ESTIMATE OF THE AMOUNT OF GRAVEL CONTENT IN THE SOIL BY AIRBORNE MSS DATA

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ABSTRUCT

Airborne MSS data was analyzed to estimate the degree of gravel content in the soil of crop fields.
According to the analysis, the follwing three areas contain large amount of gravels.

(1) Areas of high soil surface temperature
High temperature areas contain large amount of gravel.
(2) Areas where relative ground level is high
In general, areas whos ground level is relatively high compared to the surrounding areas, large amount of gravels are found in the soil.
(3) Droughty damaged area
In general, droughty damaged areas or less grown crop area contain large amount of gravel.

By using these findings as indices, the amount of the gravel in the soil could be estimated with enough accracy as can be used as one of the basic data for land improvement plan.

Introduction

In hokkaido, there is 106000 hectars of farm land whose soil contains more than 10% of 35mm diameter gravels. In such conditions, main crops such as beets and potatoes cannot be grown.
And also, areas damaged by drought (figure 1) or areas of poor cropgrowth contain large amount of gravels.
But 6000 hectar of the 106000 hectar can be used as a farm land if gravels are removed.
In order to remove gravels, it is necessary to know the amount of gravel in the soil of the subject area. Conventional method of gravel content survey is direct observation of gravel amount at plots dug in the field. Usually, 4 plots are dug per one hectar. Size of one plot is 1 square meter with depth of 50cm. This digging work is ordinary done by man power, so it takes much time and cost especially for large area need to be surveyed.
As more economical survey method, especially for large area, application of remote sensing techniques was examined. This

Fig.1 Drought damaged area

paper describes mainly about the method of using Multi Spectral Scanner (MSS) data to the detection of soil surface temperature variations in subsurface gravel amount.

At first, the relation between the amount of gravel in the soil and the surface temperature of bare soil was studied using ground survey data. The results of the ground survey was extended to incorporate surface temperature measured by a thermal scanner of airbone MSS.

Experimental

MSS airborne data provide us with information on thermal distribution at the surface of earth. Therefore, in order to use MSS airbone data for the estimation of gravel content, it is necessary to know the relation between soil surface temperature and gravel content. For this purpose one experiment was conducted.

The experiment was conducted by using three experimental pots (1m by 1m) which are thermally insulated containers filled with soil and gravel. First, gravels are placed in the pots and then they were covered by soil. Gravels and soil used for three pots are of the same character. Difference among the three pots is the depth of covering soil. Three pots of three soil depth, namely 1cm, 5cm, and 15cm were prepared. Since the total depth of the content was the same difference in the thickness of soil cover means gravel/soil ratio.

Figure 2 shows the diurnal soil surface temperatureof of the soil depth of 1cm, 5cm, and 15cm measured by using thermal radiometer. Temperature measurement was done at 15 minutes interval.

As the result of this experiment it was found that surface temperature increases rapidly if soil is thin, in other words, if the amount of gravel is large. This indicates that subsurface conditions affect the surface temperature.
In general, soil surface temperature is a function of soil heat transfer properties which is a effect of the soil types, soil moisture, and or the volume content of the gravels in the soils. If only the volume content of the soils are different it is obvious that the amount of gravel content in the agricultural crop field can be estimated by extending the result of the experiment to the field investigation.

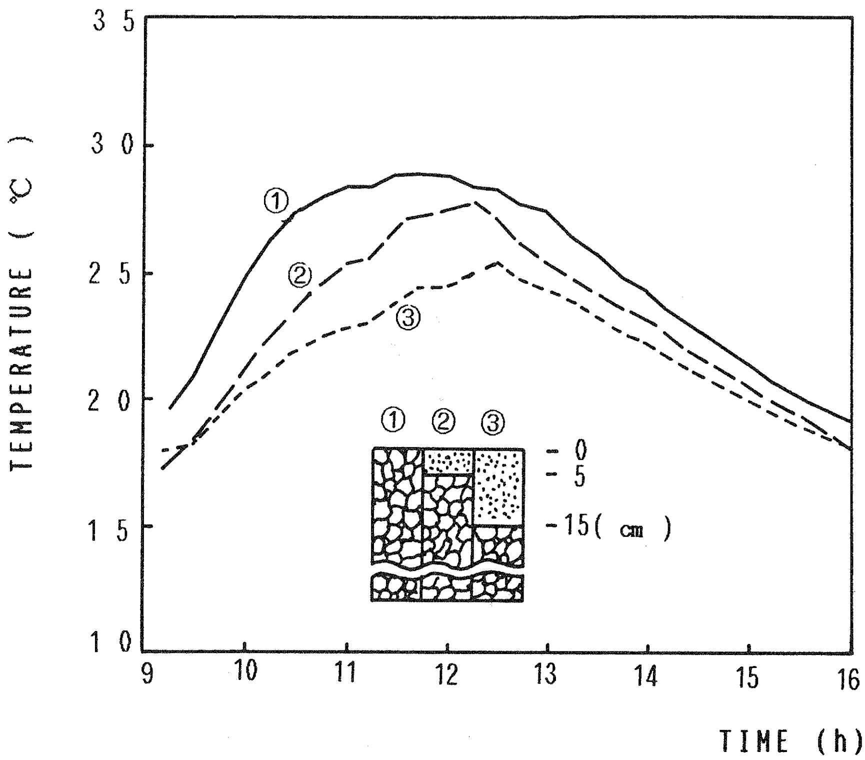

Fig. 2 Diurnal soil surface temperature difference

FIELD SURVEY PROCEDURES

Airborne MSS data of a crop field were collected in Tokachi area, Hokkaido, during the spring of 1985. Spring was chosen for this study because before the start of cultivation soil surface condition is uniform.
To estimate the amount of gravel in the soil in several parts of the study area, collected MSS data were analyzed based on the relation between gravel content and soil surface temperature which was found by ground survey.
Unfortunately, however, the surface conditions of the study area varies from one place to the other. For this reason, many of the data fell outside the range determined by the ground-based study.
According to the further studies, vegetated farm land had to be omitted from the study because the temperature of those

places depend on the vegetation cover, not the gravel content. But it was very difficult to separate vegetated farm land from bare farm land using only the thermal images.

So, we used the computated value of the ratio of near infrared band and red band to extract bare farm land which is in darker tone.

Old river channels also had to be extracted by computation of the density using red band data. Because sometimes they show relatively high temperature than the surrounding areas because of different soil even if there is less gravels.

Figure 3 show the relation between the soil surface temperature and gravel amount for 25cm soil depth cheked by ground-level measurement. The correlation coefficient was 0.46 to 0.82. Correlation coefficient of the field (d) is not as high as the other field, probably resulting from various surface conditions.

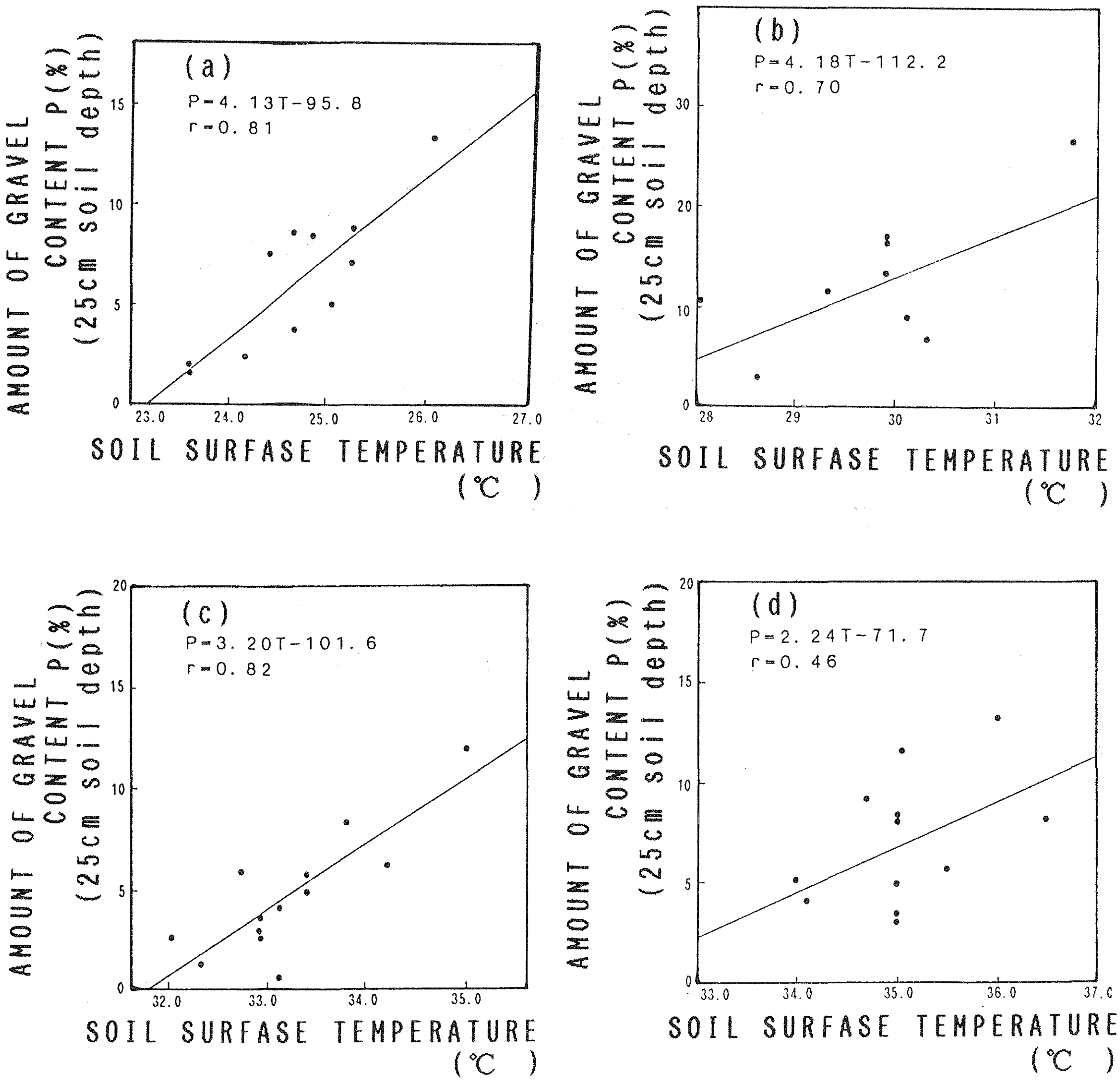

Fig. 3 Soil surface temperature versus gravel amount for 25cm soil depth

The accuracy of gravel amount derived using linear model is shown in figure 4. According to the figure 4 estimated error was about plus minus 2 - 3%, which is sufficient as a basic data to caluculate the amount of gravel in the soil.

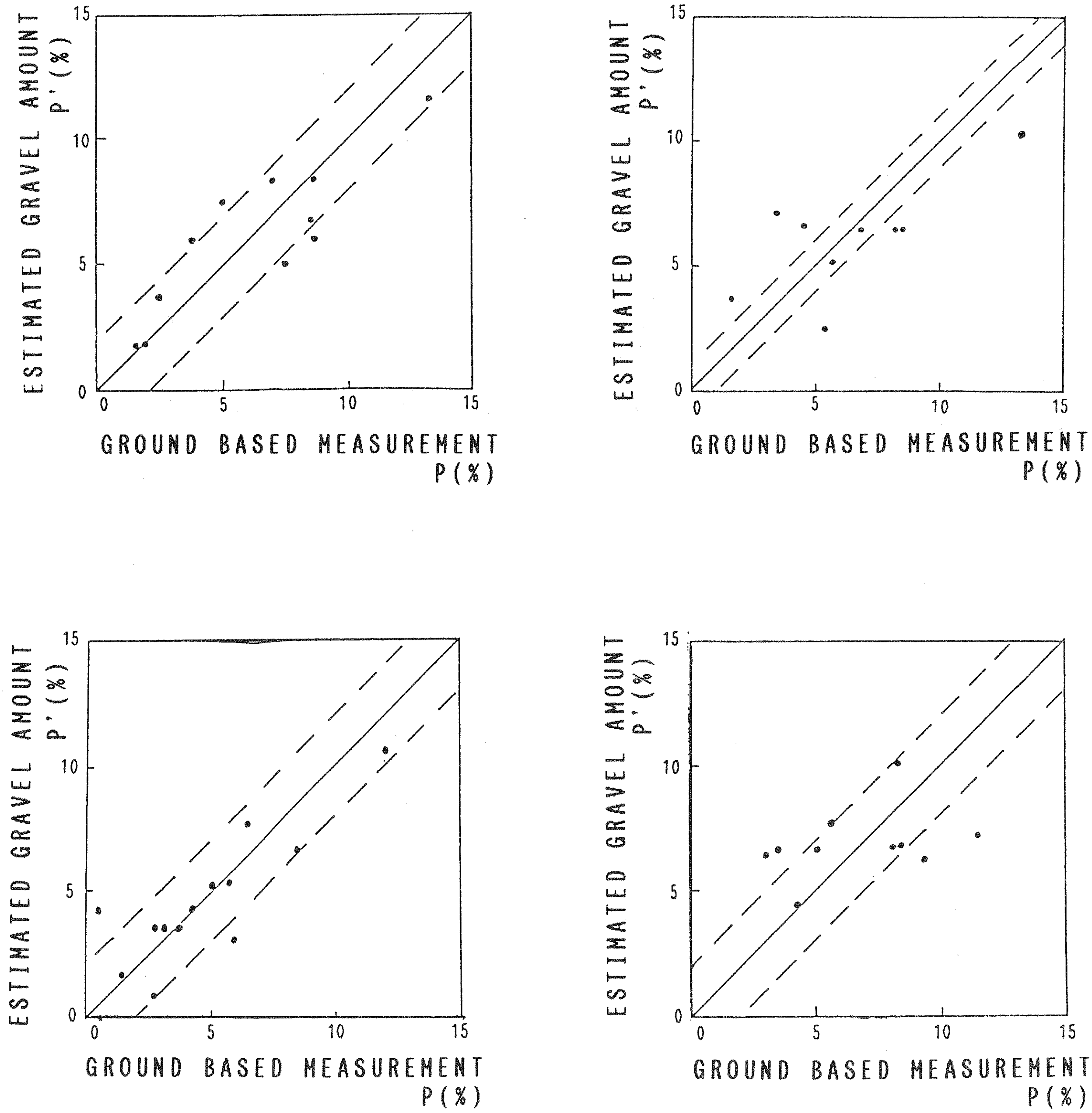

Fig.4 Ground based measurement versus estimated gravel content (--- estimated error of3%)

Above relation indicates that the amount of gravel can be estimated from soil surface temperature provided that independent linear model is made for each field as shown in figure 3. This is because each area has its own condition determined by soil type, soil color, soil moisture besides the gravel amount.

According to the further field survey, however, relation between gravel content and soil surface temperature can be divided into two parts. First part is the relation between soil depth and gravel content while the second is between soil depth and soil surface temperature.

Equation of the relation between soil depth and gravel content can be found by ground survey. Therefore, the amount of gravel can be caluculated after estimateing the soil depth from soil surface temperature.

Relation betwen soil depth and gravel content is stable regardless of soil type, soil color, and moisture content.

Compared to this relation, relation between soil surface temperature and soil depth changes from one area to another. Therefore, relation between soil surface temperature and soil depth need to be checked for each type of area, such models are less complex to soil surface temperature.

Figure 5 shows the maps of estimated gravel amount. Some grid point measurement shows the high correlation with the estimated data.

Accuracy of the estimation of gravel content drived from soil surface temperature in the study area is shown in figure 6 in the form of comparison with gravel content data obtained by ground survey.

According to figure 6 most of the estimated amount is within estimated error of 3% and this indicates that the estimation is accurate enough to be used as basic data for land improvement plan.

CONCLUSION

By conventional ground survey method, only data of very limited area can be collected.

By using thermal image for gravel content survey, data of large area can be obtained with sufficient accuracy, estimated error of 3%, for a basic data to calculate gravel amount in the soil.

Further, if MSS airbone data is used for the estimation of gravel content, the MSS data can also be used in irrigation and management plans such as the study of needs of underdrain water supply.

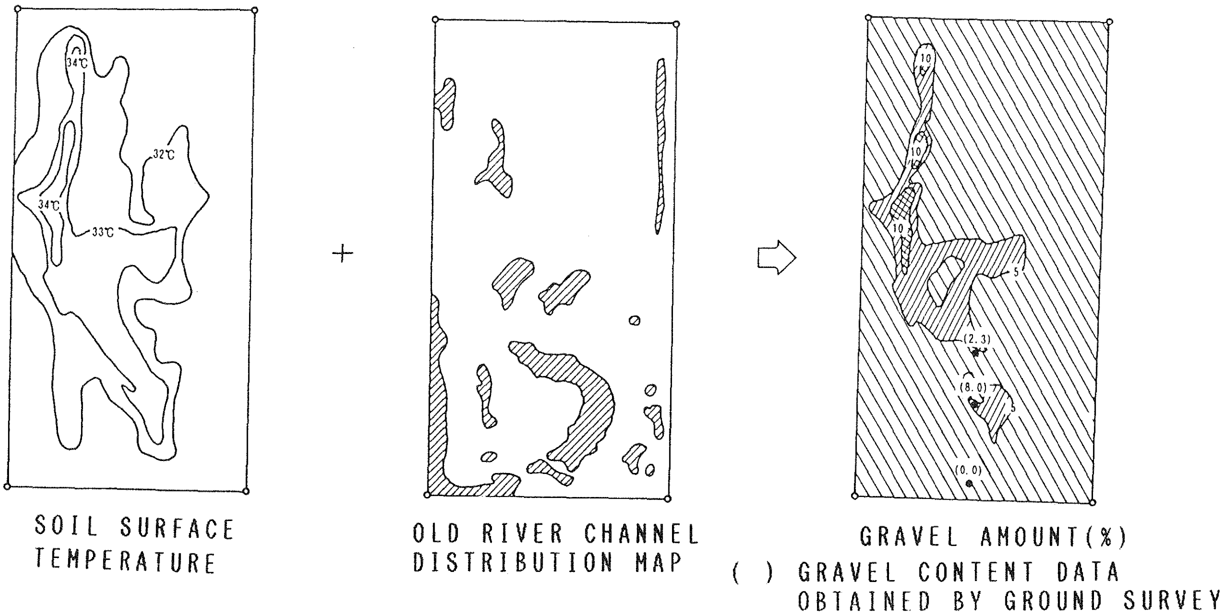

Fig.5 ESTIMATED GRAVEL AMOUNT

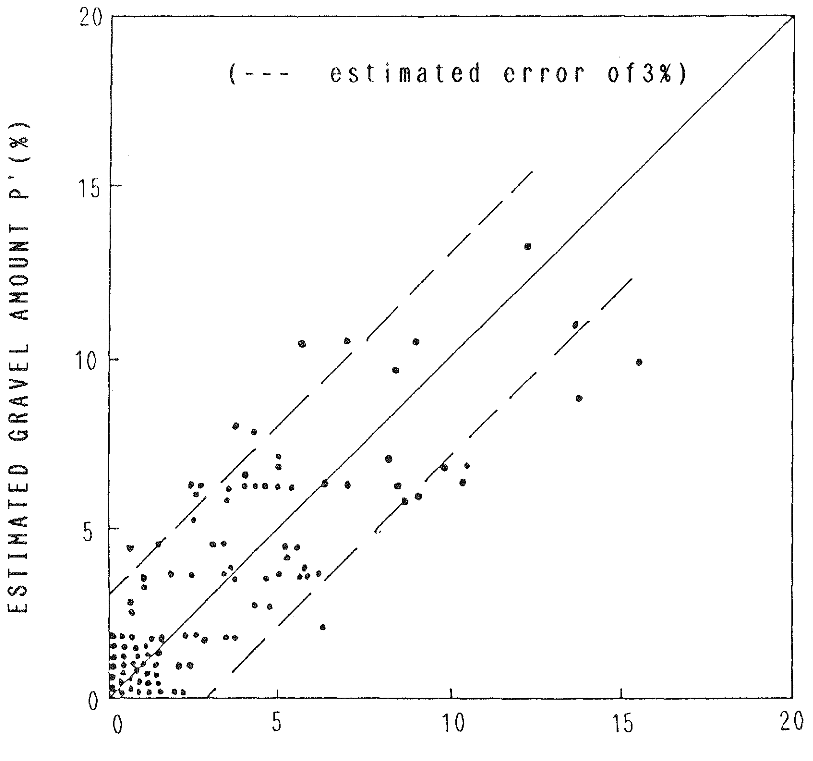

Fig 6 ACCURACY OF GRAVEL AMOUNT CONTENT VESUS ESTIMATED GRAVEL AMOUNT