Estimation of beet top yield using satellite data

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Abstract **:**
In this study, the estimation of beet top yield using satellite data was conducted in Memuro, Hokkaido. The test site can be divided into four main geographical types which are lowlands, low, middle and high terraces. To derive the beet top yield estimation equation, the multiple linear regressions analysis was executed using the surface radiance value of SPOT5 image acquired in September 21, 2006 and ground observation data of beet top weight acquired on October 4, 2006. The accuracy of predictive error was affected by geographical types. Moreover, the yield of beet top was overestimated compared with ground observation data. The result suggests that the estimation accuracy can be improved by considering weather condition such as precipitation in the future.
Keywords **:** sugar beet, estimation equation of beet top

1. Introduction

Sugar beet is suited to cool weather, and Hokkaido is the only place where it is grown in Japan. To produce a beet sugar, root of sugar beet which is raw material of sugar is squeezed. Beet pulp is used for animal feed. After harvesting the root of sugar beet, beet top is plowing-in soil. This is one of effective method to reduce the cost of beet top disposal and the fertilizer application amount. On the other hand, the concentration of nitric acid in beet leaf and stem is higher than any other crops. After harvesting the root of sugar beet, beet top is plowing-in soil to keep fertility of upland field.

However, beet top is resolved and is the source of nitric oxide gas. Also, sometimes nitrogen in soil is overstock to product crop. In this area, fertilizer management is important to rotate. Information of the amount of nitrogen in soil is basic to manage fertilizer.

In this study, it is the purpose that satellite data which continuous can research wide area use to construct the way to management fertilizer. To acquire basic information, ground observation is practiced in 2006 and 2007 at Memuro, Hokkaido. We make estimate expressions using field data and ground observation data.

2. Methodology

2.1 Study area

This study was conducted around the town of Memuro located in the middle west of the Tokachi plain, Hokkaido, Japan (longitude 143.02°E, latitude 42.54°N).
The cultivation area of Memuro town is 19,720ha, and the acreage for beet planting is 3550ha in 2005.

2.2 Data

SPOT satellite data were acquired on September 21, 2006 (SPOT2) and September 23, 2007(SPOT5). There are three bands in the SPOT2 imagery, with the observation wavelengths including green band, red band, near infrared band with a 20m image resolution. There are fore bands in the SPOT5 imagery, with the observation wavelengths including the green band, red band, near infrared band and short-wavelength infrared band, with a 10m image resolution for the visible bands and near-infrared band and a 20m image resolution for the short-wavelength infrared band.

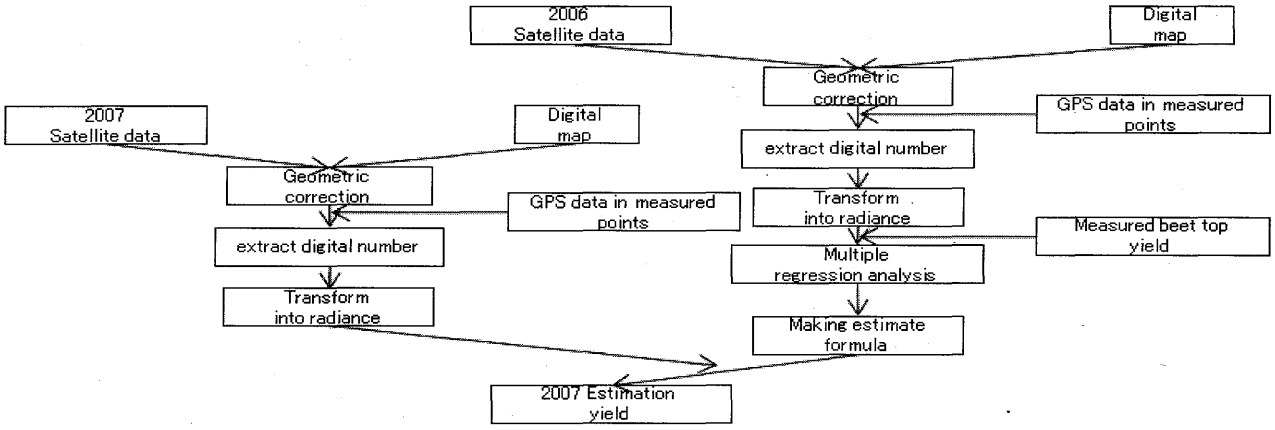
A geographic map drawn at a scale of 1 to 25,000 published by Geographical Survey Institute, Japan was prepared to rectify the satellite data.

Ground observation data of beet top weight were measured at about 40 points in October 4, 2006 and 2007. To measure the plant height and beet top weight, investigation points were set in 40 different locations each with an area of 3 rows×7 plants. The field survey was performed from June to October in 2006 and 2007.The beet top weight of the observation point was transformed into the weight of hectare using planting density value.

2.3 Procedure

Digital numbers at the ground observation points were extracted from satellite image of 2006 and 2007 which is corrected geometrically beforehand. Digital numbers were transformed to radiance value. Estimation formula of beet top weight was developed using five predictors, green band, red band, near infrared band, NDVI and GNDVI in 2006. In this study, the short-wavelength infrared band was not used as a predictor because SPOT2 does not have a sensor for the short-wavelength infrared wavelength. NDVI was derived from red (R) and near-infrared (NIR) spectral bands, which are calculated using the following formula:

$$NDVI=(NIR-R)/(NIR+R).$$



GNDVI was derived from green (G) and near-infrared (NIR) spectral bands, which are calculated using the following formula:

$$GNDVI=(NIR-G)/(NIR+G).$$

Finally, beet top weight in 2007 was calculated using the estimate formula derived from data of 2006, and comparison was performed between estimation data and the ground observation data in 2007.

3. Results and discussion

Ground observation data in 2006 shows that plant height of each geological type (low land, low terrace, middle and high terrace) is different in each month from June to October as shown in Fig 2. There is little difference in the height until the beginning of July and then the difference gets bigger gradually. After that, growing pattern of plant height was different in each geological type. So, estimation formula of beet top was developed for three different geological types.

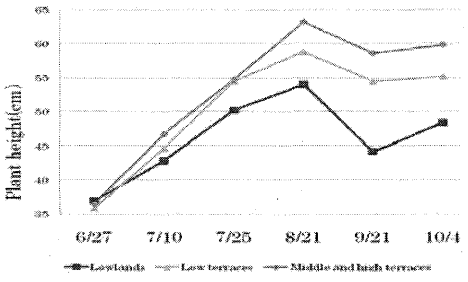


Fig.2 Transition of plant height in 2006

As a result, the green band and NDVI were selected as the predictors of beet top. The correlation coefficient of estimation equation of lowland soil is 0.207. In this area, October plant height is the second in all geological types.

Beet top weight was the highest value which is grown in lowland (Table 2).

Table 2 Beet top weight and plant height in October 2006

Geological type	Plant length (cm)	Beet top weight (kg)
Lowlands	48.35	0.700
Low terraces	55.19	0.969
Middle and high terraces	59.82	0.932

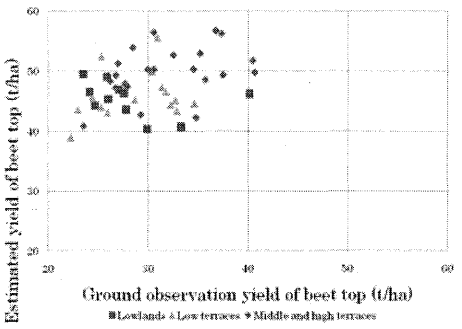


Fig.3 Comparison with observation data and estimated data of beet top in 2007

Beet top weight was the highest value which is grown in lowland (Table 2). In this area, it is suggested that the beet grows more horizontally in such a way where number of leaves increases, when compared with growth pattern of other areas. This growth pattern difference is considered to give big difference over to the reflection property.

Fig 3 shows the comparison of yield between 2 cases where calculation is made with use of the observation data and the estimated data of beet top in 2007., which indicates that the yield based on the estimated data is higher than that of the observation data.

References

1) Keiko KATO: Estimation of sugar beet yield using satellite and weather data, Graduation thesis of Department of Earth Sciences, Faculty of Science, Chiba University, 2009