

# A Study On Development Of Intelligent Irrigation Systems For Melon Cultivation In Greenhouse

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**Abstract:** The price of melon varies with its quality. It is very difficult to control the quality of melon in various growing stages, because irrigation management in a green house influences the fruit quality. In this study, the intelligent irrigation systems were developed using the know-how extracted from an expert. Fuzzy control and On-off control for irrigation were examined. Changes in soil moisture content were predicted by Fuzzy control systems with various climate sensors. As the results, the performances in Fuzzy control and On-off control were respectively 52% and 40% water saving compared to the manual irrigation by an expert. The qualities of fruits by Fuzzy control and On-off control were almost the same results from the manual irrigation.

**Keywords:** melon; irrigation; fuzzy control; on-off control

## 1 Introduction

Compared with other agricultural produce, the price differences based on fruit quality are very large with melons. Irrigation control during cultivation is a very difficult skill requiring the knowledge, experience, and instincts of an expert. Because it is so difficult, these experts must spend a great amount of time for irrigation control. Automatic irrigation systems for melons are currently on the market, but they are very expensive. Today, as melon prices remain depressed in Japan, there is a demand for inexpensive systems that can automatically control irrigation. Given these circumstances, the purpose of the present study was to extract the irrigation know-how for melon cultivation from experts, and from this, to develop an intelligent irrigation control system that uses a minimum of equipment.

## 2 Experimental apparatus

The experiment was conducted in a plastic covered horticultural greenhouse in Niigata City. A type of melon suited to forcing or late raising culture inside the greenhouse was used as the experimental crop. Fig. 1 outlines the irrigation control system in the present study. The greenhouse contained four ridges, one of which was a Fuzzy control area, one an On-off control area, and the remaining two a Manual-irrigation area irrigated by an expert. The irrigation method was tube irrigation. Water volume meters and TDR soil moisture sensors were set up in each of the experimental areas to measure the changes in irrigation water volume and soil moisture with time. In addition, a temperature and humidity sensor was set up in the center of the greenhouse at a height of about 1.5 m off the ground, and a pyranometer and barometer were set up outside the greenhouse to measure changes in radiation and atmospheric pressure with time. The software used in the control

computer was FIX32, which can gather and manage data linked to a sequencer, PC208W, which can collect data linked to a data logger, and MATLAB for Fuzzy logic.

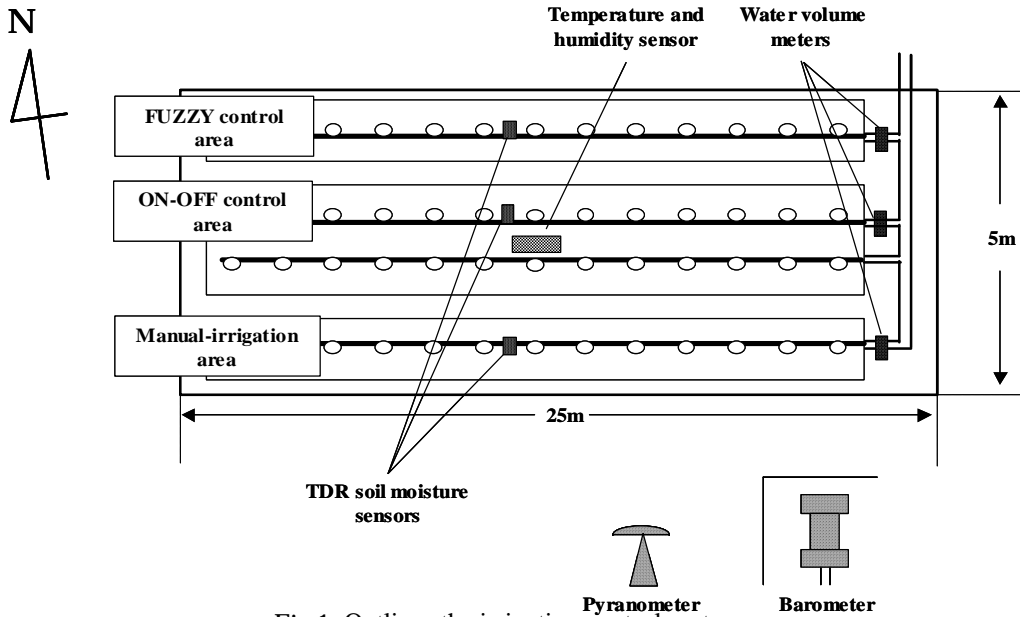
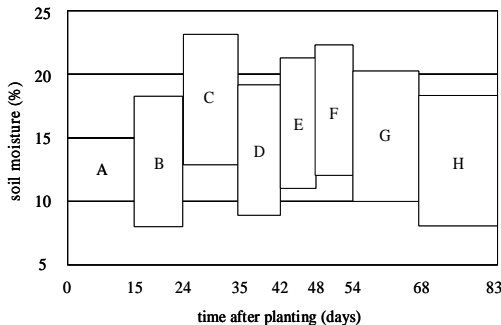


Fig.1. Outlines the irrigation control system

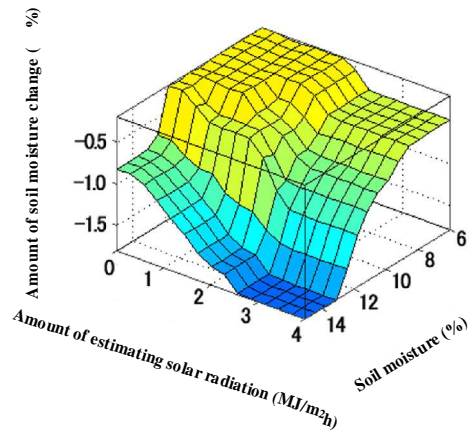
### 3 Outline of experiment

#### 3.1 Extracting irrigation control know-how

The aim of the present study was to extract the irrigation know-how of an expert, establish a target range for controlling soil moisture in the growth stage of a melon, and develop a system for irrigation control according to the established range. In the first year of the experiment, the target range for controlling soil moisture was established based on measured data for irrigation control and soil moisture under an expert (Fig. 2). In addition, a fuzzy control algorithm was constructed to predict soil moisture values 24 hours later. In making a membership function of soil moisture and amount of solar radiation, central coordinates obtained from clustering was used as method of defining a parameter and of temperature, pressure and amount of soil moisture change, these were prepared experientially from measured data. A MIN-MAX centroid method was used in the deduction method. The control rules took reported and actual data as the control knowledge, and were prepared with the aim of calculating the changes in amounts of soil moisture with consideration of the evapotranspiration rate according to weather conditions. One example of the relationship between the input and output values is given in Fig. 3.



- A: Immediately after planting
- B: Fixation of root
- C: Corpulence of fruit
- D: Hardening of fruit
- E: Appearance of vertical nets
- F: Appearance of horizontal nets
- G: Finishing of nets appearance
- H: Maturing of fruit



**Fig.2. Target range for controlling soil moisture output values**

**Fig.3. Relationship between input and in Fuzzy prediction**

### 3.2 Development the irrigation control system

In 2001, irrigation control systems were designed with Fuzzy control using the abovementioned Fuzzy logic, and On-off control which used only the target control range as the irrigation control method. The irrigation time was set at 9:00 a.m. based on the traditional practice of an expert. The reason for choosing this time of day is that it is thought to be better to irrigate when the irrigation water temperature and the temperature in the ground are about the same. Also, there was the practical reason in the irrigation control experiment that at this time of day the minimum necessary amount of actual measured data is collected. The two control systems are outlined below.

#### (i) Fuzzy control system

Fuzzy logic is conducted using actual measurements during the irrigation time, and the soil moisture 24 hours later (9 a.m. on the following day) is predicted. If that value is below the minimum limit of the target soil moisture range, irrigation is conducted to bring the soil moisture up to the upper limit of the target range.

#### (ii) On-off control system

Irrigation is conducted to bring the soil moisture up to the current upper limit only when it falls below the lower limit of the target soil moisture range. Throughout the cultivation period, actual data and irrigation data in the Fuzzy control area, On-off control area, and Manual-irrigation area were collected, and the irrigation performance and post-harvest melon quality were compared for each experimental area.

## 4 Results and discussion

### 4.1 Changes in soil moisture

In the Fuzzy control area during the experimental period, the soil moisture was kept mostly within the target range by considering the change in the amount of soil moisture until the next morning. During the period of corpulence of fruit, the soil moisture in the Fuzzy control area fell below the lower limit of the target range each day. The cause is thought to be that the lower limit of the target soil moisture range prepared in the first year was set too low.

### 4.2 Irrigation amount

The total irrigation amount during the melon cultivation period in the test areas was 6,758 liters in the Fuzzy control area and 8,321 liters in the On-off control area, against 10,101 liters in the Manual-irrigation area (Fig. 4). Compared with the Manual-irrigation area, therefore, the water conservation ratio was 52% for the Fuzzy control area and 41% for the On-off control area. This is thought to be because the amount of wasted irrigation water such as gravitational water was kept down by setting a target range for controlling soil moisture. Slight differences were seen in the amounts of irrigation water in the Fuzzy control area and On-off control area. Considering the drying rate of the soil during the control period, however, the present results alone do not establish superiority based on the differences of the control systems.

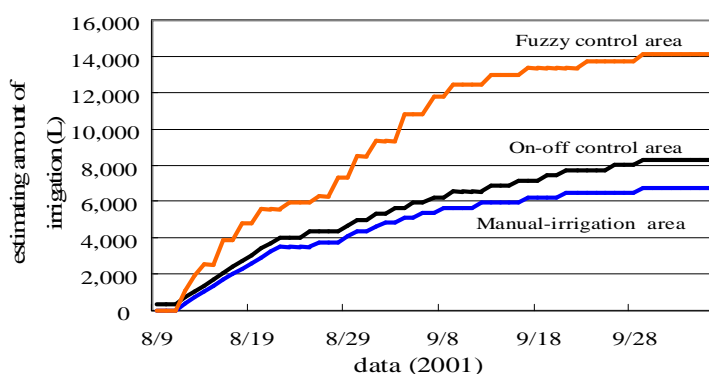


Fig.4. Total irrigation amount

### 4.3 Fruit quality after harvest

The sugar content (Brix, %) and grade of the fruit were compared for 50 melons harvested from each

experimental area. The results showed that sugar content increased similarly in the fruit from each area (Fig. 5). A general judgment of the fruit grade was made by an inspector from a fruit sorting plant based on shipping criteria. The number of “Super Excellent,” or AA, melons was slightly lower in the Fuzzy control area than in the other areas, while the number of “Excellent,” or A, melons at four was slightly higher than in the other areas (Table 1). It is said among experts that as a target “one should obtain a “Super Excellent” rating for more than 80% of the cultivated melons in habitual cultivation, and it is better not to have any “Good,” or B, melons.” Therefore, the results of the present study for each of the experimental areas should be considered satisfactory.

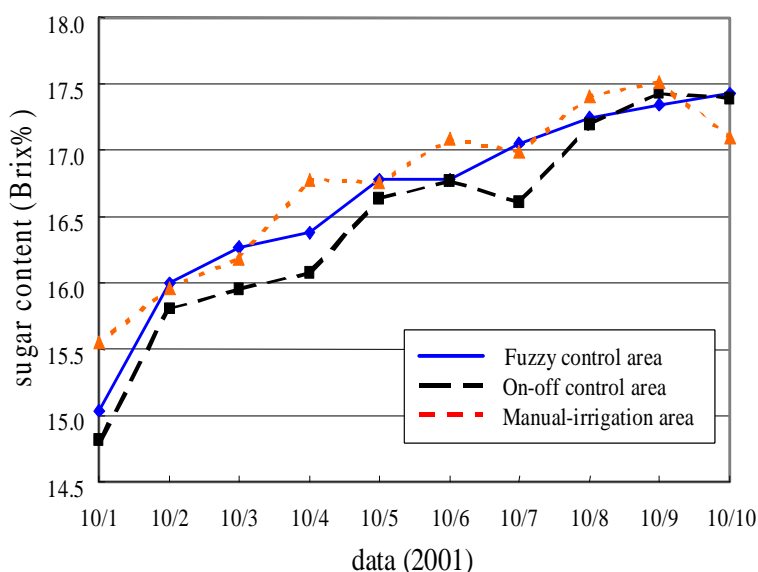


Fig.5. Char

Table.1. The number of each grade of melon

Grade	Fuzzy control area	On-off control area	Manual irrigation area
AA	46	49	50
A	4	1	0
B	0	0	0

#### 4.4 Precision of fuzzy logic

To check the precision of the Fuzzy logic prepared in 2000 to predict the changes in soil moisture, the data from the days on which irrigation was conducted were analyzed. It was found that in the Fuzzy control area in 2001 there was a mean error of 0.3 points in the predicted value of soil moisture. In addition, the correlation coefficient was 0.77, so this was a relatively good result (Fig. 6).

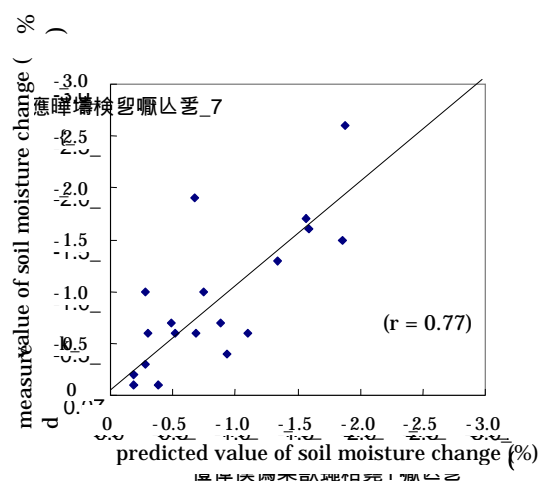


Fig.6. Relationship between measured and predicted value (2001)

## 5 Conclusions

To verify the Fuzzy logic prepared in 2000 and the practicality of the target range for controlling soil moisture, a verification test was conducted for irrigation performance in an actual greenhouse in 2001. The results showed that the soil moisture value in the Fuzzy control area was maintained nearly within the target soil moisture range, and the respective water conservation ratios of Fuzzy control area and On-off control area were 52% and 41%. Both the Fuzzy control area and On-off control area gave considerable water savings over the Manual-irrigation area, while both produced fruit of similar quality (sugar content and grade) to that in the Manual-irrigation area. The above shows that the present systems for automatic irrigation control of greenhouse melons are effective. Moreover, no clear difference was seen between the Fuzzy control and On-off control areas. In the future, it will be necessary to conduct cultivation experiments under different soil conditions, and then based on the results to improve the system and increase its general applicability.

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