CHANGE OF IRRIGATION WATER QUANTITY ACCORDING TO FARM MECHANIZATION AND LAND CONSOLIDATION IN KOREA

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ABSTRACT

Since 3000 BC, rice has been the main crop in the Korean Peninsula, and where currently most of the available irrigation water is used to grow paddy rice. Methods for calculating the quantity of irrigation water required developed in the 1990's were compared to quantities measured in the field. The largest difference between calculated and measured quantities occurred in April and May. Based on field data we obtained in the middle part of the Korean Peninsula, significant changes have occurred in rice management, which has changed the amount of irrigation water required. Rice is now transplanted earlier, and duration of the transplanting phase on the regional scale is shorter through mechanization and consolidation of land holdings. These changes need to be taken into account when calculating the quantity of water needed for irrigation.

INTRODUCTION

The Comprehensive plan of water resources in Korea says that 48% of water resources are used for agricultural purpose. And except for river maintenance flow, 62% of water resources are used for same purpose. So, it is very important to carefully manage agricultural water in order to use water resources efficiently.

Since 1970, the manufacturing sector of the economy has grown rapidly. Also the agricultural work force has declined; there are fewer people left in farming villages. To replace this source labor, farming operations have been mechanized and the land holding managed by individual farmers has increased.

These changes have influenced the management of irrigation water. The pattern and quantity of supplying irrigation water has been changed. Some reports have quoted this existing condition. The report "Study on Improvement of Rural Water Supply and Operation of the Experimental Site" says that the ratio of planning quantity of irrigation water to actual supplying quantity is over 1.3 (Rural Research Institute, 2002; Korea Institute of Construction Technology, 2001). The disparities between two quantities in April and May are larger than other months.

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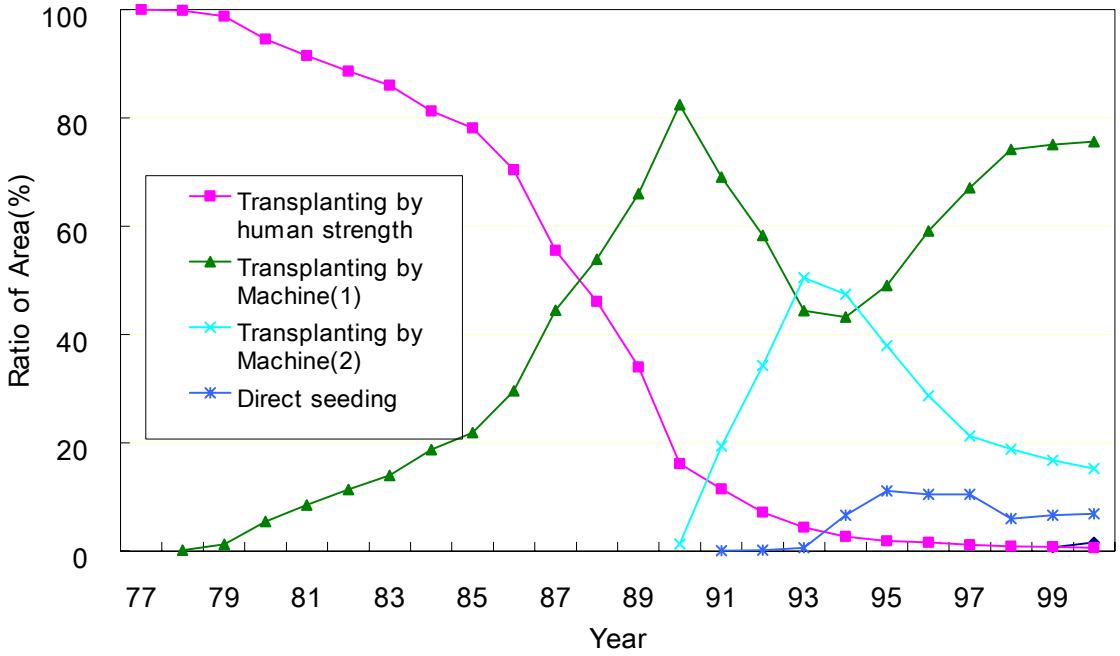
The purpose of this study is to revise the methods of estimating the quantity of irrigation water required for paddy rice to properly account for the changes in rice management that have occurred.

CHANGE OF CULTIVATING METHODS

Rice cultivating technologies have been developed in step with social and economic situation in process of time since the prehistoric age in Korea. In the Neolithic era, the upland rice is cultivated by the method of direct seeding in dry field. At the close of the Corea Dynasty (15th century), the technology of transplanting began to be used. Until 1970s, transplanting by human strength is the major method to cultivate rice.



(1) : Transplanting 30~40 day's young plant
(2) : Transplanting 10 day's young plant

Figure 1. Variation of methods to cultivate rice in paddy field

From the end of 1970s, Korea has been industrialized and urbanized, and the number of people available to transplant rice became limited. It was necessary to cultivate using machine and consolidate land to use machine. By 1988, Farmers was used machine to transplant more than 50% of the area planted rice (Figure 1). By 1994 this increased to 90.8%.

These variations have changed the date of rice growing stages and the quantity of irrigation water for rice in paddy field.

CURRENT METHOD TO ESTIMATING IRRIGATION WATER DEMAND

Irrigation water's major purpose is to supply water for growing rice healthily. Irrigation water quantity is influenced strongly by weather conditions such as precipitation and evapotranspiration.

Current methods to estimate irrigation water demand has been developed from 1910s. The system for estimating irrigation water demand is HOMWRS(Figure 2), which was established using data collected 20 years ago. The inputs of HOMWRS are total beneficial area, area by methods of cultivating rice, ratio of water loss in irrigation canal, percolation, ET data etc.

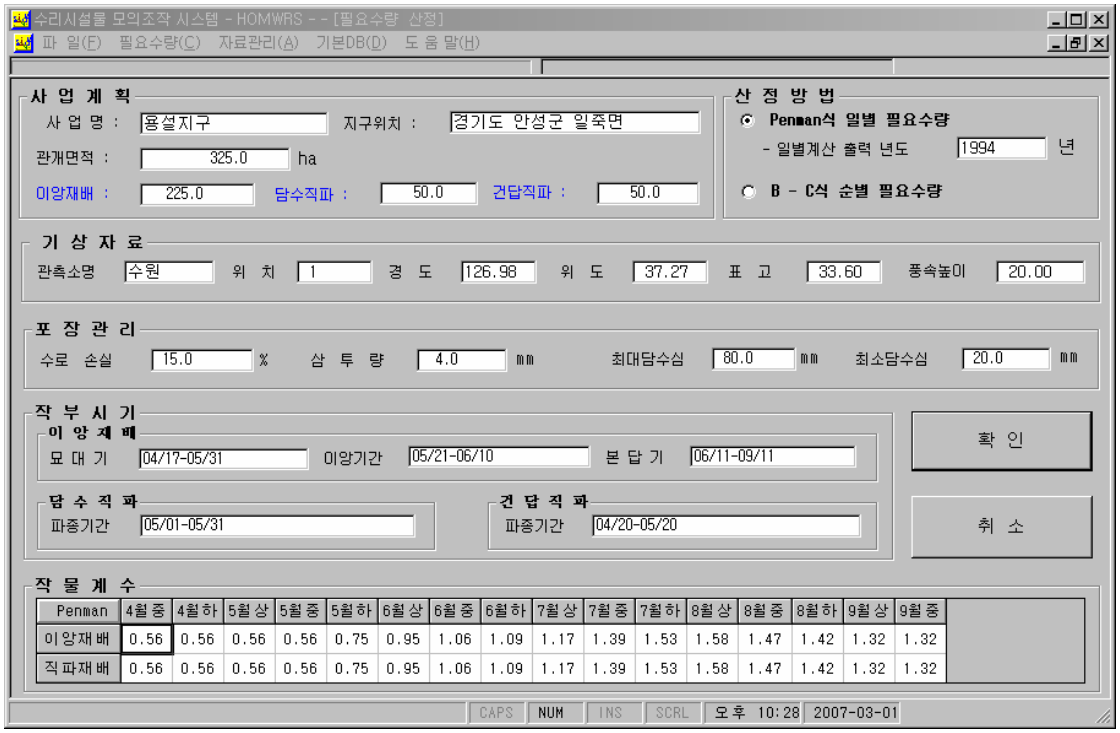
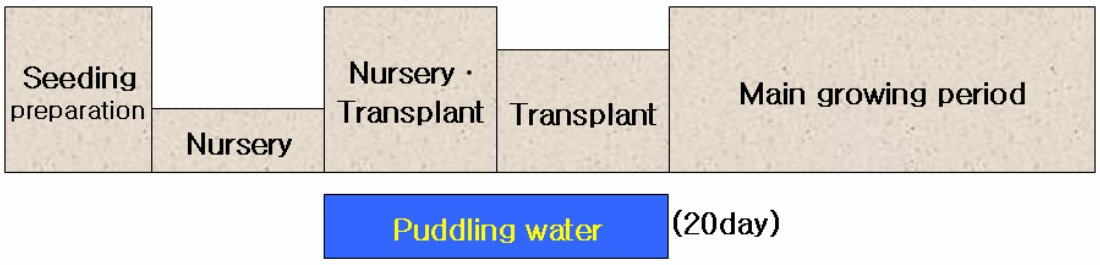


Figure 2. System to estimating irrigation water demand (HOMWRS)



Puddling water: water which should be supply before transplant

Figure 3. Stages of cultivating rice

Table 1. Dates of growing stages – rice (Month / Day)

Region	nursery	transplant	Main growing period
Central Region	4/17 ~ 5/31	5/21 ~ 6/10	6/11~9/11
Southern Region	4/27 ~ 6/10	6/1 ~ 6/20	6/21~9/21

The time step of this system (HOMWRS) is one day. This system calculates the irrigation water demand by analyzing water balance in paddy field. The consumption factors are evapotranspiration, infiltration and water losses in canals. The supplying factors are precipitation and water supply. There are 3 stages to cultivate rice(Figure 3 and Table 1). The methods to supply irrigation water are different from one another.

EXPERIMENTAL SITE AND RESEARCH METHODS

Experimental Site

In order to measure the quantity of actual irrigation water, we chose one experimental site, Yi-dong Reservoir district which is located in central region of Korea. The area of this watershed is 9,300 ha. The beneficial area of Yi-dong reservoir is 2,063ha. There are two reservoirs in Yi-Dong reservoir's watershed, Yong-deok reservoir and Mi-san reservoir. There are two pumping station in the beneficial area – Eun-san pumping station and Won-dam pumping station . There are five main canal in this district - Jin-Wie main canal, Jin-Won main canal etc. These facilities are managed by KRC (Korea Rural Community & Agriculture Corporation)

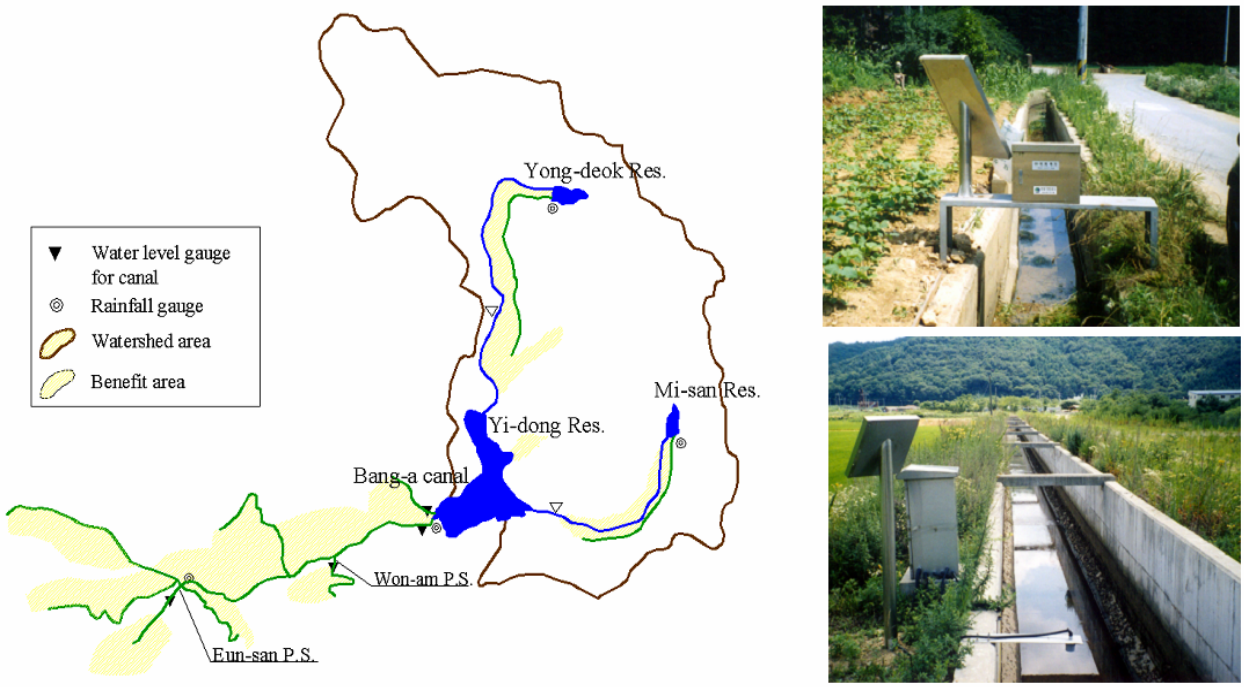


Figure 4. Yi-dong experimental site and water level measuring system in canals

Table 2. Characteristics of the irrigation canal

Canal (District classification)	Beneficial area	Facility to supply	
		Name	Watershed area
Jin-Wie main canal	2,063ha	Yi-dong Res.	9,300 ha
Jin-Won main canal	1,286ha	Eun-san P.S.	-
Bang-a secondary canal	128ha	Yi-dong Res.	9,300 ha

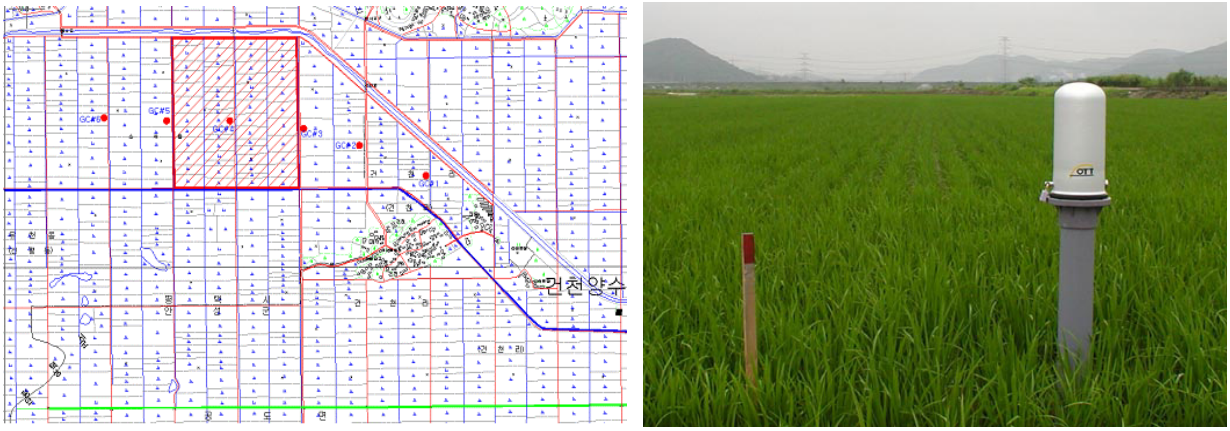


Figure 5. Equipment for measuring water level in paddy field

Research Methods

In order to measuring the supplying water quantity, three water level gauges were installed in three canals. – Jin-Wie main canal, Jin-Won main canal and Bang-a secondary canal. Water resource of Jin-Wie main canal is Yi-Dong reservoir, Jin-Won main canal is Eun-san pumping station, Bang-a secondary canal is Yi-dong reservoir.

We measured the quantities of water flowing through these canals using flow meter. We found out the relation between water level and water quantity. So, the quantity of supplying irrigation water through these canals was calculated.

In order to know the periods of 3stages of rice growing, we monitored the proceeding ratio of transplanting and the proceeding ratio of supplying transplanting water. The proceeding ratio of transplanting is the transplanted area divided by total beneficial area. The proceeding ratio of supplying transplanting water is the area supplied transplanting water divided by total beneficial area.

We installed equipment for measuring water level (ponded depth) in paddy field in order to know the characteristics of managing water in paddy field by farmers. This equipment was installed at seven locations in Yi-dong experimental district.

We analyzed the characteristics of irrigation water management and make a comparison between practical situation in field and current system for estimating irrigation water quantity.

RESULTS

Supplying water for transplanting and transplanting

There are no areas of direct seeding in central region of Korea. The major method of cultivating rice is transplanting using machinery. Most of rice is same species – Chuchung. The results of monitoring the proceeding ratio of supplying transplanting water and the proceeding ration of transplanting (Figure 6 and Figure 7).

Results of investigating practical date of rice growing stages are shown in Table. 3. The practical starting date of stage is earlier than the criteria date of current method which estimates irrigation water quantity. The period of the transplant is shorter than the previous.

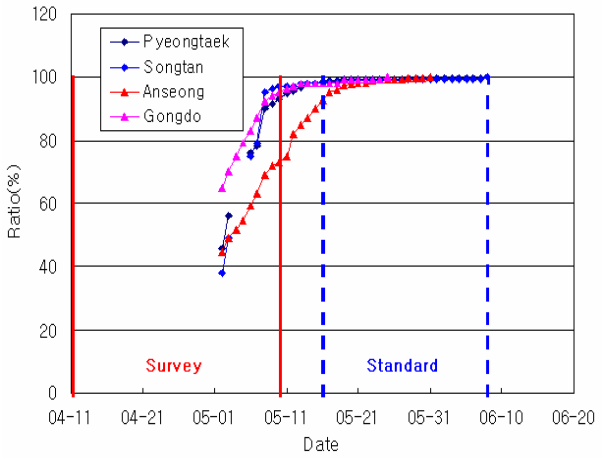


Figure 6. Proceeding ratio of supplying transplanting water

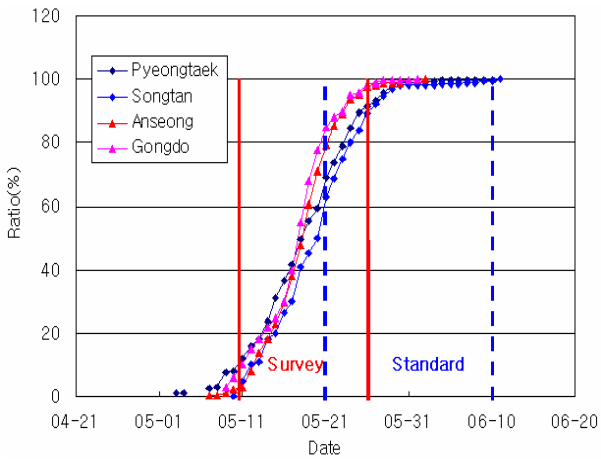


Figure 7. Proceeding ratio of transplanting

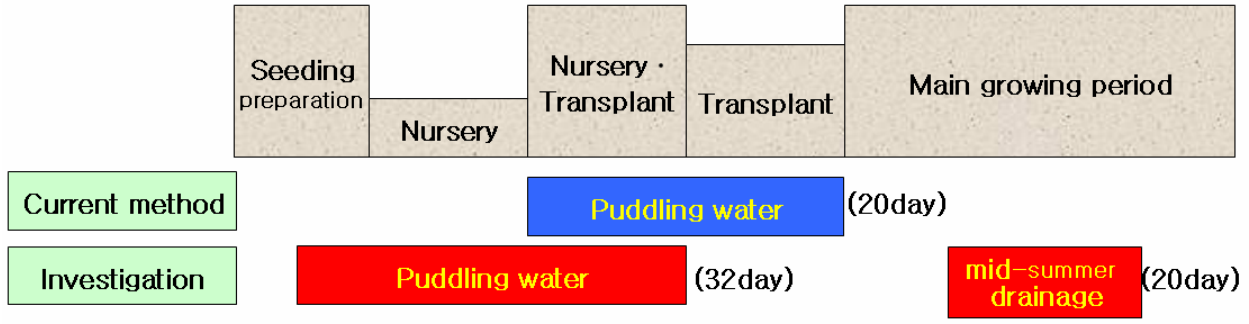


Figure 8. Practical stages of rice growing

Table 3. Practical date of rice growing stages (Month / Day)

Classification	Nursery	Transplant	Main growing period
Current Method criteria	4/17 ~ 5/31	5/21 ~ 6/10 (21day)	6/11 ~ 9/11
Investigation Results	4/11 ~ 5/18	5/12 ~ 5/26 (15day)	5/27 ~ 9/11

Water Level (Ponding Depth) in Paddy Field

The results of measuring water level in paddy fields are shown in Figure 9. Figure 9 says that mid summer drainage are practiced in most of paddy field. The period is between 26th June to 12th July.

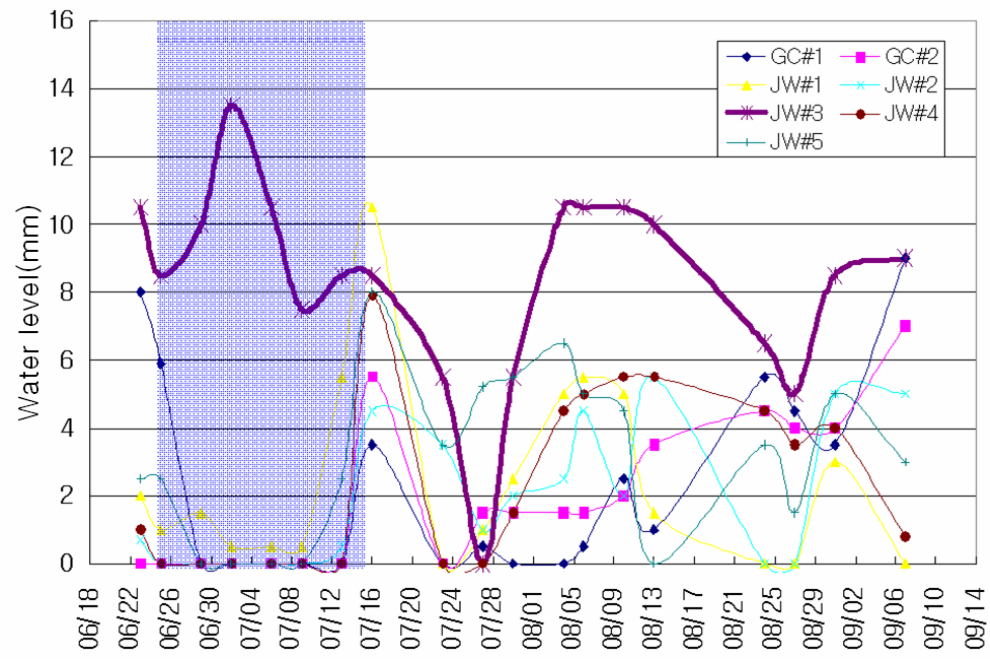


Figure 9. Water level (ponding depth) in paddy fields

The Quantity Of Supplied Water In Experimental Site

Table 4 and Table 5 show the supplied water discharge measured in Jin-Wie main canal, Jin-Won main canal and Bang-A secondary canal.

The supplied water discharge in 2004 was more than 2003. It is because that the amount of rainfall in 2004 is less than 2003. The quantity of supplied water in May was more than any other month. It is because there are few rainfall in spring and puddling water is supplied in April and May.

Table 4. Supplied ater (2003)
Unit : 1000 ㎥

Month	Jin-Wie	Jin-Won	Bang-A
Apr	4,696	843	421
May	9,573	3,055	836
Jun	6,273	2,290	660
Jul	2,703	292	59
Aug	4,093	708	543
Sep	20	0	0
Total	27,357	7,188	2,519

Table 5. Supplied water (2004)
Unit : 1000 ㎥

Month	Jin-Wie	Jin-Won	Bang-A
Apr	4,146	1,372	424
May	8,651	3,591	890
Jun	5,775	2,100	690
Jul	2,289	688	275
Aug	7,004	2,145	868
Sep	1,717	690	237
Total	29,564	10,586	3,384

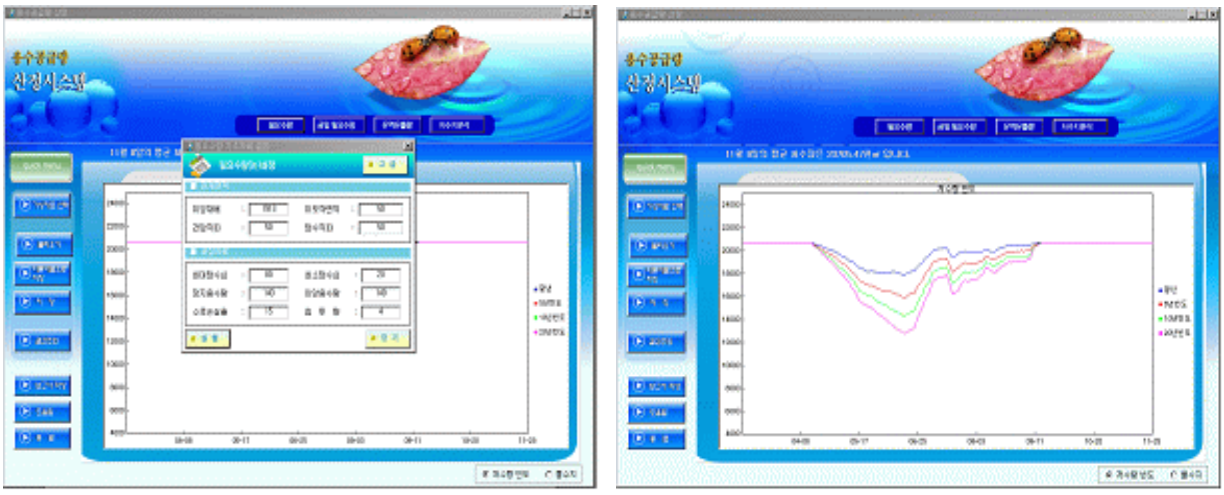


Figure 10. New system to estimate irrigation water demand

Calculating The Quantity Of Irrigation Water In Paddy Field

Considering the investigated data, new system to estimating irrigation water demand was developed. (Figure 10)

In order to compare new system to current system (HOMWRS), We calculated irrigation water demands using two system. We called Case 1, in case of using current system and called Case 2, in case of using new system. The period of supplying puddling water is 32days, But it is efficient to shorten the period of supplying puddling water in order to save water resources. So we make Case 3, in which the period of supplying puddling water is 20 days. The dates of rice growing stages for three cases are shown in Table 6.

Table 6. Dates of rice growing stages for cases

Case	nursery	transplant	Main growing priod	Puddling water	mid summer drainage
I	4/17 ~ 5/31	5/21 ~ 6/10	6/11 ~ 9/10	5/21 ~ 9/10	-
II	4/11 ~ 5/18	5/12 ~ 5/26	5/27 ~ 9/10	4/13 ~ 5/18	6/26 ~ 7/12
III	4/11 ~ 5/18	5/12 ~ 5/26	5/27 ~ 9/10	4/29 ~ 5/18	6/26 ~ 7/12

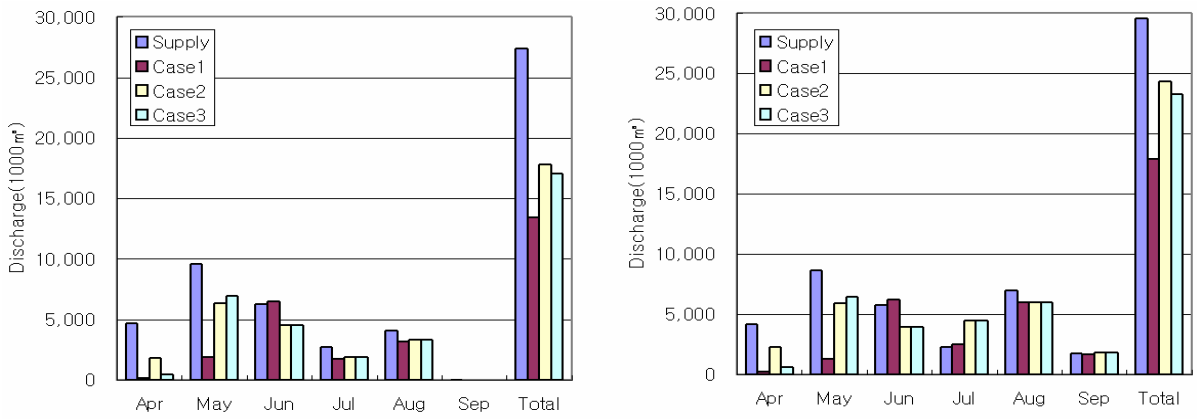
Table 7. Ratio of water supply discharge to estimated discharge for 3 cases

district	Supply/Case 1			Supply/Case 2			Supply/Case 3		
	2003	2004	Avg	2003	2004	Avg	2003	2004	Avg
Jin-Wie	2.03	1.65	1.84	1.54	1.21	1.38	1.60	1.27	1.44
Jin-Won	0.93	1.02	0.97	0.70	0.75	0.73	0.73	0.79	0.76
Bang-A	2.91	2.94	2.93	2.20	2.16	2.18	2.29	2.26	2.28
Avg			1.91			1.43			1.49

The ratios of water supplied to estimated discharge by three cases are shown in Table 7. The average ratio of 'Supply/Case1' is 1.91. The average ratio of 'Supply/Case2' is 1.43. These show that water is supplied more than estimated quantity. It is inferred that water losses is larger than the figure we applied to systems calculating the irrigation water demand. But we know that case 2 was estimated more similar to the practical supplied water.

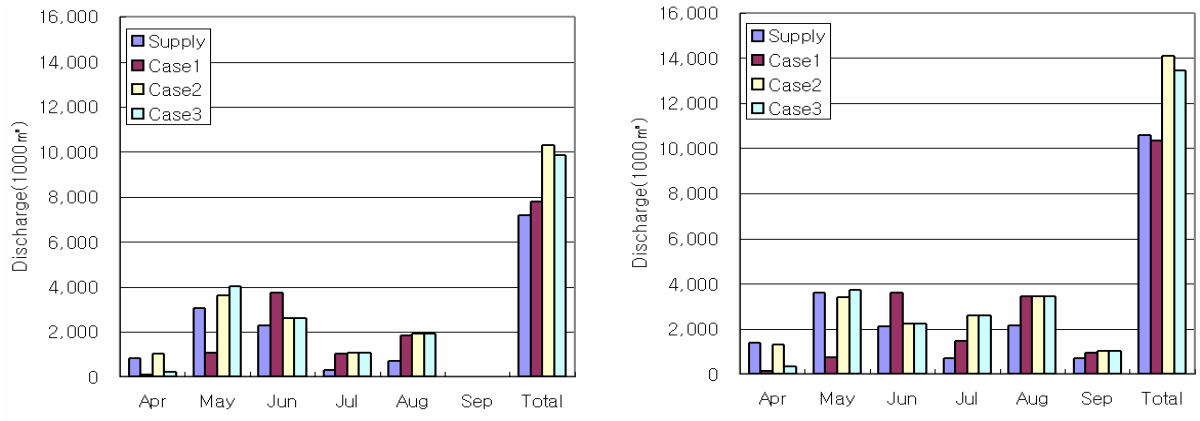
Figure 11, Figure 12 and Figure 13 shows that the amount of irrigation water. In Case 1, the disparity between supplied water and estimated water is much larger than in Case 2. Most of disparity occurred in April and May. The pattern of estimated water demand by Case 2 through month is more similar to practical supplied water than by Case 1.

The water quantity of estimated by Case 3 is equal to the estimation of Case 2 in Jun, July, Aug and September. But the ratio of water quantity divided by Case 2 and Case 3 is 1.05. So we inferred that we can save water 5% by decreasing period of supplying puddling water from 30 days into 20 days.



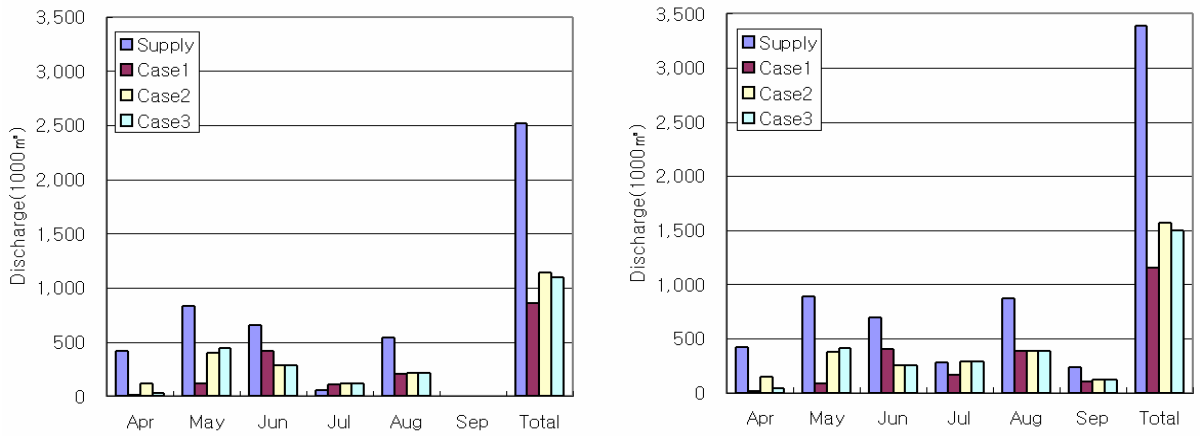
(a) 2003 (b) 2004

Figure 11. Water supply and water demand (Jin-Wie)



(a) 2003 (b) 2004

Figure 12. Water supply and water demand (Jin-Won)



(a) 2003 (b) 2004

Figure 13. Water supply and water demand (Bang-A)

CONCLUSION

The main purpose of this study is to develop proper method to estimate irrigation water quantity. To do so, we investigate cultivating behavior in paddy field, compare to current system of estimating irrigation water quantity and developed the system to estimate irrigation water quantity considering practical field condition.

The summarized results are as follows.

1. The practical starting date of stages is earlier than the criteria date of current method which estimates irrigation water quantity. The period of transplant is shorter than it of current method.

2. Mid summer drainage are practiced in most of paddy field. The period is between 26th June to 12th July.

3. The system developed in this study was estimated more similar to the practical supplied water than the current system in use.

4. 5% water could be saved by decreasing the period of supplying puddling water from 30 days into 20 days.

But we cannot calculate the irrigation water quantity more accurately because water losses in irrigation canals and crop coefficient are not determined appropriately. So, it is necessary to study on irrigation canal losses and crop coefficient in future.

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