DRAINAGE PROBLEMS IN THE PADDY FIELDS

By :

Sigit Supadmo Arif*

Introduction

Cultivation of rice is adapted to a variety of agrohydrological conditions. Van de Goor (1974) classified those conditions such as : (1) unpland, (2) low land, (3) deep water, (4) semi-floating water, (5) double transplanting, (6) mars rice and (7) the combination upland-lowland rice culture.

This array of different types of rice cultivation demonstrates the great adaptability of rice to a wide range of ecologic and more specially hydrologic conditions, so the role of water in rice cultivation is a dominant one.

The lowland or wetland rice both irrigated and rainfed conditions are estimated approximately three quatters of the world rice area (Pande and Pande, 1974) and about 70% of the total rice area in humid tropical Asia (Kush, 1984).

Even the wetland rice cultivation lies in widespread areas in the Asian Humid tropics, but is risky in many areas in the wet season due to frequent tropical cyclons and consequent flooding problems. Over 25% of 126 million hectare rice lands in Asia suffer excess water problems in rice culture (IRRI, 1982; IRCN, 1974).

A specific feature of lowland rice culture is the maintenance of a layer of water on the field throughout most of the growing period of the crop, this unique characteristic is often misinterpreted as if drainage is not important for rice culture. Moreover, the issue of drainage in rice irrigation systems has tended to be neglected because the immediate effects on production output of efficient drainage, or the lack of it are not easly seen like those in irrigations.

The consequences of poor drainage are obvious : land gets flooded for suffuciently long periods to disrupt cropping schedule and farming activities, flooding reduces crop yield or may totally destroy the crop, and it may render cultivation impossible at the onset of farming season (Agua and Rust, 1985).

Those consequences mean substansial economic losses not only to farmers, but also to the community and even to the country in general. Since rice is the staple foods of the most developing countries in Asia and Africa, reduction in yield of rice and land productivity due to drainage deficiences should be a great concern

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*Staff member of Dept. of Agricultural Engineering Gadjah Mada University, Yogyakarta.

to those involved in rice irrigation and drainage development.

Growth of Rice and Water Management

The period of rice growth is generally divided in two distinct sequential growth stages : vegetative and reproductive (Yoshida, 1981; Nishio, 1983). Furthermore, the reproductive stage can be subdivided into preheading and postheading periods. The latter is better known as the ripening. However, according to Yoshida (1981), agronomically it is convenient to regard the live history of rice in term of three growth stages : vegetative, reproductive and ripening. The vegetative stage refers to a period from germination to the initiation of panicle primordia; the reproductive stage, from panicle primordia initiation to heading and the ripening period from heading to maturity.

A 120-day variety, when planted, in a tropical environment spends about 60 days in the vegetative stage and 30 days each in both the reproductives and ripening stages. To ensure satisfactory growth and high yield it is necessary to practice suitable water management at each of those stages.

Based on the results of previous workers, Bhuiyan and Undan (1986) stated four cultural practices of wetland rice needed good drainage facilities, i.e :

a) *Land preparation :* between plowing and harrowing, the paddy field is generally flooded with 2 — 4 cm of water to prevent the soil from drying and hardening. Extra water must be drained to bring the land to a final puddled condition.

b) *Crop establishment :* after transplanting, the puddled field is maintained for about 3 days at saturated conditions or with a thin layer of water over the soil.

c) *Crop maintenance :* from about three days after transplanting until 10 — 15 days before harvest. Modern varieties of rice in heavy soils need a standing water of about 5 cm deep and 5 — 10 cm deep for traditional tall varieties to reach the best yields.

d) *Pre-harvest (terminal) drainage :* surface water is drainage about 10 — 15 days before harvest for uniform and timely ripening of grains and to facilitate harvesting.

Drainage Problems in the Paddy Fields

The basic problems in areas with drainage problems is the presence of water in excess, which restricts or reduces crop production. Many drainage problems can readily be identified by investigating the surface conditions. Water-logging, salt deposits, sticky top soil and injury or death to crops can be readily identified as problems associated with overabundance of water. However, on the other hand, some problems due to excessive subsurface water such as rising watertable, salinity in the root zone and diseases in the plant roots may not be readily identifiable to drainage problems (Bhuiyan and Sahni, 1980).

Moreover, Bhuiyan and Undan (1986) classified major types of drainage problems in paddy fields (as : (i) intermittent or seasonal flooding; (ii) waterlogging within irrigation systems during major part of season or year; (iii) prolonged waterlogging in soils with nutrient deficiency (or toxicity); and (iv) excessive water on soil or high soils-moisture for upland crop culture.

In humid tropic regions, the major excess water in paddy field are due to a) rainfall, b) river flooding, and c) local flooding in irrigated land (Agua and Rust, 1985; Bhuiyan and Undan, 1986). When rainfall occurs and it falls on saturated land with the rainfall rate greater than percolation rate, a high proportion of rainfall will remain on the land surface unless it can be removed. The situation is complicated by the high intensity and large volume rainfall associated with tropical storms, so the natural drainage channels are generally inadequate to cope with the volumes of runoff derived from the areas and some additional surface drainage infrastructure has to be installed.

In encontering drainage problems due to rainfall, a difficulty will arise since rainfall is varied in space and time. It is very often that rainfall data are inadequate and it will make calculation process of design discharge of surface drainage facilities more complicated. In This case, data generation through a mathematical model is needed prior to come up with design discharge calculation.

In irrigated lands, very often inundation occures due to improrer system design and management. Rao (1982) reported that in Sundarbans, West Bengal, India, waterlogging hampered increasing of productivity, nearly 70% of the area was having standing water more than 15 cm depth through out the crop season with maximum depths around 60 cm. The operation of sluice gate situated in the protective embankment benefits only a limited area of the catchment. Gadjah Mada University (1986) found of arising of drainage problems in some irrigation areas in Ponorogo, East Java, Indonesia due to be unsuited irrigation channel design with the operation of irrigation system. In Hirakud Ayacut, India, a development new irrigation system caused an increasing waterlogging problems in the area due to improper irrigation water distribution system and very high seepage losses increased watertable depth in downstream area (Lenka et al, 1974).

Lack of water management in the irrigation system such as improper operation and maintenance (O&M) of both irrigation and drainage cause inadequate drainage channel capacity and lack of drains and outlets. Those will create serious drainage problems in the area. The ill-drained areas in North coastal plain of Java and some regions in

UPPRIS, the Philippines, are examples of drainage problem due to improper O & M of the system (Storsbergen and Bos, 1981; NIA, 1983).

Inundation in irrigated land also some times are due to flooding from the adjacent river. The mode of flooding in the river plain depends on several factors, including the overall lenght wise gradient of the plain, the rainfall regime of both the plain and the watershed area, and the degree to which the riverbed and adjacent levees have been builth up in relation to the lower basin areas (Moorman and van Breemen, 1978).

In some areas in the particular watershed, floods generally follow heavy rainfall. Deforestation of upper part of watershed Causes a great convertion value of rainfall to runoff. In the Bicol River Basin, the Philipines, on the annual basis, about 58% of the total rainfall is converted to runoff (NWRC, 1978). This phenomenon becomes more seriously since deforestation also causes erosion, uncontrolled sedimentation and siltation in natural channel. Those processes can reduce the capacity of the channel as found in the Philippines and North coast plain area of Java, Indonesia (Undan et al. 1987; Storsbergen and Bos, 1981). Reducing capacity of the channel is also due to man made obstruction and bad maintenance of river dikes. Another type of flooding is groundwater induced flooding. This type of flooding occures in the area, where groundwater lies very close or at the ground surface. Under that condition it is not possible for water to percolate in large quantities and most rainfall remains ponded on the land surface. The watertable depth may fluctuate due to several factors. In irrigated area, increasing watertable may due to heavy seepage in both canal and paddy fields, over irrigation in undulating topography and improper water release and distribution system. Drainage problems in Hirakud Ayakut, India, and PB VII/PB VIII tertiary bloks in Cikeusik Irrigation Scheme in Cirebon, West Java, Indonesia, are examples of this kind of flooding (Lenka et al, 1974; Arif, 1989).

Effect of Excess Water in Rice

The most important effect of drainage problems in paddy fields is in the reducing rice yield. The extent of waterlogging in the field may directly reduces the rice yeild by influencing rice plant physiologic or in directly through creating unfavourable physicochemical soil properties to the plant growth.

If flooding occurs during early growth phases it will cause a trouble. Applying a deep water in tillering stage may not only suppress the development of tiller but also supress the growth of stems and leaves and the issuance of roots (Nishio, 1983). A study conducted by Plant Physiology Research Institute of the Academy of China Sciences, indicated that the parts of the plant above ground surface decomposed while cultivated under submerged conditions for 6—10 days during tillering stage, but the growing point and the tillering node tissue did not die. After drainage was applying, new leaves and tillers could grow out again. During booting stage, pollen and anther could be killed if submergence excess 6 days. More harmfull is done as submergence depth and timing increase (Zhang and Si-tu, 1987). Deep water during panicle formation results in sterility and smaller panicles.

Experiments in IRRI as reported by van de Goor (1974) showed that when 20 days old seedlings of an IR variety were submerged to a depth of 35 cm, 80% of the plants survived 6 days of submergence. The survival rate after 8 and 10 days was 50%, and after 12 days was 25%.

Undan (1978) reported that the decreasing of yield of inundated rice crops varied from zero for partially submerged to 100% for fully submerged ones. Those results were depending on stage of growth and time of submergence.

Drainage System for Rice

To control permissible water layer in corresponding rice growth, two types of drainage method have already known, i.e : surface and subsurface drainage. Most of waterlogging problems in paddy field is solved by applying surface drainage method. However, in the particular area, subsurface drainage may play an important role to proceed a high yield of rice. A shallow surface drainage system may be combined with a subsurface to provide groundwater table control (van de Goor, 1974).

In evaluating the drainage problems and determining type of drains, several items are very important to be considered. Those are : soil, topography, source of excess water and the hydrologic interrelationship of the area with major water cources (Bhuiyan and Shani, 1980; Zhang and Si-tu, 1987).

In surface drainage method the excess water is transported out from the suffered field through the ground surface by particular channels. Open channels is usually applied in that purpose. Generally surface drainage system is composed of three kind of channels, i.e : (1) field drains or field lateral; (2) collector drains, whose function is to collect water from the feild drains and to transport it to the main drains; (3) main drains, whose function is to transport then water out of the area (Wesseling, 1974). Natural channels are very often used as the main drain in several irrigation system in Indonesia (Dept. of Public Works, 1986). Drainage of surface water at field level is usually done through the bunded paddy fields. Higher fields easily discharge excess water through the gaps in the dikes to the lower fields.

The depth-duration-frequency analysis of rainfall is needed to be applied in expecting drainage design discharge. Rainfall events with recurrence interval of 5 to 10 years are commonly used (Kessler and de Raad, 1974; Agua and Rust, 1985). Storsbergen and Boss (1985) used 5 years time period to determine design discharge of drains in coastal plain of Java. While in the Philippines, the terminal drainage fasilities in the National Irrigation System were built based on 10 years reccurrence intervals (Mercado. 1978). Also in flood prone area due to runoff, frequancy analysis of depth of runoff has to be done to proceed the drainage design discharge. Unfortunately, it is very often the runoff data are lack or may not available. In that case, theoretically, the runoff data can be generated by developing a conceptual simulation model of rainfall-runoff relationship if the rainfall data and the physical characteristics of watershed and other necessary data are available.

Beside the technical and physical aspect, the design discharge also has to satisfied the economic feasibility. Dahmen (1982) proposed that the design criteria also should consider operational and financial aspects.

A perfect drainage in most cases is not economically feasible since full protection of the paddy fields again flooding may be too expencive. So, it is a usual practice to allow a certain amount of water pounding in the field during a certain period. And the design discharge rates for drainage facilities are chosen such that the design flooding event will not allow pounding of water in the rice fields beyond a selected depth and duration (Bhuiyan and Undan, 1986; Park, 1973; Dahmen, 1982). The allowable submergence depth and time differ greatly related to the variety and crop growing stage.

A several workers reported about the designing drainage discharge for flood protection which be used in some Asian countries, those values of discharge were determined based on the choise of the design flooding event, depth and duration of submergence considered allowable. In Japan, the allowable submergence can be as 0.3 m deep for 1—2 days and at frequency of once in 10 years. By those assumptions, generally 4—6 lps/ha of drainage requirement is recommended for farm drainage design (Park, 1973). In UPPRIS, Philippines the recommended design channels is 8 lps/ha in the tributary level and 12 — 15 lps/ha in the main drains with 10 years return period (NIA, 1983). Van de Goor (1974) reported that the design criterion used for the Chao Phya delta in Thailand was 5.32 lps/ha for tertiary drainage channels on a 3 days rainfall at least once in 10 years. Whereas in the irrigation projects in Indonesia and Malaysia, the average drainage canal capacity was 7.3 and 6.5 lps/ha respectively, based on a rainfall of 5 years recurrence interval.

Subsurface or internal drainage is defined as removal of excess moisture or water downward and/or lateral throught the soil profile (Krutkun, 1966). In the particular area, subsurface drainage plays the important role in getting the high yield of rice. In China, during 1984—1986 the average yield increased by 0.42 t/ha by appliying subsurface drainage (Zhang and Si-tu, 1987). Subsurface drainage is also practiced to provide possibility operation of farm machineries, to control soil moisture and watertable for secondary upland crops and to leach salt and other toxic matterial in saline and alkaline soils (Rao, 1981; Narayana et al, 1981; Tabuchi, 1985; Dieleman, 1980).

As like as surface drainage method, subsurface drainage system is also composed of three kind of drains : field lateral, collector drains and main drains. Open channels can be used as all of three drains. The disadvantage of using open channels as drains, their occupy a large area of cultivated land and hamper the operation of farm machienaries in the fields. To encounter those problems, buried pipe or mole channel can be used as field lateral drains and collector drains. The drainage pipes can be ceramic, concrete, asbestos cement or plastic. Water enters through the joints and some pipes are perforated. Proper depth of installation also is determined by soil permeability, depth to the impermeable sub-soil and the equipment available for installation (Si and Zhang, 1985).

One disadvantage of applying subsurface drainage is a great amount of nutrient may be lost through percolation process.

Information Related to Drainage Alleviations

In considering to overcome the drainage problems in paddy field, information and analysing of type and causes of the problem are important. Bhuiyan and Undan (1986) and Undan et al (1987) proposed two kind of strategies which may can be used to improve the productivity of paddy field with drainage problems, ie : (i) the development related strategies and (ii) the management related strategies.

The development related strategies also can be termed as "Engineering solutions" to the problem. These strategies will provide new infra structure facilities for flood protection and removed of excess water. Lack of good quality topographic and hydraulic data are often considered as a limiting factor in the design of flood protection and drainage fasilities.

The management related strategies often require no physical design of drainage infrastructure or to focuse on more managerial solutions. It will depend on some aspect considerations such as : economical, financial and even social.

Experience from Thailand in developing the Greater Chow Phraya basin showed that it has been uneasy task to encounter the social aspects (Kaida, 1978).

Conclusions

The issue of drainage problems in paddy field has tended to be neglected because the immediate effects on production output are not easyly seen as those of irrigation. This is true since most of the Asian tropics are not traditional drainage concious countries, so, the knowledge of important of drainage to the rice growth and yield of farmers and irrigation management organizer are limited.

To overcome the drainage problems in paddy field, information of sources, type and development process of the problems are important.

Two strategies or approaches in related to alleviate the drainage problems in the paddy fields have been proposed, i.e : The engineering solutions or development related strategies and the management related strategies. There is no easy answer to the question of whether to select among of the two strategies. To proceed with the best decision other aspects such as economical, financial and the social should be considered.

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