CREATION OF PRESCRIPTION FOR OPTIMAL NITROGEN FERTILIZATION THROUGH EVALUATION OF SOIL CARBON AMOUNT USING REMOTELY SENSED DATA

Chiharu Hongo[1*], Eisaku Tamura[1], Kensuke Aijima[1], Katsuhisa Niwa[2], Osamu Nagata [3] and Katsufumi Wakabayashi[3]

[1*] Center for Environmental Remote Sensing, Chiba University
[2] Zukosha Co., Ltd.
[3] National Agricultural Research Center for Hokkaido Region, Japan

Introduction

In these years, drastic increase of agricultural production costs has been induced, which was triggered by the sharp rise of costs relating to agricultural production materials such as fertilizers and oil. In Japan, the substantial negative influence is anticipated to spread over to management of the farmers particularly in Hokkaido, the northern part of Japan. As one of the measures against this influence, a plan of effective fertilizer application and also a comprehensive review of prescription for the fertilizer application have become critical issue.

On the other hand, recently, the carbon capture and storage has been attracting attention as a method for the mitigation of the global warming in agricultural sphere. In Japan, since its topography is complicated, precision monitoring and investigation has a limit. So, utilization of the remote sensing is expected as a precise and effective investigation method. Previous research in Japan, Sekiya et al. (2010) estimated the soil carbon stock from soil surface down to 100 cm depth in Hokkaido. However, the estimated values may not reflect current situation, because in this research relatively old soil survey data from the 1960's to the 1970's were used to estimate the soil carbon stock.
Because carbon materials in the soil exist as the form of organic matter, increase of the soil carbon storage lead to the increase quantity of soil fertility. Creation of the nitrogen fertilization prescription in considering of carbon storage and quantity of nitrogen leads to realization of reduction and the environmental conservation of the farm management cost.

Under these backgrounds, we developed an estimation method using satellite data to evaluate the soil carbon stocks in the agricultural field covering wide area to be used as the fundamental data. In the next step, the data of carbon stock was converted to the hot-water extracted nitrogen amount to generate a fertilization map, per 6 m resolution unit and individual field

unit.

Study site and data

The analysis was executed in the Tokachi district, Hokkaido, Japan, using SPOT6 data which were obtained on May 27, 2013, and also data of soil carbon rate and volume weight in soil from surface to 30 cm depth. The main parent materials constituting geographical types of the test site are as follows: the alluvial deposits in the lowland, volcanic ash and alluvial deposits in the low terrace, and volcanic ash in the medium and high terraces. The major crops are sugar beet, potatoes, wheat, and the cultivation acreage of three crops account for approximately 60% of total cultivated areas. The rotation of crops is performed by the combination of major crops with sweet corn and legumes at three or four-year interval.

Results

(1) Result of our study suggests that there is a significant correlation between the amount of soil carbon and the reflectance value from visible to near-infrared wavelength region. This is the reason that color of the soil becomes dark and electromagnetic wave absorbency from visible to near-infrared wavelength increases corresponding with increment of the soil carbon content. Especially, a high negative correlation is found between the reflectance value of green wavelength and the soil carbon stock ($r^2=0.86$, meaningful at a 1% standard).

(2) Next, the relation between the hot-water extracted nitrogen amount and the soil carbon amount was studied with the result that there is an exponential correlation of $r^2=0.58$, which is meaningful at a 1% standard. Then, using the conversion formula ($y=2.5283e^{0.0856x}$) from the soil carbon amount to the hot-water extracted nitrogen amount, a map of the hot-water extracted nitrogen amount covering wide area was created.

(3) The Agricultural Department of Hokkaido issues a fertilization guideline “Fertilization guide in Hokkaido”. In this guideline, a standard nitrogen fertilization amount is calculated on basis of hot-water extracted nitrogen amount contained in soil, which is practically used by farmers as prescription of fertilization. For example, in case of sugar beet, for a field containing 1~2 mg of the hot-water extracted nitrogen amount per100g soil, 24kg/10a of nitrogen is recommended to be applied as a basal fertilizer. So, using the guideline, the results of the above (2) were converted to the nitrogen fertilization amount to be recommended for sugar beet, potatoes and wheat respectively, and then a visualization map was created on GIS of each

individual field.
The result of this study is considered to be valuable as an effective measure to reduce the fertilizer cost through optimization of fertilization suitable for specific soil conditions of each crop, and also it will contribute to establish a logical and environmental conscious management of the fertilization.

Key words,
soil carbon stock, nitrogen fertilization, satellite data, Environmental conservation