15. SOME ASPECTS OF FARM WATER MANAGEMENT IN MALAYSIA

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Introduction

Two significant features have characterized the development of irrigated agriculture in Malaysia during the past 15 years or so. The first is the harnessing and use of water resources for the cultivation of a second crop of rice on a large-scale in the dry season, and the second is the development of the high yielding varieties adapted for local planting. These, together with certain important measures designed to promote rice cultivation have resulted in the rapid increase in rice production to the extent that Malaysia is now fast approaching the threshold of self-sufficiency in this staple food. However, the full potential created by the recently completed major irrigation projects and the advent of the HYVs has yet to be exploited fully as the average yield in many of these projects at present is still well below what the HYVs are capable of producing. A key factor for improving upon the present yield level lies in the improvement of the standard of management and control at the farm level of water made available by irrigation projects.

Farm water management in the context of increasing productivity must of necessity be related to the physical conditions in which plants grow, and in most cases will entail substantial investment in additional works in the form of on-farm irrigation and drainage facilities. The pertinent aspects concern the change in the requirements for water distribution and control, the knowledge of water requirements for rice cultivation as well as on-farm drainage requirements, the development of on-farm facilities and its effects on future development of irrigated agriculture. It is proposed to discuss these in general terms in this paper.

Change in Requirements for Water Distribution and Control

The majority of the wet rice growing areas are established on coastal plains where the conditions are suitable for the flooding of the paddy field over large areas. Elsewhere paddy is grown, to a very much lesser extent, on the alluvial bottoms of low-land valleys below the 30-meter contour. Prior to the advent of double-cropping, the crop was grown during the wet season and irrigation was only required to supplement rainfall so as to ensure a reliable water supply throughout the growing season. Irrigation schemes constructed for this type of operation comprised facilities for conserving water largely derived from rainfall and for diverting, or pumping from, a nearby river and distributing the supplemental irrigation water to the rice fields.[1]

The system is relatively simple: water is conveyed through a canal system to distributaries from where it is passed on to the adjacent fields through a number of unregulated offtake pipes. Thereafter the water is passed further on from field to field. Such schemes are thus operated for continuous supply of water to all parts of the field at the same time, and field offtake pipes are installed to cater for the

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[1] See "Irrigation Development and Present Status of Farm Warter Management in Malaysia" by the same Author.

high water requirement during the presaturation period at the beginning of the irrigation season. The supply is not reduced thereafter though water requirement for normal irrigation will be much less than presaturation. In practice, it is more convenient to drain off excess water rather than to adjust the supply. Furthermore distribution is easier as excess water is available to make up for the high field losses caused by passing water from field to field in a long chain.

Distribution of water in the fashion as described above is left entirely to the farmers and often is not done in an organized manner. In-field water control is achieved by means of field bunds, the maintenance of which varies according to the ease with which water can be obtained. Thus field bunds in areas receiving the benefit of irrigation are rather neglected. In contrast, such bunds are usually well maintained in areas which are dependent largely on rainfall. As for the efficacy of water control, little difficulty is experienced with supplying water to lower fields, but for higher fields there may be difficulty in maintaining the required depth of standing water. Thus the lower fields are sometimes flooded with a greater depth of water in order to effect a supply to the higher fields. The effects of this are excessive water use, late supply to the higher fields and deep water layers in the lower fields. Notwithstanding these short-comings, this system of irrigation had worked reasonably well on the whole with the wet-season crop for which the so-called traditional long-term varieties were planted and when irrigation was required to supplement rainfall and sufficient water could usually be obtained from rivers.

For double-cropping, the second crop must necessarily be grown during the dry period of the year when the rainfall is less and is less dependable. Apart from the need to construct storage dams, major diversion works or pumping installations on major rivers, it has also been necessary to adopt a more positive system of water distribution and control in the fields. This change in requirements has been due to several reasons. Firstly, water supply for cultivation in the dry season is not available in unlimited quantity, and the high field losses which occur in the former system of irrigation are no longer acceptable. Secondly, for successful double-cropping, the planting activities must be completed within the time period available. Irrigation water must be supplied to the fields according to the planting schedule. The practice of passing water on from field to field over long distances tends to take far too long a time to complete the presaturation process with the result that the activities for one crop extend into the time period of the next crop. Thirdly, the HYVs are more susceptible to flood and drought damage: for optimum yield, better control of water depth is necessary.

Improved water distribution and control will require the provision of on-farm irrigation and drainage facilities which must be operated accordnig to water requirements and drainage requirements.

Water Requirements

In rice irrigation, water is applied first to saturate the soil and then to establish a layer of standing water. It is also applied to make up the various losses. The water requirements may be considered for two separate phases, i.e. the presaturation phase and the normal irrigation phase.

Presaturation may be defined as the process during which water is supplied to the fields to wet the ground to saturation and to establish a layer of standing water to facilitate land preparation and transplanting. During this phase, water requirement is the highest and this is for:—

(i) making up evaporation loss,
(ii) making up percolation loss,

(iii) saturation of the soil, and
(iv) establishing a water layer in the field.

Evaporation takes place constantly from both saturated and unsaturated soil surfaces. In drained soils, it is conceivable that at the beginning of an irrigation season there is a higher proportion of unsaturated soil surface, which reduces as presaturation takes place. For practical purpose, evaporation from unsaturated soil may be regarded as constant and under the climatic conditions in Malaysia is taken to be 4 mm/day. As for the evaporation from saturated soil, observations have shown that evaporation from the flooded field bears a certain ratio to that of pan evaporation (Standard Black Pan used by the Drainage and Irrigation Department, Malaysia) and this is 0.7. Given therefore the pan evaporation of a locality the evaporation from saturated soils can be calculated. Typical values range from 5 to 6 mm/day.

When there is standing water in the field, water loss may occur through percolation to the subsoil and through the subsoil to a natural or artificial drainage way. The loss depends on the permeability of the soil strata. Recent investigations[2] show that for the two main rice soils in Malaysia, there exists generally an impermeable layer just below the soil layer which supports the rice plant. In alluvial clays, there is a well-developed impermeable layer which effectively reduces percolation to a negligible amount, while in marine clays, the impermeable layer is generally not very well defined and is ineffective in reducing percolation. However, as this latter group of soils occurs on coastal plains which are little if any above high tide level, and as it is the normal practice to close all drainage gates during presaturation to prevent loss of water, percolation is in effect reduced to a minimum. It would appear then that in general percolation in major rice soils in Malaysia is little.

Field trials[2] have indicated that for the major rice soils, up to 120 mm of water are required to bring the soil moisture to full saturation. Whilst it may be possible for rice to grow well in saturated soils without any standing water, this condition favours weed growth. In practice, given the uneven ground levels and the high costs for other forms of weed control a standing water layer of 5 to 15 cm seems to be an optimum as depth greater than 15 cm or so appears to have an adverse effect on the yields of the new varieties.

At the start of irrigation, most of the water supplied will be used for saturating the land and only a small portion of the supply will go to maintain the water layer already established above the saturated soil. However, as presaturation continues, and a bigger area of the field becomes saturated, the greater portion of the water will go to maintain the water layer in the field until towards the end of the presaturation period all water is required to maintain this layer.

Thavaraj has attempted to relate mathematically the rate of water supply to the presaturation period and the various factors affecting water requirements,[3] thus:—

$$q=\frac{L-Eu}{1-e^{\frac{-T(L-Eu)}{F}}}$$

where q = rate of water supply in cm/day
L = sum of evaporation loss from a saturated soil surface and percolation loss in cm/day
T = presaturation period in day
E_u = evaporation from an unsaturated soil surface in cm/day

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[2] Reference 1.
[3] Reference 2.

F = sum of water depth required for saturating the soil and the standing water depth in cm.

Once presaturation of the field is completed, irrigation supply will be required to make up the loss of water due to evapotranspiration. This is the phase of normal irrigation. As there is no lack of soil moisture in a flooded field, the process of evapotranspiration is governed largely by climatic conditions, mainly the amount of solar energy available for evaporation. In Malaysia, this varies only slightly over the country. Soon after transplanting evapotranspiration comprises mainly of evaporation and little transpiration. As the plant develops, transpiration increases as evaporation decreases until the rice plant fully develops vegetatively when evapotranspiration consists mainly of transpiration. Notwithstanding this reversing situation, the sum of the two is fairly constant throughout the growing season. In Malaysia, this ranges from 5 mm to 5.5 mm per day.

Whereas during the presaturation period, field losses can be brought to a minimum due to the fact that the land undergoing presaturation can be discerned quite readily and the water directed accordingly by closing or opening the "gaps" in the field bunds, such losses are relatively difficult to control once presaturation is over. For this reason a fairly high allowance must be made for field losses during the normal irrigation phase. It is usual to allow as high as 50% or more to make up for such losses.

Drainage Requirements

Drainage in rice fields is required to meet two specific requirements:—

(i) Removal of excess water due to run-off after a storm to prevent total submergence of the rice plants;

(ii) Draining-off of irrigation water for soil regeneration and mechanized farming.

Insofar as the design of drainage system capacities is concerned, this is governed by the first requirement. This is because of high rainfall intensities resulting in large volume of runoff. In some of the major rice growing areas, the maximum recorded 24-hr., 48-hr., and 72-hr. rainfall exceed 580 mm, 980 mm and 1,230 mm respectively. During irrigation season, when the land is completely saturated, there can be no allowance for the reduction of runoff from the rice fields. With such high rainfall intensities, it is not practicable to provide a drainage system so that submergence can be prevented at all times. Rather the system capacities are so sized that the submergence damage can be reduced to an acceptable limit. The present drainage standard requires that floodwaters due to a 5-year storm be evacuated within 72 hours.

Once irrigation is over drainage of the fields is considered important for aeration and regeneration of the soils whereby oxidation of the harmful reduced substances formed under flooded condition can take place. This is especially so in the case of rice soils under double-cropping and an effective system of on-farm drainage becomes essential to ensure that the regenerated process can be completed within the off-irrigation period.

Another important aspect of drainage relates to the preservation of soil bearing capacity to permit continued mechanized ploughing. In double-cropping areas, labour shortage and the need to prepare the fields for transplanting within a relatively short period of time have necessitated the increased use of tractors to prepare the land for transplanting. Evidence[4)] exists that repeated tractor ploughing of rice fields

[4)] References 3 and 4.

under prolonged saturated condition has resulted in the progressive weakening of the soil bearing capacity. The subject has been under investigation and initial findings have indicated that the deterioration of soil bearing may be averted by a process of effective drainage which must be artifically induced during the off-irrigation period. Investigations continue with regard to the practical methods of effecting the process of rapid drainage of heavy clay soils during this period.

Development of On-Farm Facilities

The development for on-farm irrigation and drainage facilities has stemmed from the need for proper water management. Water shortage, late supply of irrigation water and excessive depth of standing water can cause considerable yield reduction. This is especially true of double-cropping with the short-stemmed high yielding varieties. Effective water distribution and control will ensure high yields for both the wet-season and dry-season crops. Furthermore, efficient water management will permit the management of rice soils with a view to their regeneration for continued cultivation and the introduction of mechanized farming.

In Malaysia, there are less than 10% of the existing paddy lands where the farm lots are parcelled out in regular rectangular shape. These lots are mostly 2 ha in size and are found in the more recently developed paddy areas. The tertiary canals and drains are set at 400 m or 800 m apart. With each farm lot fronting the canal at one end and the drain at the other, the ratio of the length to the breadth of the rectangular is high. Two typical layouts of the tertiaries and the farm lots are shown in Fig. 1 and Fig. 2. Fig. 1 shows the case where the terrain is sloping and the drains collect water from one side only. The tertiary drain of an upper block runs parallel to, and is separated by a farm road from, the tertiary canal of a lower bolck. Two adjacent farm lots share a common offtake from the canal. Because lots slope from the canal to the drain, field bunds at right angles to the common lot boundaries are required to be built at suitable distance apart such that the standing water depth in the fields can be maintained within the range of 5 to 15 cm. For better and more efficient water control quaternary canals and drains should be constructed alternately along the common boundaries.

When the terrain is relatively flat, the tertiary drains and canals are set at 400 m apart, in which case, the tertiary canals supply water to both sides. Similarly, the tertiary drains also collect water from both sides. Note the size of the farm lots are less elongated in this case.

The majority of the farm lots in Malaysia are very irregular in shape and size. Existing irrigation and drainage facilities may serve blocks varying from 10 ha to 1,000 ha within which irrigation water is passed on from field to field. In the absence of a land consolidation and large-scale land levelling programme, the layout of on-farm facilities within these blocks must necessarily conform to topography and, to some extent, boundaries of farm lots. A typical layout developed on this principle is shown in Fig. 3. As a rule, quaternary canals are located on ridges or levees while drains in depressions, and where possible also sligned along common boundaries. By means of separate quaternaries the block is divided into several sub-blocks which can now be irrigated independently of one another, so that rotational irrigation can be practised. The irrigation system capacities are sized to permit completion of presaturation within the period as desired.

A pre-requisite for proper water control and management is the installation of measuring devices in offtakes and other structures to facilitate control and regulation of irrigation supply to the fields according to requirements. Such measuring devices form an integral part of on-farm facilities and require adequate treatment in the planning and design of the on-farm system.

Prospect of Irrigated Agriculture through On-Farm Development

The object of irrigation development has always been to increase the agricultural productivity. Large-scale development of water resources for rice double-cropping has greatly increased the cropping intensity of existing paddy lands and hence their productivity. On-farm development will no doubt further enhance this productivity.

Double-cropping has contributed much towards lifting the rice farming community from the position of agricultural subsistance to that of agricultural production. On-farm development offers an opportunity to incorporate in it a development strategy in that it can be instrumental to the evolving of a system whereby the farmers in the benefitted area can further increase their income both at present and in the future. This would mean that the option exists for the choice of design criteria which will ensure an optimum development on a short-term and allow adaptation to future developments, i.e. the design should be such that it has the potentials of modern irrigated farming. Taking the present stage of on-farm development a step further, the layout of the on-farm facilities should permit mechanized farming, multiple-cropping and crop diversification. The successful development of such a system will involve social and economic considerations in addition to consideration of physical conditions. The acceptability by the farmers and their ability to take full advantage of the system will greatly influence its viability.

References

1. FAO Report No. 1671: Consumptive Use of Water, Possibility of Double Cropping, and Irrigation Requirements for Rice Lands in Malaya.
2. S. H. Thavaraj: Presaturation of Padi Fields.
3. Shigeo Yashima & Kaname Ezaki: Agricultural Engineering Study on Weak Foundation in Muda Irrigation Project.
4. Hisao Anyoji: Report on Weak Soil Foundation in Paddy Fields.

Question and Answer

H. K. Pande, India: What is the slope of the land? Whether the length of the lot has some relationship with the slope and the size of the stream for irrigation? Whether the lots shown in your slide were further being divided with bunds while paddy being grown.

Answer: In Malaysia, the slope of paddy fields varies. On the coastal plains, this ranges commonly from 1/1000 to 1/5000. As flood irrigation only is practised, no direct relationship has been established between the length of the farm lots and the size of the stream. However, the farm lots are subdivided by field bunds (border ridges) for purpose of maintaining the desired standing water depth.

J. A. Lewis, Sri Lanka: In your formulae in page 7, don't you agree that the rate of discharge each plot q should be depended on. How much rate a farmer can handle with the hoe and non erosive q? Firstly a q should be tried in the field and the other parameters determined in formulae.

Answer: The formula is used to calculate the field water requirements for presaturation. It is not used to determine the discharge to individual plots of paddy field as such.

S. I. Julian, Philippines: Do I understand that q for presaturation period is being used for the design coval capacities, which in our experience is the period for peak water demand. May I have some of your views behind the use of said formula?

Answer: Yes. It is the experience in Malaysia that the peak discharge in irrigation canals occurs when water is supply for presaturation, and this is used as the design criterion for canal capacities. The formula has been developed taken into consideration the various factors that influence water losses in the paddy field, and is a rational one.

S. Okabe, Japan: Regarding the scheme of on-farm development you have described that the option exists for the choice of design criteria, envisaging both of the short-term and long-term developments. Who would make a final decision in adopting any appropriate design; the government authority, the farmers' group or association or the joint committee consisting of the government officials and the farmers' representatives, or other body?

Answer: This is a planning concept. The adoption of any design should be subject to the acceptance by farmers. Pilot projects are considered to be an effective way of testing the acceptability of a design, and farmer's views are assessed through informal group discussion.

K. Sugimoto, Japan: When do you stop the irrigation supply to the paddy field? As for irrigation charge, tell me roughly which dept. does collect the water charge? Who does pay such water charge either landowner or tenant? I remember there are three grades in water charge depending on paddy productivity. If you know, tell me the present water charge per acre per in a certain project area?

Answer: Irrigation supply is normally withdrawn about two weeks before harvesting. The collection of irrigation water rate is the responsibility of the Collectors of Land Revenue. Irrigation water rate is paid by land owners. The current water rate for the Muda Irrigation Project is M$8/-per acre per annum.

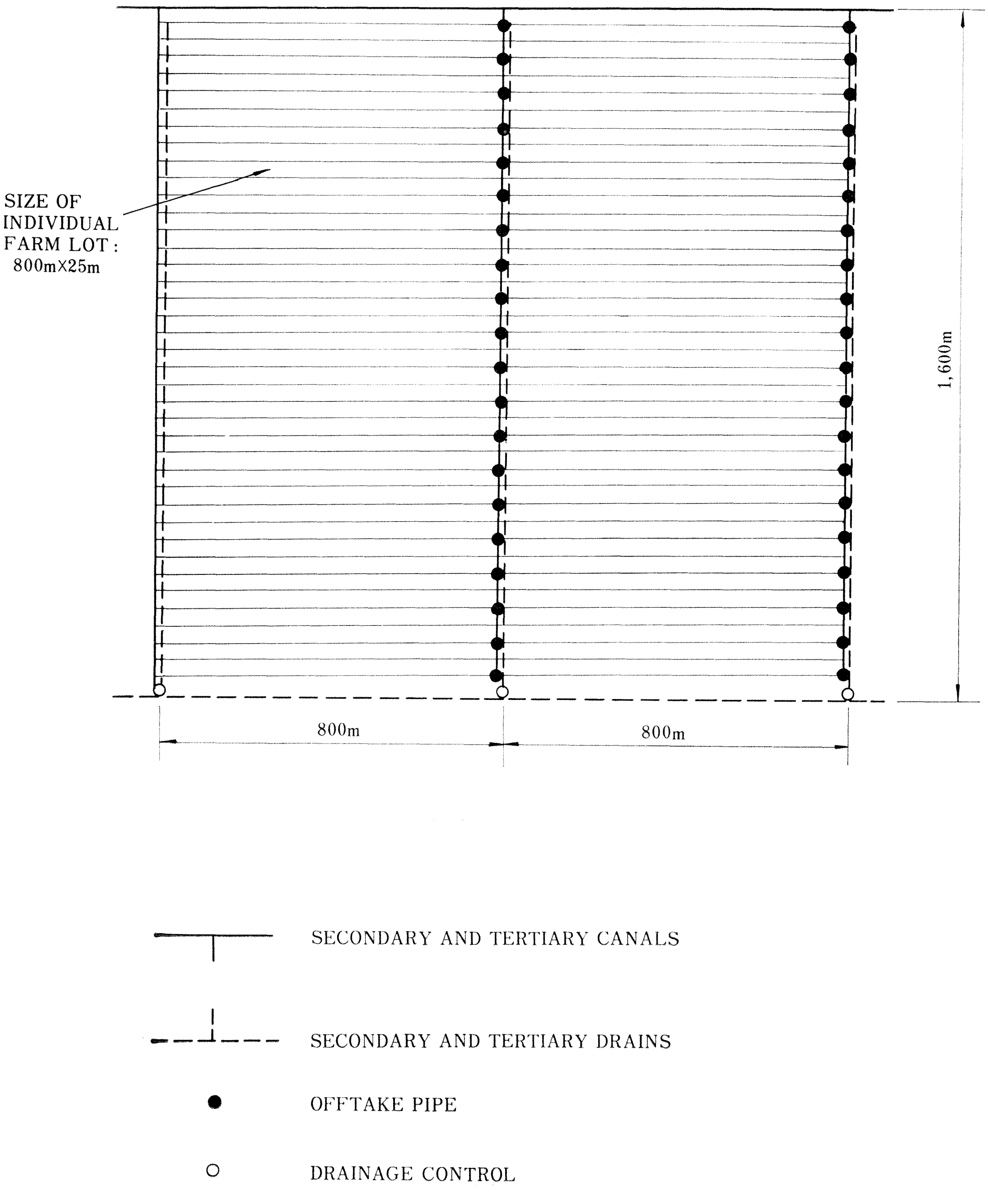
SIZE OF
INDIVIDUAL
FARM LOT :
800m×25m
1,600m
800m
800m
SECONDARY AND TERTIARY CANALS
SECONDARY AND TERTIARY DRAINS
OFFTAKE PIPE
DRAINAGE CONTROL

Fig. 1.

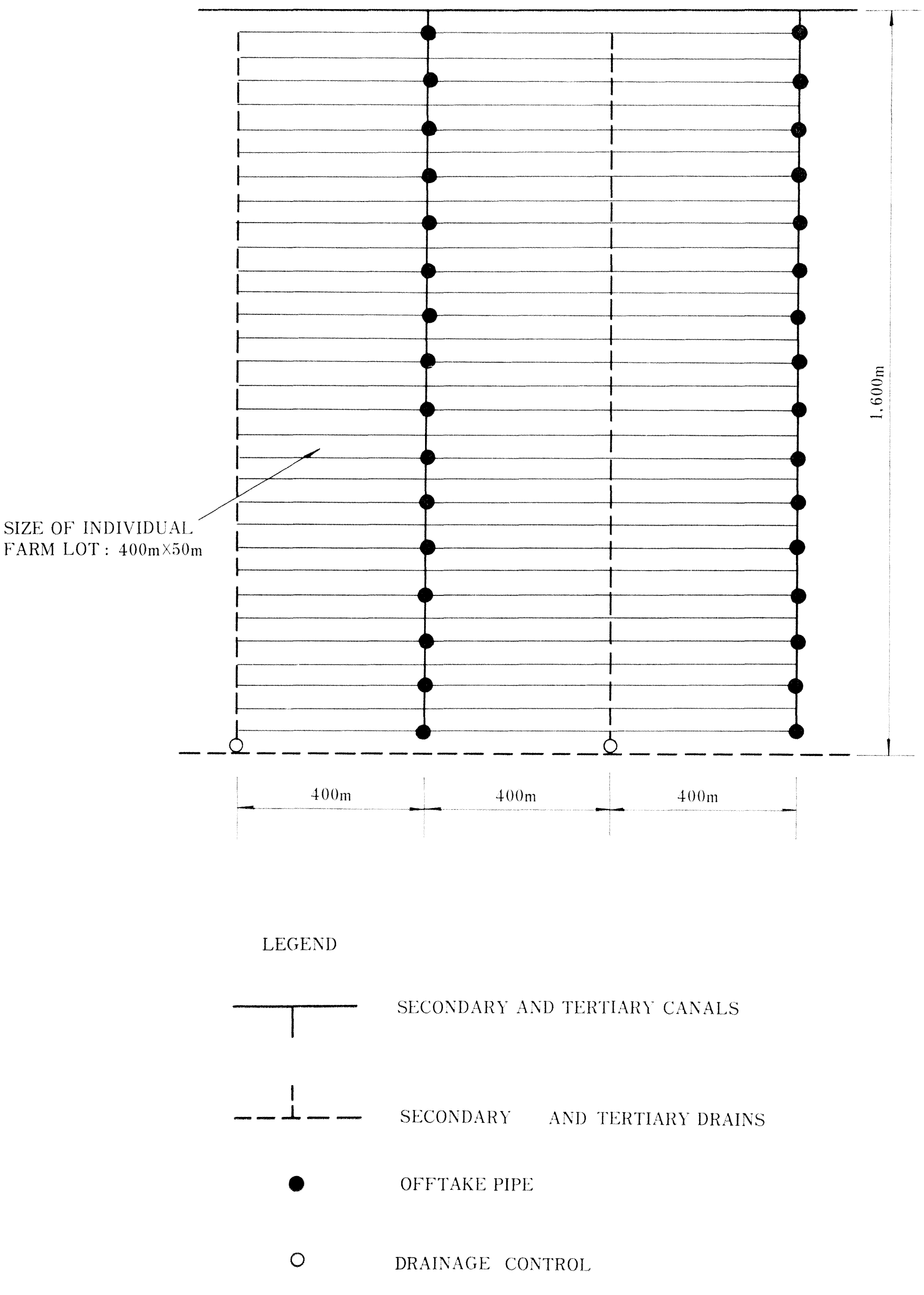
SIZE OF INDIVIDUAL
FARM LOT : 400m×50m
1,600m
400m
400m
400m
LEGEND
SECONDARY AND TERTIARY CANALS
SECONDARY AND TERTIARY DRAINS
OFFTAKE PIPE
DRAINAGE CONTROL

Fig. 2.

Fig. 3.