yield value after calculating the predicted yield value in proportion to the NDVI value.

RESULTS AND DISCUSSION

Relationship between the growth data of sugar beet and satellite data

There is positive correlation between [SPAD×plant height] on July 12 and the root yield on October 4, 2007 (r^2=0.64) (Fig.1). Moreover, there is positive correlation between [SPAD×plant height] and NDVI on July 27, 2007 (r^2=0.60) (Fig.2). The result shows that sugar beet with a larger amount of leaf and stem in July has a higher root yield in the harvesting season, and it is also suggested that the root yield in the harvesting season is determined by the growth status of beet tops in July.

Prediction of root yield of sugar beet fields using meteorological and satellite data

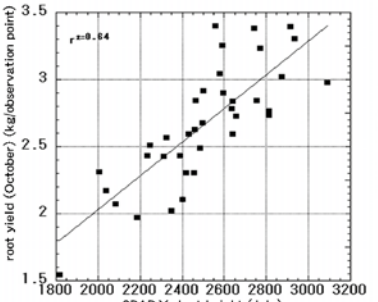
The cumulative temperature (T), cumulative precipitation (P) and cumulative solar radiation (R) from the end of April to the middle of July were selected as the predictors of the root yield(RY) prediction formula.

RY=0.043675R+0.02783T-1.09513P-39.634(r^2=0.87**)

The coefficient of determination of the prediction formula is 0.87, which is significant at the 1% level. RMSE is 3.2t/ha, which is calculated from the predicted root yield and observed root yield. The root yield predicted using this formula is replaced by the majority NDVI value of the beet fields cultivated in the study site. The sugar beet root yield of individual fields in 2006 is illustrated in Fig.3, for which RMSE is 6.1t/ha and the correlation coefficient between the predicted values and observed values is 0.54.

In previous research, it was reported that the root yield and beet sugar yield can be estimated using solar radiation, temperature and precipitation data from transplantation to the middle growth stage (Chiharu Hongo et al.). From this, it can be considered that the photosynthetic rate (sugar production) is strongly affected by solar radiation and that the rate of expansion leaf area is affected by temperature. In addition, the sugar beet yield in Memuro depends particularly strongly on the water content in soil.

The results suggest that it is possible to predict the root yield three months before the harvesting season. Most methods of yield estimation reported in previous research involve estimation equations using digital satellite data and ground observation data. In this study, we have constructed a new yield prediction method using the average root yield in region predicted from meteorological data replaced by the majority of NDVI value of the beet fields. By providing such results to sugar companies much earlier before the harvesting, the efficiency of sugar beet collection and sugar production will be increased.



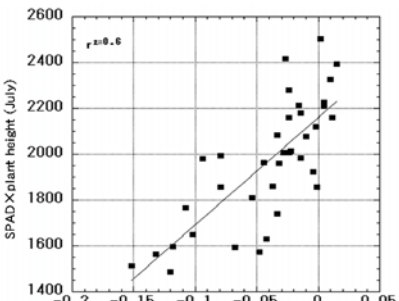


Fig.1 Relationship between SPAD×plant height and root yield

Fig.2 Relationship between SPAD×plant height and NDVI

Fig.3 Sugar beet root yield of individual fields in 2006

REFERENCE

Chiharu Hongo et al., Development of an efficient sugar beet cultivation support system using the agricultural spatial information -Part2-, Proceedings of the 42th spring conference of the remote sensing society of Japan, 42, 155-156, 2006