Water management: Table Of Contents

Introduction to water management

Rice is a semi-aquatic plant, which has a high demand for water, particularly over the reproductive stage from panicle initiation to early grain development. Most field crops usually grow best when at least 50% of the usable soil moisture is available to the plant. With rice, this figure is closer to 75% especially during the reproductive phase. Continuous ponding of water in the rice fields is one way of meeting these moisture demands which also reduces the risk of plant stress and yield loss. Ponding also helps suppress weed growth, improves the efficiency of use of nitrogen and, in some environments, helps protect the crop from fluctuations in temperatures.

Water use

Factors that will determine the total water requirements of a crop are:

- Evapotranspiration
- Permeability of the soil
- Drainage
- The length of the growing season
- The levelness of the soil surface

Evapotranspiration

Water is used by a rice crop through evaporation from the soil or water surface and by transpiration through the leaves. In the early stages of crop growth, most water is used through evaporation. However, when the crop develops a full canopy cover, transpiration accounts for most of the water used. The combined use, which is called evapotranspiration (ET), accounts for up to 80% of the water used by the rice crop.

The total evapotranspiration of a rice crop is between 800 and 1200mm of water. This quantity depends on seasonal conditions such as temperature, humidity, wind and sunlight hours as well as the length of the growing period. Evaporative demand is commonly measured by a U.S Class A pan-evaporimeter. While the relationship between the A pan-evaporimeter and the ET vary during the growing season, over a full season, the ET will average close to 100% of the pan-evaporimeter.

Permeability of the soil

The amount of water that is lost through infiltration and deep percolation below the root zone of the crop is dependant on :

- Soil type,
- Presence of a restrictive layer or hard pan in the soil profile,
- Depth of water in the field and
- Depth of the water table.

Soils that have high clay content to depth will have much lower permeability than sandy soils. Water losses in clay soils may range from 200mm to 400mm whereas in very sandy soils 1000mm to 2000mm of water could be lost to deep percolation. Increasing the depth of water in the field increases the hydraulic pressure which forces more water into the soil profile. Puddling will help form a hard pan or restrictive layer in most soil types, which will reduce deep percolation. During the wet season in some Asian countries the water table will often rise to be near the soil surface. This is especially important as it helps reduce water use especially in the sandy soil types.

Levees of sufficient height and soil density are also required to maintain water at the desired level in the field. Levees require regular maintenance to stop water loss through the wall caused by pests and soil cracking in the dry season. Seepage of water through the levees is a bigger problem in dry season crops.

Drainage

Drainage of water from the field can be very important during the time of crop establishment, high rainfall events and during attacks by crop pests.

In direct seeding situations which include nurseries, fields often need to be drained during the establishment stage to improve both the rate and number of plants established. While a growing rice crop can withstand total inundation for short periods, major yield losses will occur if lodged crops are flooded during the grain ripening stage and water cannot be removed because of poor drainage. In dry periods water may need to be re-circulated from one field to another to help save the crop. When pests such as the golden apple snail attack crops, the only recourse is to drain the whole field rapidly.

In most level fields drains around the periphery of the field will be sufficient to drain off excess water in a timely manner. In large fields and some nurseries, small internal drains running from the center of the field to the extremities of the field may also be needed.

Length of Growing Period

The longer the crop growth period the higher will be the water requirement. A general rule is that a rice crop will need approximately 10mm of water per day. Therefore a crop that matures in 100 days will require approximately 1000mm of water while a crop that matures in 150 days will require 50% more.

In areas that are affected by deep water or surface flooding, later maturing crops may be necessary so that the crop is sufficiently developed and tall enough to withstand the higher levels of water.

Land Preparation

Dry land preparation uses less water than wet land preparation, but this is not always possible in systems that rely on animal power for plowing. Land preparation systems that use animals or require free water on the soil surface before tillage can commence require up to 20% more water to grow the rice crop. Between 100mm and 300mm of water is required to saturate and weaken the soil so that animals are able plow it.

When preparing the land wet, as in puddling, the field should initially be worked dry and water added just before the puddling operation. Dry working of the soil helps reduce clod sizes, fills the soil cracks and reduces deep percolation of the water.

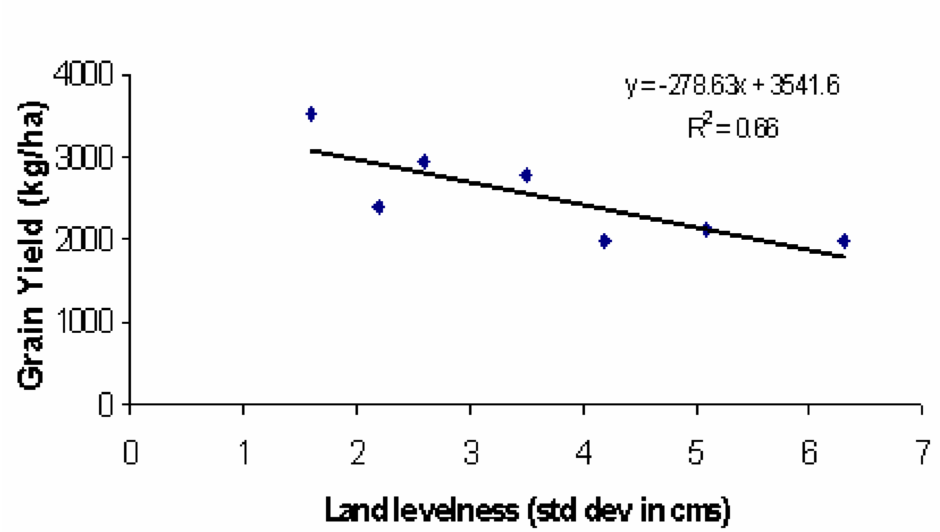
Land Levelness

The variability in land levelness within a field will have a major effect on crop management and crop yields. Uneven fields require more water to wet up the soil for land preparation and plant establishment. Uneven water coverage often results in uneven crop stands, weed problems, uneven ripening and uneven yields within each field.

The average unevenness (i.e. the difference in height between the highest and lowest portions of the field) in Asian rice fields averages 160mm with the range from 70mm to 330mm. This means that an extra 80mm to 100mm of water, or up to 10% of the total water requirement to grow the crop, must be stored in the field to attain complete water coverage.

Crop yields are also improved by leveling the fields. Each 10mm of variation in the surface topography reduces grain yield by approximately 280kg/hectare.

Figure 1. Crop yield as affected by land levelness



Water use efficiency has also been improved by using water from higher fields to wet up, establish, and secure crops in lower fields.

Water quality

Good quality water is necessary to maximize crop growth. The rice plant is susceptible to salinity especially at the seedling stage and during the panicle development stage from panicle initiation to booting.

During the seedling stage, the effects of salinity are vegetative and fairly visible. “Firing” of leaves and reduced dry matter production being the most obvious. The effects of high salinity during panicle development are less obvious as there is little leaf effect but florets and grain numbers per panicle are reduced which greatly effects yield.

The following table highlights acceptable levels of pH, salinity and potential levels of ion toxicity.

POTENTIAL PROBLEM	UNITS	NO PROBLEM	SLIGHT TO MODERATE PROBLEMS	SEVERE PROBLEMS
pH	no units	6..5-8.5	<6.5;>8.5	<6.5;>8.5
Salinity - ECw	dS/m = mmol/cm	<2.0	2.0-2.6	>2.6
Salinity - ECe	dS/m	<3.0	3.0-3.8	>3.8
TDS	mg/l	<450	450-2,000	>2,000
Specific ion toxicity				
Sodium - SAR	no units	<3	9-Mar	>9
Chloride	me/l	<4	10-Apr	>10

Boron	mg/l	<0.7	0.7-3.0	>3.0
Bicarbonate HCO_3^{2-}	me/l	<4	>4	>4

- ECw = irrigation water salinity
- ECe = Soil salinity as measured on a saturation extract

SAR = Na/(square root(Ca+Mg/2); Na, Ca and Mg in me/

If pH is out of the range (6.5-8.4) but is combined with low salinity (e.g., < 0.2 dS/m) then there is not likely to be a problem as the water has very low buffering. However, additional checks should be pursued for possible nutrient imbalance.

The most likely problem with abnormal pH's is equipment damage as the water can be corrosive.

Reference:

University of California, 1993, Integrated Pest Management for Rice, 2nd Edition,
State-wide Integrated Pest Management Project,
Division of Agriculture and Natural Resources,
Publication 3280

Measuring Water Flow

The measurement of water flow can be done in many different ways. Some of the more common devices used are :

- Inline water flow meters. As the name suggests these are placed in the outlet pipe and record water flow by measuring the number of revolutions of a propeller or turbine in the water stream. These often have both analogue and digital readouts and can store data
- Weirs. Rectangular and V notch weirs are very commonly used to measure open channel flows and as the name suggests record the height of water flowing over a rectangular or V shaped weir. The flow rate is then calculated using a predetermined algorithm
- Inflow water wheel. (e.g. Dethridge wheel) Water wheels are often used to measure flows in large channels. Flow rates are determined by measuring the number of turns of the wheel over a given time period. Different sized wheels are used according to the volume of water flow.

Water Balance

The water requirements of a rice crop can be calculated by using simple water balance models. A typical water balance model showing the different inflows and outflows in a paddy field is shown in figure below.

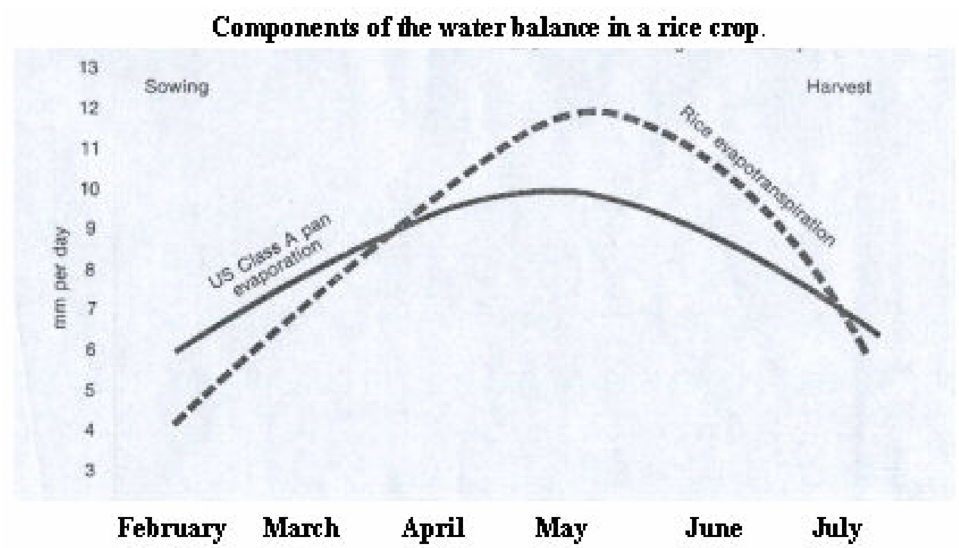
The model can be described by the following equation:

ERI + I = ET + P + S + SD + CWS

where:

ER = effective rainfall
I = irrigation supply
ET = evapotranspiration loss
P = deep percolation loss
S = seepage loss
SD = surface drainage or run off loss
CWS =change in water status

The inflows into the equation, which are the irrigation supply and the effective rainfall, make up the total water supply. Each outflow such as evaporation, deep percolation, seepage and runoff represents water used in the field. The change in water status is the residual water in the field after all the other inflow and outflow components have been considered. In the equation all components are expressed in the same unit, normally mm of water.



Components of the water balance in a rice crop.

Rice Water Terminology

Some handy conversions for water management are:

1 megalitre (ML)	1 hectare covered to a depth of 10 centimetres (cm)
1 megalitre	0.83 acre oot or 1 acre covered to a depth of 10 inches (25 cm)
1 acre foot	1.25 megalitres
1 hectare	2.5 acres
1 revolution (rev) of a 12 megalitre per day (5 cusec) dethridge wheel for 24 hours	1.23 megalitres or 1 acre foot
1 revolution of a 12 megalitre per day dethridge wheel	enough (normally) to supply 8 to 10 hectares(20 to 25 acres) during January to early February

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