Growth analysis of potato using a satellite image and GIS

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Abstract : Site-specific crop management requires the evaluation map of crop conditions, yields and crop quality. In Hokkaido, evaluation maps of rice and wheat were created and used effectively for precision farming. To continue with this trend of research, the current study focuses on producing potatoes. Then for developing the map of potato, the analysis of the growth was conducted in the Memuro town, Hokkaido. The equations to estimate root yields and starch concentration of potatoes were derived from Quick Bird satellite image acquired on July 18, 2004, and the spatial distribution maps were created through these equations. The result indicated that root yield and starch concentration were affected by species of preceding crop. The fields with the highest root yields were detected in the fields where the sugar beets were cultivated in the previous year, and the average yield was 37.4t/ha.
Keywords : precision farming, root yield, starch concentration

1. Introduction

It has succeeded in evaluating of wheat and sugar beet yields using satellite imagery in Hokkaido. For instance, these maps are used to decide the harvesting order. But the cost effectiveness is not approved to evaluate the crop yield because satellite data is expensive.

A rotation crop management is performed in Tokachi, so it is possible to extract some kinds of crop information. This is the effective method to resolve the cost effectiveness issue. In this study, the growth analysis was executed to potato crop to extract more crop information from a satellite image.

2. Methods

2.1 Study site

The study was conducted in Memuro town, Hokkaido, Japan(Fig.1). The size of test site for analysis is 8km in east and west, and 8km in north and south. A large-scale agricultural management is performed here. The cultivation area of Memuro town is 19,720ha, and the averaged cultivation area is 28ha per farmer. The major crops are sugar beets, potatoes, wheat, sweet corns and legumes at planting ratio of 20.9%, 19.8%, 36.0%, 5.6%, and 14.2% respectively(Fig.2). Rotation of crops are executed by combination of major crops and vegetables at three years or four years interval.

Potatoes were selected in order to analyze yields and quality. The usage of cultivated potatoes are for edible, for starch materials and for seeds at ratio of 47.2%, 30.0%, 16.1%, and 8.0% respectively. The mayqueen was selected as analysis crop with the highest planting ratio among nine cultivars of edible potatoes.

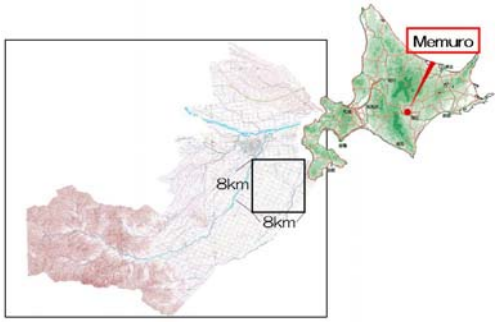

Fig.1 Study site

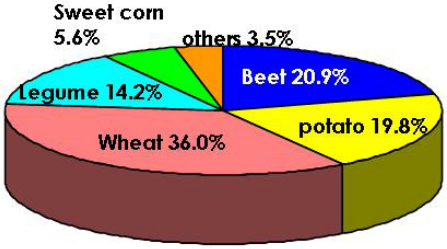

Fig.2 Planting ratio of major crops

2.1 Ground truth data

Farmer'sfields within the test site were used in this study. The investigation points were set in 33 places per five fields, which are two rows×2m width area. The field survey was performed on July 21 and 22, 2004. The plant height, hill number, leaf color were measured. Root yields(total amount of M,L,2L3Lsize) and starch concentration were measured on august 23 to 25.

2.3 satellite data and GIS deta

Quick Bird data was acquired on July 18,2004. The resolution is 2.4m. The GIS data of 2004 were selected from data base of JA Memuro data center to extract potato fields from satellite data. And the GIS data of 2003 was used to evaluate the yields of each kind of preceding crops.

2.4 Procedure

The procedure of image analysis is described in Figure 3. The satellite data and GIS data were rectified against 1:25000 digital topographic maps by nearest neighbor resampling algorithm using selected ground control points. The shape file of potato field was created from GIS data and overlaid to satellite data to extract potato fields. The position of investigation on satellite data was determined using ground based positioning data. The digital number(DN) values for investigation points were extracted and regression analysis was executed on yields and starch concentration, then the maps were developed. Finally the GIS data of 2003 was overlaid to these maps, and the relationships between root yields, starch concentration and preceding crops were evaluated.

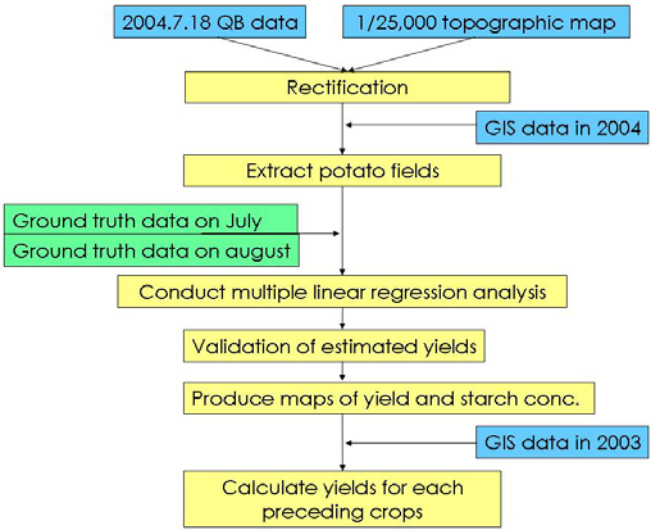

Fig.3 The procedure of image analysis

3 Result and discussion

Because harvest parts of the root vegetables like potatoes are hidden in the soil, information of root area is not contained on the satellite image. Therefore, the DN value extracted from the image is the only information on the potato with which soil face is covered stem and leaf. It is necessary to find the relation between the ground part and the underground part to estimate the amount of the yields from a image.

In general, growth rate of stem and leaf increases as the amount of nitrogen fertilizer application increases, also root weight increases. On the other hand starch concentration in root decreases. There was a positive relation between root yields and (SPAD x plant height)(Fig.4), on the other hand there was a negative relation between starch concentration in root and (SPAD x plant height)(Fig.5).

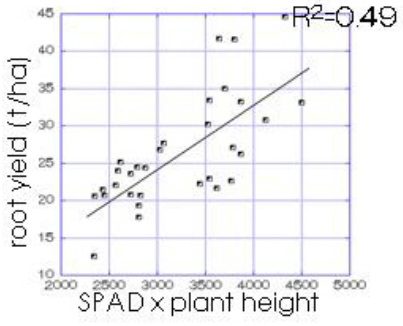

Fig.4 Relationships between root yield and vegetative parts

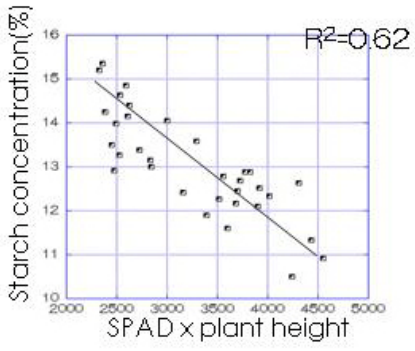

Fig.5 Relationships between starch concentration and vegetative parts

This relation indicates that root yields could be estimated from vegrtative parts. Regression analysis was executed on the root yield, starch concentration and DN value of satellite data. There was a positive relation between root yields and (B4-B2)/(B4+B2)(Fig.6). There was a negative relation between starch concentration in root and (B4-B2)/(B4+B2)(Fig.6).Then maps of yield and starch concentration were developed(Fig.7).The average of the percentage of relative error was 4.6% against root yields and 9.9% against starch concentration.

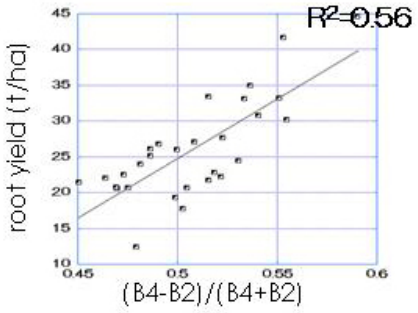

Fig.6 Relationships between root yield concentration and Band ratio

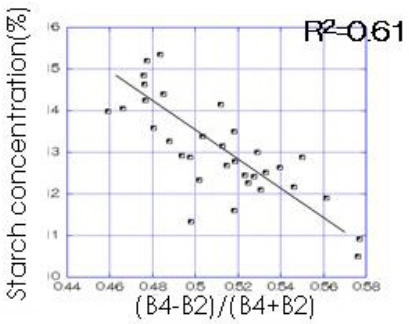

Fig.7 Relationships between starch and Band ratio

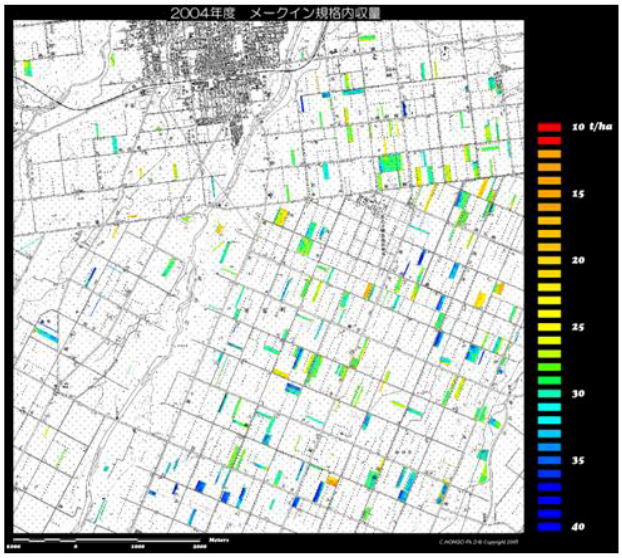

Fig.8 Sectional map of root yield

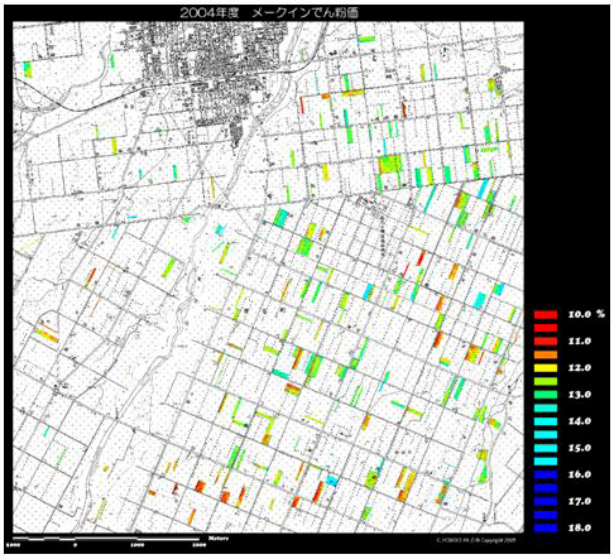

Fig.8 Sectional map of starch concentration

Comparing the yield data of each crop indicated that root yield and starch concentration were affected by species of preceding crop. The fields with the highest root weight were detected on the fields where the sugar beets were cultivated in the previous year, and the average yield was 37.4t/ha. The highest starch concentration value was found on the fields where the red beans were cultivated in the previous year.

It was possible to estimate the root yields and starch concentration of potato for large area using high resolution satellite data. The analysis of satellite data produced a better understanding of the relationship between preceding crops and yield. These results can be used for fertilizer application improvement, site specific planning for harvesting .

Preceding crop (2003)	Root yield (t/ha)	Starch concentration (%)
beet	37.4	12.3
Red beans	33.7	12.9
wheat	35.1	12.7
potato	35.1	12.8
Soy beens	36.4	12.6

Fig.10 Root yield and starch concentration on each crops