EXPERIMENTAL STUDY ON RICE GROWTH DYNAMIC MONITORING BY DIGITAL PHOTOGRAPHS

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ABSTRACT

This paper describes rice growth dynamic monitoring which was carried out as one of the acts of "Design of large scale rice farmer management based on the direct seeding cultivation in large sized field" as one experiment in Fukushima prefecture. The direct seeding cultivation is accepted by the agricultural industry as a new cultivation technique for labor-saving and efficient rice production instead of transplanting which has been main cultivation method so far.
However some drawbacks are pointed out such as an unevenness in the rice growth process because of large sized field. According to the above background, we proposed the rice growth dynamic monitoring by applying the concept of real-time imaging and dynamic analysis. The main purpose of our study is to estimate the rice growth condition efficiently and accurately for improving direct seeding cultivation.
In the case of applying the concept of real-time imaging and dynamic analysis for rice growth monitoring, the method how to obtain representative information effectively and efficiently for whole covered large sized field is the most important. Accordingly two methods, Fixed and Moving Point Observations, are adapted for our study. Fixed Point Observation was the time dimensional growth identification and Moving Point Observation was the detailed growth difference recognition, at any stage of growth. The trend of general rice growth was discussed using multi-temporal digital photographs obtained by Fixed Point Observation. In addition, effective and efficient estimation of rice growth was evaluated using the digital photographs obtained by Moving Point Observation.
Through this study, rice plant photographs confirmed to be high capability for providing effective information for improving the drawbacks of direct seeding cultivation. More continued research is needed to substantiate this study in order to establish new rice growth management.

1. Introduction

In Asian countries, including Japan, people have been living on rice since early times so that to keep the stable rice production is one of the important factors for their nations on keeping daily life. Recent years Japanese agricultural industries have been confronted with the following two serious problems: 1) decrease of population engaged in agriculture, and 2) increase of population of advanced age. One reason why these trends occurred is that traditional rice cultivation is known as hard work and so that most of young generation leave countryside and move to urban regions to seek employment. This is also the problem from the social structure point of view.
From the above mentioned social conditions, main rice production regions have been making efforts to improve cultivation techniques focused on labor-saving. Particularly in Fukushima prefecture, the local government had conducted the project of "Design of large scale rice farmer management based on the direct seeding cultivation in large sized field" as one experiment in FY1997.

This paper describes the rice growth dynamic monitoring which was carried out as one of the stages of mentioned project.

The direct seeding cultivation is accepted by the agricultural industry as a new cultivation technique for labor-saving and efficient rice production instead of the transplanting that has been the main cultivation method so far. However some drawbacks are pointed out such as an unevenness in the rice growth process because of large sized field.

According to the above background, we proposed the rice growth dynamic monitoring by applying the concept of real-time imaging and dynamic analysis. Main purpose of our study is to estimate the rice growth condition efficiently and accurately for improving direct seeding cultivation.

2. Rice Growth Dynamic Monitoring

2.1 Concept of Fixed and Moving Points Observation

As one of the stages of the "Design of large scale rice farmer management based on the direct seeding cultivation in the large sized field" project, rice growth dynamic monitoring had been carried out in Taka county of Hara city, Fukushima prefecture.

In the case of applying the concept of real-time imaging and dynamic analysis for rice growth monitoring, the method how to obtain representative information effectively and efficiently for whole covered large sized field is the most important.

Accordingly two types of observations using film and digital camera were adapted for our study.

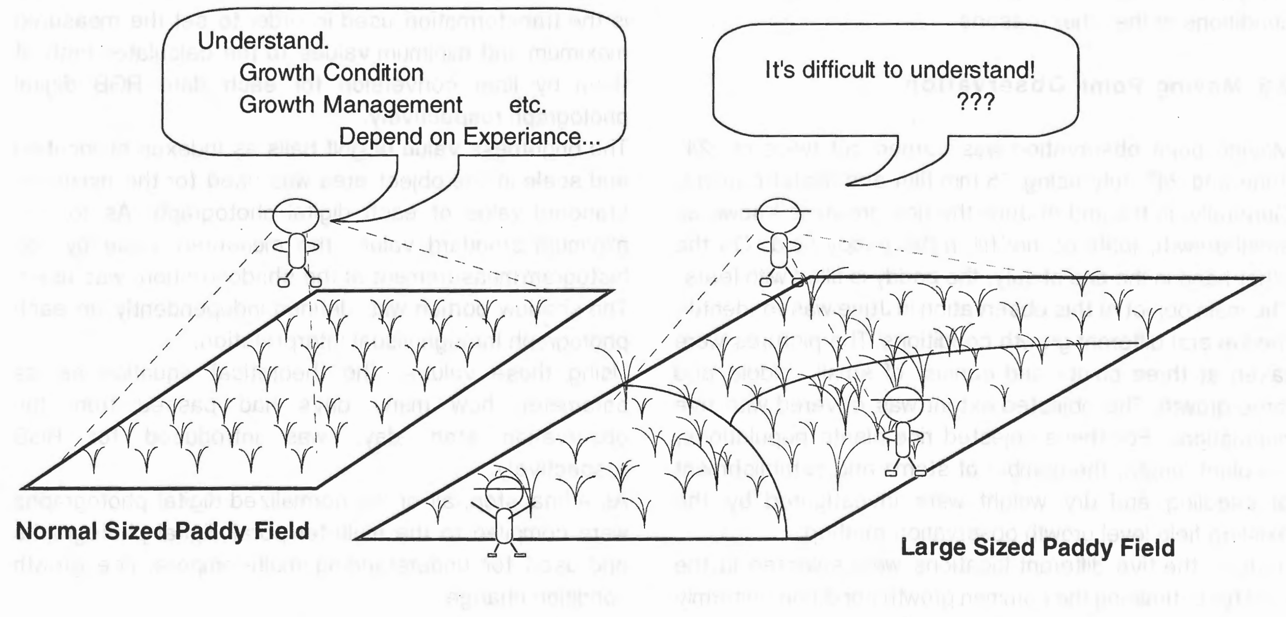
One purpose of the observations was to monitor the time dimensional growth identification and the detailed growth difference recognition of any what is its stage.

We call the former the fixed point observation and the later the moving point observation.

Figure shows the comparison of the different types of paddy fields in this study and concept of understanding the condition.

Table 1 shows the kinds of information we obtained.

The following are each descriptions of the observation.



	Normal Sized Paddy Field	:	Large Sized Paddy Field
1) Area ;	Comparative Small	<---->	Large
2) Growth ;	Uniform	<---->	Variety
3) Growth Management ;	Depend on Personal Experience	<---->	??
4) Growth Monitoring ;	Field Investigation	<---->	??

Figure 1, The comparison of different typed paddy fields and concept of understanding field condition

Table 1, Contents of each Observation

Observed Type	Date	Object	Aspect	Camera
Fixed Point	1998/7/13-10/13	2.5m x 2.5m for Rice Plants	Right Over	35 mm Film
Moving Point	1998/6/24	Different Growth / Five Populations	Right Over	35 mm Film
	1998/7/24	Different Location / One Population	Right Over	Digital

2.2 Fixed Point Observation

Fixed point observation had been done during the period from mid-July to mid-October. This season is from the time of starting rapid leaf growth to the cutting ear. 35 mm film camera was put in a durable box for water and sunshine. The camera was set on top of a tower about 4.7 meters height, and pointing straight down. The object was about 2.5 meters by 2.5 meters area. Three white golf balls put on poles of 1.4 meters in height and were deployed in 1.4 meter interval as indexes of location and scale in the object area. These golf balls were also used for the image normalization of the brightness depending on an acquisition condition after conversion to digital photographs. One picture was taken everyday at 10 a.m. . By this method, totally 41 pictures were accumulated for analysis, except bad pictures because of weather conditions or the other reasons.

2.3 Moving Point Observation

Moving point observation was carried out twice on 24th June and 24th July using 35 mm film and digital camera. Generally, in the end of June the rice growth is known as small growth, leafs do not fill in the paddy field. On the other hand in the end of July, the paddy is filled with leafs. The main object of this observation in June was to identify the several different growth conditions. The pictures were taken at three points and consist of small, middle and large growth. The objected extent was covered with five populations. For these objected rice plants populations, the plant length, the number of stems and establishment of seedling and dry weight were investigated by the existing field level growth observation method.

In July, the five different locations were selected in the field for estimating the common growth condition uniformly from an unevenness caused by different locations. Also the dry weight was investigated for one population of the objected rice plants by the same method as mentioned before.

In both cases, these pictures were taken looking straight down.

3. Data Processing for Observed Photographs

Most pictures except those of digital camera, were obtained by 35 mm film camera and also needed to be converted to RGB digital photographs, for the preparation of the following processing and analysis.

Each of them is the same as the observation type and its description is noted as follows:

3.1 Compilation of Multi-temporal Digital Photographs by Fixed Point Observation

The first step of processing, for the accumulated 41 digital photographs involved a normalization that was performed in order to correct the unevenness of the RGB brightness depending on the different observed conditions up to the observation date. Here, normalization is the transformation used in order to set the measured maximum and minimum values to the calculated both of them by liner conversion for each date RGB digital photograph respectively.

The brightness value of golf balls as indexes of location and scale in the object area was used for the maximum standard value of each digital photograph. As for the minimum standard value, the measured value by the histogram measurement at the shadow potion, was used. The shadow portion was defined independently on each photograph through visual interpretation.

Using these values, the theoretical equation as its parameter, how many days had passed from the observation start day, was introduced for RGB respectively.

As a final step, all of the normalized digital photographs were compiled to the multi-temporal digital photographs and used for understanding multi-temporal rice growth condition change.

3.2 Leaf Area Detection for Digital Photographs by Moving Point Observation

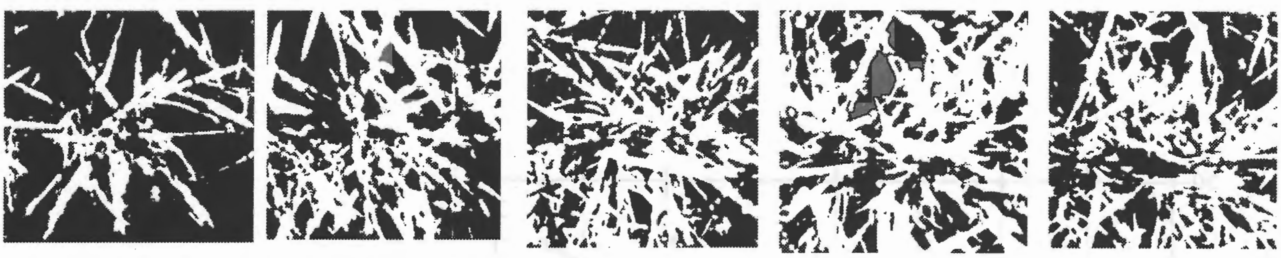
There were totally 8 images, 3 images observed in June and 5 images in July. At first, focused area which covered over five populations in June and one population in July, was extracted from the observed digital photograph, then converted from a 8 bit color composite image to a 6 bit Index Color image using Adobe Photoshop image processing software. This reason was to consider for the

limitation of color isolation by visual interpretation.
On each Index Color image, leaf body was extracted by identifying what kind of colors there are in leaf area using a function of the software. Each of colors detected were compiled to one item as leaf body and others put into the other item as leaf deteced image with 1 bit.

However, small areas like holes with a few pixels (noise) still remained in each of these images. These noises were removed by use of the "Dust and Scratch Tool" similar to a majority rule of Adobe Photoshop.
Figure 2, 3 shows these leaf area detection images.

Small Growth Middle Growth Large Growth

Figure 2, Leaf area detection images at three different growth stages



Point 1 Point 2 Point 3 point 4 point 5

Figure 3, Leaf area detection images at five different locations

4. Results and Considerations

4.1 Fixed Point Photographs Analysis and General Rice growth

The trend of general rice growth was discussed using multi-temporal digital photographs.
From each of these multi-temporal images, the area of rice plant with 190 pixel in diameter around the pole using index for location was sampled.
The average value was measured for the sample area in RGB respectively. And every value plotted on a graph with data value axis and date axis, how many date had passed from the observation start day, as the result of multi-temporal rice growth change. An upward trend was recognized in the period from early to mid September. It appears that the drastic change of rice growth was reflected to the RGB value change in the short period after ear emergence.

4.2 Comparison with Moving Point Photographs Analysis and Field Level Observation

The amount of leaf area occupied in each of these leaf area detection images, was calculated in ratio (%).
These calculated rates were compared with the leaf blade weight (g) (L.B.W.) of these items of dry weight at the field level observation.

4.2.1 Different Growth : At first the L.B.W. of small growth was divided by the leaf area occupation rate (L.A.O.R.), the L.B.W. per one percent was calculated. Then each of these estimate leaf blade weight (g) (E.L.B.W.) was calculated. Table 2 shows these results of L.B.W., L.A.O.R., and E.L.B.W.

Table 2, The results of L.B.W., L.A.O.R. and E.L.B.W.

Growth	L.B.W. (g)	L.A.O.R (%)	E.L.B.W.(g)
Small	2.16	16.84	2.16
Middle	2.70	19.65	2.53
Large	4.38	42.23	5.43

Concerning the E.L.B.W. of middle growth, it was close to its L.B.W. On the contrary the E.L.B.W of large growth, it was more 25% than its L.B.W. One reason appears that leaf tip hung down from right over to horizontal direction according to the process of leaf growth so that L.A.O.R. could increase rather than its volume only in the use of image which obtained from right over direction.

4.2.2 Different Location : Figure 4 shows the relationship between L.A.O.R. and L.B.W. Although there are not many samples, the correlation coefficient 0.92 was taken. From this result, this kind of relation could be useful information for estimating L.B.W. from L.A.O.R..

Also in this stage of rice growth, the condition was changed from the enlarging period to the period of preparation for generating grain so that this analysis could be effective for the growth management such as estimation of yield and fertilizer distribution.

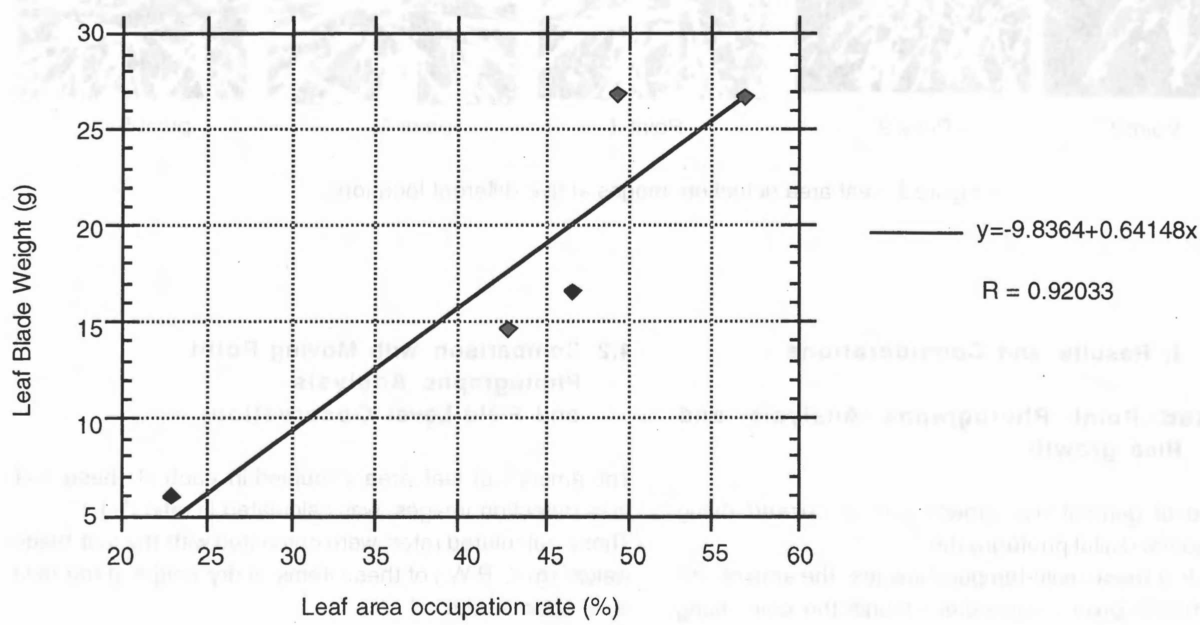


Figure 4, Relationship between L.A.O.R. and L.B.W. at five points

5. Conclusions

In this study, rice growth dynamic monitoring by applying the concept of real-time imaging and dynamic analysis, was discussed for direct seeding cultivation, is noticed as new cultivation technique for labor-saving and efficient rice production instead of the traditional cultivation by transplanting. Actually the estimation method of rice growth condition was proposed by those of digital photographs, obtained by fixed and moving point observations.

Obtained results and future research subjects are as follows:

1) Basic and general rice growth conditions could be identified using observed fixed point digital photographs.
2) Appears to be possible to estimate the growth in time dimension in the period from the beginning of cultivation to the end of July.
3) Variety of growth conditions could be identified and used as reference for cultivation management.
4) Future detailed consideration is necessary toward actual utilization of proposed observations. For instance, more moving point observation points than this experiment, are needed.
5) In the moving point observations, taking direction for any photographs from the fixed same direction could be considered for future investigations.

Through this study, rice plant photographs confirmed a high capability for providing effective information for countering the drawbacks of direct seeding cultivation. More continued substantiation of this study is needed in order to establish new rice growth management.

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