7. EFFECT OF FLOODING DEPTH ON YIELD AND WATER REQUIREMENT

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Introduction

At present time, extension and rehabiliation of irrigation system are being carried out throughout Indonesia. The projects rae ranged from small scale of few hundred hectares up to large scale of more than hundred thousand hectares. As those irrigation projects are aimed at the improvement of physical environment for agricultural intensification, a good water management should be a prerequisite in achieving such an objective. However, up to last few years management of irrigation systems was not carried out properly as the proper irrigation requirement of the irrigated area was not taken into account.

The applied criteria for irrigation rate is not relevant anymore because formerly it was merely based on physical requirement of soils. Such criteria was also applied mostly for all irrigation systems either in designing or in operation purpose.

This paper has tried to review the recent investigations on water requirement in various region, held by Water Management Service, Ministry of Agriculture, as it will be necessary to support better management of irrigation systems in the area, in terms of improvement of design criteria for irrigation rate, so that efficient use of irrigation water can be achieved. Another subsequent benefit is that the possibility to increase net irrigated area in the irrigation scheme that has shortage and limited available of water or to increase net irrigated area in dry season.

Studies and Results

Objective of this trials is to know the influence of flooding depth on water requirement and field in connection of water saving. The trials were conducted at three places i.e. Cianjur District, in West Java Province, Sidrap District in South Sulawesi Province, and Nganjuk District in East Java Province. The first was held in the dry season 1972, and both the second and the third were carried out in the dry season 1973. Two of them those are Sidrap and Nganjuk were at aluvial soils, where Cianjur was at grumosol soil. All of them using Pelita I/1, one of the new high yielding varieties which is now planted extensively in Indonesia.

The irrigation treatment observed was continuous flooding with various depth. In Cianjur and Sidrap the depth were 2.5 cm, 5.0 cm, and 10.0 cm while in Nganjuk they were 2.5 cm, 7.5 cm, and 12.5 cm. Each treatment had four replications. The consumptive use and water requirement were observed and measured at 6:00 a.m. and 6:00 p.m. every day during 100 days by using N-type lysimeter.

1. Water Requirement

Water requirement is a total amount of water needed by crops for its proper growth and good production. The rate of water requirement depends on the rate of consumptive use and percolation.

Consumptive use is well understood as evapotranspiration (symbolized as ET) that

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Table 1. Effect of flooding depth on consumptive use and water requirement in dry season. Cianjur 1972, Sidrap and Nganjuk 1973

Continual flooding depth cm	CIANJUR		SIDRAP		NGANJUK	
	Consump. use mm/day	Wt. req. mm	Consump. use mm/day	Wt. req. mm	Consump. use mm/day	Wt. req. mm
2.5	5.99	728	6.25	932	4.74	510
5.0	6.24	788	6.67	1,000	—	—
7.5	—	—	—	—	4.90	527
10.0	6.71	838	6.76	1,000	—	—
12.5	—	—	—	—	5.12	548

is a total amount of water loss due to transpiration process and direct evaporation from the soil surface.

At the end of transpiration process, water evaporates from the plant leaves into the atmosphere. It means that the end of evapotranspiration process is evaporation. ET is also function of the duration of growing period.

Consumptive use $= E + T$

Water requirement $= E + T + P$

where: $E =$ Evaporation

$T =$ Transpiration

$P =$ Percolation.

The result of measurement held at the three places (Cianjur, Sidrap and Nganjuk) by using lysimeter shows that the lowest water requirement was occured at the shallow flooding (2.5 cm). The rate of water requirement during 100 days of observation at shallow flooding are as follows: in Cianjur 728 mm, in Sidrap 932 mm, and in Nganjuk 510 mm. The lowest consumptive use was found also at shallow flooding as it can be seen at Table 1. The average percolation rate in Nganjuk was very low i.e. around 0.4 mm per day, while the highest percolation rate was found in Sidrap with average about 3.5 mm a day. The low rate in Nganjuk is caused by shallow water table in Nganjuk area because it is below the water surface of the rain. The average percolation rate in Cianjur is 1.5 mm/day. This low rate is caused by impermeable characteristic of grumosol soil.

From Table 1 it can be seen that the deeper the flooding, the greater the water requirement, though the percentage of th increase was varied from one to another place.

2. Effect of flooding depth on yield

The result of the experiment held by IRRI in 1968 in Philippine shows that the depth of flooding doesn't have significant influence on yield. The result obtained in Cianjur and Sidrap with the depth of flooding 2.5 cm, 5.0 cm and 10.0 cm shows that there is no significant difference on yield. Also from Nganjuk with the depth of flooding 2.5 cm, 7.5 cm and 12.5 cm shows the same result. The results of Cianjur, Sidrap and Nganjuk prove that also in Indonesia there is no significant influence of the depth of flooding on yield.

From yield point of view, the depth of flooding up to 12.5 cm is still tolerated, because it doesn't affect yield, as long as there is sufficient water supply or in wet season. The result obtained by IRRI in 1968 shows that the depth of flooding 15 cm begins to decrease the yield.

Though there is no significant influence of the depth of flooding on yield, but the efficiency of water use on yield (grams of yield produced per liter water used) decreases if the depth of flooding increases as shown in Table 2. Average efficiency of water use

Table 2. Effect of flooding depth on grain yield of Pelita I/1 paddy varieties, and effeciency on water use at dry season in Cianjur (1972), in Sidrap (1973) and in Nganjuk (1973)

Continual flooding depth	CIANJUR			SIDRAP			NGANJUK		
	Wt. rq. mm	Yield ton/ha	Eff. gr/lt	Wt. rq. mm	Yield ton/ha	Eff. gr/lt	Wt. rq. mm	Yield ton/ha	Eff. gr/lt
2.5	728	7.5	1.08	932	6.7	0.72	510	7.2	1.44
5.0	788	7.3	0.92	1,000	7.2	0.72	—	—	—
7.5	—	—	—	—	—	—	527	6.8	1.29
10.0	838	7.4	0.89	1,000	6.8	0.68	—	—	—
12.5	—	—	—	—	—	—	548	6.7	1.22

in Nganjuk is above 1 gr/lt, in Cianjur about 1 gr/lt, and in Sidrap below 1 gr/lt.

3. Irrigation rate

Irrigation rate is ratio of the area irrigated to the flow discharge. It is used to know the hectareage of the area that could be irrigated per CMS of discharge. Irrigation rate is very important factor for water management plan of a certain irrigation area. The formula for irrigation rate is: $E=8640/D$,
where: E=irrigation rate, ha/CMS.
D=water requirement in mm.

As consequence of the above formula, the irrigation rate can be computed if the water requirement has already been known. So, measuring the water requirement is the first step in computing the irrigation rate. In is well understood that the factors affecting the irrigation rate are the same with the factors affecting evapotranspiration and percolation, i.e. climatic factors, soil characteristics, and plant characteristics. By using water requirement as listed in Table 1, it is clearly revealed that the deeper the flooding, the lower the irrigation rate. It means that the area can be irrigated at shallow flooding is larger than that can be irrigated at deep flooding. If the irrigation rate with the flooding depth of 2.5 cm compared with the irrigation rate with the flooding depth of 10.0 cm, it is clearly seen that in Cianjur, the increase of irrigation rate is 13% while in Sidrap is 7.4%.

In Nganjuk, the flooding depth of 2.5 cm increased the irrigation rate with 7.8% compared with the depth of 12.5 cm. Table 3 illustrates that the deeper the flooding the smaller the area irrigated. By applying 2.5 cm deep, the expected increase is 7 to 10% of the area flooded at 10 cm deep.

Farmers in Indonesia are used to irrigate their farm fields with more than 10.0 cm

Table 3. Effect of flooding depth on irrigation rate in dry season in Cianjur (1972), Sidrap (1973), and Nganjuk (1973)

Continual flooding depth in cm	CIANJUR		SIDRAP		NGANJUK	
	Wt. req. in mm	irrigation rate Ha/CMS	Wt. req. in mm	irrigation rate Ha/CMS	Wt. req. in mm	irrigation rate Ha/CMS
2.5	728	1,170	932	927	510	1,700
5.0	788	1,105	1,000	864	—	—
7.5	—	—	—	—	527	1,620
10.0	888	1,032	1,000	864	—	—
12.5	—	—	—	—	548	1,576


0°
SIDRAP
NGANJUK
CIANJUR
JAKARTA
0°
LOCATION MAP
1 : 10,000,000.

flooding depth. If they want to irrigate their fields with shallow flooding, it could be expected that the planting area in dry season would be increased.

Consulusion

1. Decreasing the flooding depth of the farm fields could raise the irrigation rate. As an evidence, the supply of irrigation water in dry season is limited. Thus, decreasing of flooding depth could be used as one of the methods for increasing the efficiency of irrigation water use, so that the irrigation rate in dry season could be higher. If the whole area of irrigated rice field in dry season covering 1.6 million hectares (Ha) in Indonesia, where the farmers usually irrigate their farm fields with more than 10 cm flooding depth could be flooded only with 2.5 cm deep, the planting area in dry season could be enlarged with about 150.000 Ha. By assuming that the average yield per Ha is 2 ton of unhusked rice, the enlargement of planting area in dry season means to obtain additional 300.000 ton of unhusked rice per year.

2. Decreasing the flooding depth is not the only one manner for highering the irrigation rate. Intermittent or rotational irrigation system could also enlarge the planting area irrigated. Unfortunately, due to the shortage of qualified personnel and budget, studies made by Rural Water Management Service is still emphasized on the influence of flooding depth against water requirement and yield.

For raising the irrigation rate, various studies in water management practises in Indonesia should be conducted.

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Question and Answer

H. K. Pande, India: How would you advice the farmer to maintain 2.5 cm of water which might required frequent application involving extra effort. Whether economics have been worked for saving in water visa-vis extra effort needed for more frequent irrigation application.

Answer: Agriculture technology was transferred to farmers by extension. Tertiary pilot unit ("Petah Tersier Pereoutohan") is one of our extension method. Now we have about 30 pilot units scatered at several irrigation scheme and covered ±3500 ha. In the future it would be expand. Main activities of tertiary pilot unit are:

a. Established or improves the terminal system.

b. Training for local agriculture extention personnel and farmers.

c. Recruiting field extension worker ("P.P.L."=Penguluh Pertanian Lapanga").

d. Establish and improve water users association.

We adopted the shallow flooding step by step through the water users association. Distribution of water done by association and water master. For this farmers paid contribution. So there is no extra works for farmers.

T. Kimura, Japan: 1) Actual application irrigation depth have been done more than 10.0 cm by the farmer in Indonesia. I suppose there are some reason: As it purpose of weed control?

2) How do you consider drainage conditions on your experiment by using lysimeter?

3) May I know field practices (Mr. speaker recommended 5.0 cm flooding) under the plot irrigation circumstances?

Answer: 1) Yes, one of the reason is to control weeds. But the other reason is to make sure that they have enough water for their paddy. Caused of lack of knowledge, they only know that paddy needs much water, they didn't know that paddy not need water in an excess.

2) In these trials, we use triangular weir to control the drainage or the depth. We installed two triangular weir (or Thompson weir) for each plot, that is for inlet and outlet.

3) For the practice, we advise the water user association to make or install the outlet in each plot with height not more than 5 cm, and it should be controlled by deputy or leader of quarternary blocks.

N. Yamada, Japan: Many people say that shallow irrigation is desirable and recommend the shallow irrigation, but it is said that farmers usually practice deep irrigation. I have in my mind a question whether the deep irrigation is effective in preventing field rodents invasion into paddy field or not. Is deep irrigation effective in reducing rodent damage?

Answer: I don't know exactly the relation among depth of flooding and rodent damage. In my opiinon, deep flooding will reduce the height of unflooded paddy levees where rodents make their holes. So by reducing the height of paddy levees, shallow flooding has the same result as deep flooding.

Peter Kung, FAO: I have no doubt about the experiment results because they were collected from three places and they all have shown the same reaction. But I worry about the weed growing under such shallow water condition. Did you record down the growth of weeds in the experiment plots. My second question is that shallow irrigation needs very flat surface of paddy field. If the farmers prepared their land very rough or the surface is not very flat shallow irrigation will cause uneven distribution of watesr.

Answer: 1) I'm agree with you, that shallow depth will bring more weeds. But I'm very sorry that in these trials, weeds growth unrecorded. In my country farmer did not use herbicide, they done by hand, 3 times during growing period.

2) It's true, and I'm agree that shallow irrigation needs flat surface of paddy field. That is why we recommend 5 cm depth (medium depth). This 5 cm depth is enough for our small plot of paddy field. In Indonesia the size of paddy fields less than 0.1 m per plot (about $40 \times 25\ m^2$/plot). Also we recommend this medium depth step by step, through farmer association/water user association.

Cheong Chup Lim, Malaysia: The conclusing part of the paper seems to have suggested that the farm loss has not been taken into consideration in aiming at the irrigation rate. Could the Speaker please give some information on the farm losses in Indonesia?

Answer: In general, on farm water losses in Indonesia, varied, about 15%–30%.