PRACTICES FOR YEAR AROUND IRRIGATION IN MAHAWELI SYSTEM B

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CHAPTER 1

1. Introduction

Year around irrigation water to farmers forms a good foundation for promotion of cultivation practices that consider price trends of markets. The traditional cultivation practices are based on two seasons (Yala and Maha) identified on rainfall patten. The seasonal crop production practiced through out the country creates market gluts and lower prices specially for non-rice crops. A good example is low price for the big onion occurring in August and September every year. It has also become standard practice to operate irrigation systems to facilitate paddy cultivation with a view to maximize efficient use of rainfall. As consequence of operation of irrigation systems, cultivations periods are confined to 4 to 5 month period per season and there are two off seasons of about one to two months in between yala and Maha seasons. Irrigation system managers use the off seasons to attend to maintenance of irrigation canals. However, this short length of cultivation season limits opportunity available for the farmer to plan non-rice crop (or Other Field Crops (OFC)) production considering the price he gets from markets available. Naturally, farmers are discouraged to produce non-paddy crops when it is difficult for them to obtain reasonable price for their products. This situation can be easily overcome by scheduling plating considering available markets and prices. But, it is important as well as necessary to create conditions that help farmers to decide and start planting when they feel time is right. As a first step, the farmer need to have access to all inputs that his cultivation require. Irrigation water is one such input that the farmer requires for successful crop production. Hence, availability of irrigation water at any time to the farmer forms a good foundation for crop diversification.

System 'B' farmers have a relatively dry period of ten months from Jan. to Oct. where non-rice crops can be successfully grown. Thus, they have an opportunity to get the highest price available in the market by scheduling planting to suit market windows. Further, they can undertake to supply vegetables on a regular basis on an agreed price throughout the year. In this scenario farmer will be employed gainfully in his farm throughout the year. He also could provide employment to at least two or there persons on full time basis. In contrast, when paddy cultivation is considered farmer is employed only four months of the year during planting and harvesting period. Providing irrigation water on a year around basis to farmers would create two most important conditions among many other advantages. One, a market oriented production (cultivation practices) and the other, full employment at his farm throughout the year.

Year around operation of the canal system, however, limits the time available for maintenance or repair works that becomes necessary during operations of the canal system. Hence, MARD project first conducted a study to identify factors that could prevent operation of canal system on a year around basis. It was subsequently established that maintenance practices of main irrigation system can be improved to accommodate supply of irrigation water to System 'B' farmers. This report presents the observations and recommendations of the studies conducted in system B to promote availability of year around irrigation for farmers willing to grow non-rice crops during off seasons.

2. Background

It is an accepted fact that paddy cultivation is not highly remunerative to the small farmer. But, non-rice crop cultivation is very attractive in terms of income and labour absorption potential both on and off the farm. However, it is necessary to avoid market gluts of certain crops usually occurring at the end of yala and maha seasons. A success and sustainability of crop diversification programs depends on the number of farmers cultivating OFCs with due regard to the price available at the time of selling their products. Otherwise, farmers are discouraged when they receive a marginal profit by selling their products. In order to promote market oriented crop production, irrigation water should be made available whenever farmers require it, like any other input. Then, it becomes necessary to operate the canal system throughout the year to provide water to farmers who require water during the off season. When it was first proposed to operate the canal system provide irrigation water to farmers on year around basis, it was necessary to have good answers to the questions listed under the objectives. The MARD Project also conducted a number of studies to collect data and to form recommendations for year round cultivation through increasing flexibility of irrigation water supply and better management practices in Mahaweli System 'B'.

3. Need for Year Around Irrigation

Year around operation of irrigation systems is practiced with great success in many parts of the world and specially southwestern United States. As an example, the Colorado river which originate in the Rocky Mountains of Colorado is one of the extensively used rivers in the world and 48,000 Ha. of land in the U.S. and Mexico are irrigated with the Colorado river water and year round irrigation is practiced since the irrigation system was constructed and operated (i.e was about 90 years ago). This system provide the irrigation facilities to some of the most productive irrigated areas in the US which included the Coachella valley water district imperial irrigation district etc. In Coahella valley water district a large variety of crops such as lettuce, cauliflower, broccoli, cabbage, melons, carrots etc. are grown successfully on year round basis (Schaack, 1991).

To maximize the economic returns from the physical and human resources of Mahaweli areas the Mahaweli Authority promotes diversification of agriculture into the cultivation of cash crops for domestic and export markets and development of related processing, packing and other industries. Providing irrigation water on year around basis will accelerate the anticipated development of Mahaweli Projects. For example. cultivation of horticultural crops like grapes or any crop that has a growing period extended beyond a season need irrigation during dry periods without interruption. Further, even for short duration crops like okra and baby corn need to be planted on staggering dates to ensure continuous supply and hence, require water during off season for paddy. It is also possible to increase cropping intensity when irrigation water is available throughout the year. The MASL accepted as a policy to provide irrigation water to farmers in System 'B' on year around basis after considering the reasons forwarded by MARD project. Hence MARD project continued its efforts to create conditions favorable to promote crop diversification on a year around basis in System 'B'.

4. Definition

When the topic of year around irrigation was discussed among professionals of various fields they perceived the concept in a number of different ways, Some of them assumed that irrigation water was to be provided for an additional crop season (Meda Kanna) in between two traditional seasons. Many of them thought that it was an extension of normal water issue dates. A few of them perceived it as promotion of cultivation of crops on the same land without a fallow period. It is therefore necessary to define Year Around Irrigation. It is operation of canal system to supply water to farmers who need to irrigate non-rice crops during the normal close season for canals on request. Usually, requests for water from farmers during the off-season for canals are not entertained. Hence, this an extension of a facility to farmers. However this facility will not be provided for rice cultivation.

5. Objectives

Traditionally, irrigation water has not been provided to farmers in Sri Lanka on a year around basis. But providing this service to System 'B' farmers would greatly increase the farmers potential to increase their productivity and income. Further, practicing 12 months irrigation is a challenge since it is to break the conventional (traditional) irrigation and cultivation practices base on monsoon cycle. It is important to identify all possible constraints and recommendations to practice year round cultivation successfully in Mahaweli system B. The following aspects contribute substantially to the decision of promotion of year around cultivation and hence require detail discussion on each topic to identify limitations.

1. Availability of water

2. O&M of irrigation system.

3. Crop rotations.

4. Soils and climate

5. On-farm development methods.

6. Motivation of farmers

7. Effects on environment

The general objective of the report is to provide information, observations and conclusions on each of the above topics with special reference to System 'B' conditions. The specific objective is to provide answers to the following questions.

1. Is there sufficient water available to System 'B' to provide water on year around basis?

2 Will farmers waste more water when water is available on year around basis?

3. Can MEA maintain the canal system without emptying the main canal for routine maintenance works annually?

4. Is it necessary to inspect the canal lining annually to ensure safety?

5. Can minor repairs be done without emptying the main canal?

6. Could MEA could operate and maintain the main canal system on year around basis?

7 Are there suitable crop combinations for year around cultivation ?

8 Will year around irrigation create water logging problems in the system?

9 Will it be possible to train farmers to practice a year around cultivation

In addition to the availability of water it was also required to access suitability of climate, soils, crops available and on-farm irrigation infrastructure. This report presents answers to the above questions in detail and advantages and disadvantages of practice of year around cultivation.

CHAPTER 2

AVAILABILITY OF WATER

1. Introduction

This chapter looks into the availability of water to System 'B' and whether there will be sufficient water for all the lands in System 'B' if a large percentage of farmers adopted year around cultivation program. In this chapter the data obtained from field trials conducted at Mahadamana unit with year around irrigation water are analyzed and discussed. The data from the Mahadamana trails proves that farmers would not waste water when water is available on year around basis.

2. Availability of Irrigation Water

When addressing the feasibility of year round cultivation it is important to consider the irrigation water first. Rice and other field crops differ by their water requirement in terms of volume and scheduling. According to the report published by **ACRES INTERNATIONAL LIMITED** on Studies of Operating Policy Options of Mahaweli Systems, there is a possibility of cultivating 100% paddy /paddy for two seasons in system B. A simulation period of 32 years was considered for this study. The proposed irrigable area excluding zone 4B "drop off" area is 38,200Ha. The **ACERS RESERVOIR SIMULATION PROJECT** shows that cropping intensity of 2.0 in the full project area could be supported with adequate reliability .(ACRES ,1985). It can, therefore, be concluded that there is sufficient water for two seasons for paddy cultivation.

The Annex I of this report shows that non rice crop cultivation of one hectare on year around basis saves almost 33 % water allocated for paddy cultivation of one hectare for two seasons. More specifically, cultivation of one hectare of non rice crop saves 10000 cu.m of water. The operation of main canal for addition two months of a year require only 7,464,960 cu.m of water to compensate for additional distribution losses of the main canal system. This amount of water can be saved by cultivation of 746 hectares of non rice crops when total extent under cultivation is 38200 Ha in System 'B'. Until the total cultivated area of paddy reaches 37,454 (38,200 - 746) Ha. there will be sufficient water in System 'B' to practice year around irrigation.

The original assumption of 38,200 Ha irrigable area is based on an assumption that there will be 24,000 Ha. in Left Bank and 14,000 Ha. in Right Bank of System 'B'. According to the latest structural plan the irrigable area under the left bank main canal is only 22,000 Ha. So, total area of System 'B' will not exceed more than 36,000 Ha at the completion of total development. Hence, the answer to the question:

Is there sufficient water available to System 'B' to provide water on year around basis?

is YES.

The total cultivated area of System 'B' is nearly 13,000 Ha. As a result the project has more water than it required at present. Hence irrigation engineers of the project have not taken adequate steps to achieve the recommended levels of water use. According to Table 1 of Annex 1 excess water use during yala season is about 43 percent. It cannot be assumed that water use will not remain at this level. Otherwise full development of the project cannot be justified. The filed trials conducted at Mahadamana Unit confirmed that the estimated water requirements can be achieved. Hence, for this study it is assumed that water use will come down to the acceptable levels. So, effect of the present higher water use was not analyzed. However, cultivation of 746 Ha. of non rice crops saves enough water required to balance the canal water loss occurring during extended period of canal operation even under the present level of water use by farmers.

3. Field Trials

It was argued that farmers would waste water when it was freely available on demand under year around irrigation as farmers used more water even under normal conditions. Hence, it was required to study the on-farm water use and irrigation scheduling when both OFC and paddy are cultivated in a turnout with full flexibility of water issues. It was also necessary to study to response and performance of farmers when the concept of year around cultivation was introduced. A special study was, therefore, initiated in 1991 yala season. Mr. Neil Bandara, Deputy Resident Project Manger at that time included additional objectives to cover agricultural aspects in addition to irrigation objectives. He published the finding of the study in a report titled ' FEASIBILITY STUDY ON YEAR ROUND CULTIVATION IN SYSTEM 'B' (MARD Project Report No. 214). The study continued till the end 1994 Yala season to refine recommendations for on-farm development methods.

3.1 The area of study

The special study was conducted in the turnout no. 66 of Mahadamana unit of Ellewewa Block in System 'B'. The field canal of the turnout was fed by the distributory canal SD5/D1/101 staring from a small reservoir called Jayanthiwewa. The reservoir received from branch canal LB - L1. The study area was selected considering the following reasons.

i. The turnout area can be provided with irrigation water during off season as it is fed by a domestic tank.

ii. The study area has a moderate land slope up to the drainage canal and hence lands are suitable for OFC cultivation.

iii. Easy access to Aralaganwila Regional Agricultural Research Station. Hence, it is easier for research officers to visit the area to advice on agronomic problems that would arise.

iv. Farmers agreed to cultivate OFC on year round basis according our schedules.

There are 11 paddy lots in the T.O.66. (Fig.1). Only ten farmers could participate in the research program as one of them had leased out his farm at the beginning of the program.

4. Observations on Water Use

An attempt was made to determine the water issued to each lot in Mahadamana trials for the 91 Yala and 91/92 Maha seasons. The results are summarized in the Tables 2.1, 2.2 and 2.3. These results show that the maximum consumption of water at the field (i.e for Lot No. 1) was 1.44 m/ha for the Yala season, and 1.32m/ha for the Maha season. The area cultivated with OFC during Yala season was 2,72 ha or 30.3 % of the study area. The average water duty of the project area during the season was 2.48 m/ Ha. during the season when the recommended value was 2.00 m/ha. When allowance for distribution loss are included, highest water duty at the study area becomes 1.80 m/ha. Hence, cultivation of OFC has reduced water duty by almost 10 % when other farmers in project used 24 % more water. When average value of 1.3 m/ha is considered, farmers of the study area have saved about 1.0 % from the recommended amount of 1.71 m /ha (Ref Annex I). The results showed that farmers would not waste water when properly educated and guided. This results provides the answer to the question;

Will farmers waste more water when water is available on year around basis?

The study shows that farmers will not waste water. Monitoring of water use during the subsequent seasons also confirmed the water use was reasonable and within acceptable limits in the study area. However, observations on use of irrigation water in System 'B' reveals that wastage of water is considerably high. As the results of the study conclusively proved that farmers did not waste water, it can be assumed that farmers will not waste when water is available on year around basis.

The other interesting observations which contribute to waste of water are as follows. A common problem observed in most of the turnouts was the unequal distribution of water in the turnouts

(Table 2.1 to 2.3). This is because, the head enders gets more water than tail enders. In this study too it was noted that the head end fields drew more water than the tail end fields. As these trials were closely monitored and farmers were trained on water distribution in turn outs, there was no water deficit problem and the cultivation was successful. This shows the tendency to draw more water,

TABLE 2-1 WATER ISSUES IN MAHADAMANA TRIALS
1991 YALA SEASON

Period:From 91.04.30 To:91.08.25

PLOT NO.	TOTAL DISCHARGE IN(L)	TOTAL DISCHARGE IN(CU.M)	HEIGHT IN (M)/ha.
01	14430000.00	14430.00	1.44
02	14150000.00	14150.00	1.41
03	13050000.00	13050.00	1.30
04	-	-	-
05	12550000.00	12550.00	1.26
06	12103000.00	12103.00	1.21
07	11810000.00	11810.00	1.18
08	12005000.00	12005.00	1.20
09	13100000.00	13100.00	1.31
10	13800000.00	13800.00	1.38
	Ave.Duty		1.30

TABLE 2.2 WATER ISSUES IN MAHADAMANA TRIALS 1991/1992 MAHA SEASON

Period:From 91.09.08 To:92.01.17

PLOT NO.	TOTAL DISCHARGE IN(L)	TOTAL DISCHARGE IN (CU.M.)	HEIGHT IN (M)/ha.
01	13200000.00	13200.00	1.32
02	12900000.00	12900.00	1.29
03	12100000.00	12100.00	1.21
04	-	-	-
05	12300000.00	12300.00	1.23
06	12205000.00	12205.00	1.22
07	-	-	-
08	1235000.00	12350.00	1.23
09	127000.00	12700.00	1.27
10	126500.00	12650.00	1.26
	Ave.Duty		1.25

The water issues at the head gate of FC 66 from 01st May 91 to 30th April 92 are given in Annex I. During first five weeks of the yala season, continuous issue of various discharges were released through the FC 66 and farmers did their land preparation during the period. The maximum discharge through the field canal according to the head gate reading was 0.0286 m3/s which is equivalent to 1.02 ft3/s. After the period of continuous water issues, a 4 day rotation was practiced in the field. The water table was maintained between 0.3m and 0.35m in the OFC grown areas.

In 91/92 Maha season, farmers managed to minimize the land preparation period by organizing Vapmagula (ploughing ceremony). All the farmers did their ploughing in their paddy fields simultaneously. This proved that land preparation can be completed with in three weeks. This was very helpful to minimize water wastage in paddy lots during the land preparation period.

The study found that distribution loss of the field canal was as high as 16 % of the field water requirement. According to the results of water issues done through the turn out structure during 1991 Yala was 1.61 m/ha (Annex I). When compared with the field water usage of Yala season (Table 2.1) the conveyance loss of the canal during 91 Yala season was about 19% of the field water requirement. Similarly for 1991/1992 Maha season water issues done through the turn out was 1.49 m/ha. When compared to the field water requirement (Table 2.2) the loss of diversion in the field canal was about 16%. In the case of 1992 mid season water issues through the turn out was 0.944 m/ha. When compared to the field water consumption the loss of diversion in this season was about 16%. However, condition of the field canal was good and operational losses were negligible. Hence, these excess canal seepage losses need to be considered in estimation of water duty for the project.

An another aspect of this study was to maximize use of rainfall to reduce irrigation requirement. Unfortunately rainfall was not considerable during the yala season until the cultivation was over in this area other than the third week of July 91. Hence entire Yala season had to completely depend on the irrigation water supply. The rainfall figures in the years 1991, 1992 in this area is shown in the Table 4.1. But, a considerable amount of rainfall was experienced during the Maha season. At the beginning of the season itself there were few showers but that was not significant and effective. Hence in the first one and quarter month, there were continuous water issues for land preparation and soaking. After that a 3-4 day rotation was started. Depending on the amount of rainfall, its effectiveness etc. the water issues were done at the turnout. Monitoring of water table depths were very helpful to decide the time to issue water to the fields. The highest rainfall of 339.9 mm was experienced in the last two weeks of the year and during this period the water issues were completely stopped (Ref. Annex A1).

This indicates that rainfall could be effectively utilized for cultivation purposes to save irrigation water at the field level. At the tail end of the Maha rainfall period, rainfall was experienced intermittently till the third week of January 1992. Following that there was a long dry spell. In the case of 1992 mid season there was no significant rainfall and farmers had to totally depended on irrigation water supply.

The Yala water duty of Ellewewa block was 3.05 m and the total duty of the entire project was 2.86 m (Table 4.4). Water consumption as per head gate reading of FC 66 in 1991 Yala season was 1.61 m (Annex A1). When compared with Mahadamana trial results, the percentage wastage of water in Ellewewa block in 91 Yala season was about 50%. When compared with the entire system the percentage wastage of water was about 43%. On the other hand under average rainfall condition paddy needs 1.8 m during Yala season (Source - RARC Aralaganwila). This shows that there was a considerable loss of water at system level.

In the case of 1991/1992 Maha season the water issues through the head gate of FC 66 was 1.49 m (Annex I). This was about 10 % higher than the water duty recommended to cultivate paddy in Maha season (i.e. 1. 3 m). The Ellewewa block duty for this season was 2.278 m and the system water duty for 1991/1992 Maha season was 2.28 m (Table A1.2). Hence, the percentage loss of water at the block level and the system level against Mahadamana trial water duty was 57% and 83% respectively. The above analysis shows that there was considerable loss in water consumption at block level as well as system level. Even though the water duties in Mahadamana trials were relatively lower than the water duty of Ellewewa block for these particular seasons, the crops in the trial area did not show the usual drought effect due to water inadequacy. Water adequacy was evident from the high yields obtained in the trial area.

Other important observation by this study was the cultivation of other field crops in the paddy fields under irrigation during Yala and Maha seasons and its contribution to water consumption. The effect of growing non paddy crops is illustrated with respect to five selected crops which were successfully grown in the trial area with paddy during the 1991 Yala season and the 1991/1992 Maha seasons are indicated in Tables A1.3 and A1.4. There were substantial differences in field water requirements between rice and non rice crops. For example, under average rainfall conditions the field irrigation requirement of rice was 1.8 m. (Source RARC Aralaganwila). The quantity of water issued for different crops grown in the trial area is only 0.64 m/ha. A paddy crop, therefore needs almost three times of water compared to the cultivation of other field crops. This indicates that the cultivation of other field crops contributed to the saving of water in the Mahadamana study area.

According to the above obse:rvations, the Mahadamana trials showed that the water conservation in Maha and Yala could be used prcvide water during off season.

CHAPTER 3

OPERATION AND MAINTENANCE OF CANAL SYSTEM

1. Introduction

Under the year round irrigation, a variety of crops can be grown in a calendar year on the same piece of land in sequential manner (Ref Chapter 4). Similarly, crops may be grown in the field by staggering the cultivation period to ensure a uniform supply of produce to market throughout the year. It is intended to supply irrigation water to suit any cropping pattern that the farmer decides to adopt in his field. Hence, it will become necessary to operate the irrigation system to match with the demand generated by complicated crop rotations. This chapter looks into the operation and maintenance practices required to increase flexibility irrigation water supply.

2. Feasibility of Operating the Irrigation System

All major irrigation systems in Sri Lanka are operated in a manner that there are two canal closure periods of about one to two months soon after each cultivation season. Irrigation Engineers use these periods to attend to maintenance of irrigation canals. When a irrigation system is operated on year round basis compared with partial year service, there will not be a canal closure period for the maintenance works. Hence, it would require development of special O & M procedures. The MARD project obtained service of Mr. Jerry Schaack, a well qualified engineer from US to study the feasibility of operating the irrigation system on a year around basis. Mr. Schaack says in his report " I am confident that System 'B' can also be operated to provide year around irrigation water service in an effective and efficient manner. This very likely can be accomplished at about the same cost as partial year operation and with no decrease in system efficiency and with equal or better system integrity". His report discusses the practices, polices, and procedures which should be implemented for successful year around irrigation service on System 'B' lands. Based on the recommendations of the report the MASL accepted as a policy to provide irrigation water to settlers and commercial farmers of System 'B' on a year round basis (Ref. Annex 2, page 1).

3. Operational Procedures

As pointed out in the previous section, the irrigation system can be operated on a year around basis. The irrigation system can be divided into four main components, namely, field canals, distribution canals, Branch canals and main canal. The operational procedures of the canals are described in detail in the O&M manual for System 'B'. These procedures are quite adequate for year around operation even thought they were developed for seasonal operation. The responsibility for the operation and maintenance of field canals lies with the water users. The special study conducted at Mahadamana showed that training and guidance were required to minimize excess use of water for paddy cultivation at the field canal level.

3.1 Field Canals

Each farmer in system B is allocated a one Ha. plot of agricultural land that can be used for either paddy or other field crops. Each plot directly receives irrigation water from the field channel through a farm turnout. All farm plots in the field canal receive irrigation water simultaneously and continuously during the land preparation and crop establishment stages of paddy cultivation. During the crop development phase, water is delivered on an intermittent irrigation schedule. Then irrigation frequency, rate and duration of delivery can be changed during the season as required. Rice and other field crops differ by their water requirements in terms of volume and scheduling. As paddy requires less water than OFC, the irrigation system can supply adequate water for diversified crops under the present conditions. Further, the field canals can be operated to irrigate any combination of paddy and OFC.

The farm turnouts are not designed as a self flow control structure. Hence, fluctuation in water levels of the field canals results a severe flow distortion through individual farm turnouts. Wooden planks are provided to divert and check water in the field channels. However, farmers are not using them correctly and as consequence, it leads to water management difficulties and wasting of water. According to the present design, controlling flows through the farm turnouts are not practical without cooperation of the farmers. At the design stage it has been assumed that farmers would play a major role in water distribution along the field canal. Hence, it is necessary to have well organized farmer groups at the field canal level to achieve the effective distribution of water in the field canal. As the farmer organizations are developing at a rapid rate in System 'B', it is assumed that farmers will be able to manage water in the field canal. The cooperation of farmers to distribute water is required even for seasonal operation. Moreover, participation of farmers in distribution of water is essential to prevent excess use of water. Rainfall causes the ground water table to rise and damage upland crops. Hence, water issues need to be stopped whenever heavy rainfall occurs to prevent crop damage as well as to save water. This will also will not be a problem, as it can be easily coordinated with the MEA O&M staff.

The above discussion proves that field canal operation will not pose any problem to year around irrigation practices.

3.2 Distribution Canals, Branch canals and Main canal

The O&M manual describes in detail preparation of Canal Operation Plans for the distribution and the branch canals. This procedures can be followed without any modification. The operation of the above canals will not pose any problem to provide year around irrigation to System 'B' farmers.

4. Maintenance Procedures

Maintenance activities play a important role in deciding the life span of a irrigation project. Many irrigations projects in Sri Lanka experienced rapid deterioration as a result of neglect or delayed maintenance. It is, therefore important to implement the recommendations made by Mr. Schaack on maintenance of the irrigation system prolong the service life of the irrigation system. He pointed out three main disadvantages of the year around irrigation service. They are:

1. Special O&M procedures and equipment will have to be developed to confirm to year around operation, For example, equipment may have to be constructed to do maintenance or cleaning while water is in canal.

2. Timely maintenance will be required during partial and/or major shut down of the canal so deliveries will be interrupted for a minimum length of time. Organized and documented procedures and well qualified personnel are a requirement.

3. Continuity of the O&M program is required rather than an intermittent one.

In the light of above restraints, let's look at the ways and means to face the challenge of maintenance of the irrigation system effectively and efficiently for year around operation. Under normal operation conditions, there is a off season of one or two months soon after each cultivation season and maintenance of the irrigation net work could be accomplished during this period. However, when water issues are done on year round basis there will be a problem for maintenance of the canals as there is water in the canal system to obstruct maintenance activities. It is therefore important is to find solution to the constraints which could be anticipated in future if water is to be issued on year round basis. Otherwise, inequality and inefficiency of distribution may cause problems that require sticking to a rigid rotation or any other pre-scheduled method in irrigation water issues. Then, flexibility required in water issues for year round cultivation cannot be achieved.

The types of maintenance work which need to be attended in the canal system are as follows.

1. Desilting operation in canal beds.

2. Replacement of panels of concrete lining.

3. Cleaning up of weep valves.

4. Repairs to structures.

5. Maintenance of bund roads,side drains etc.

6. Maintenance of other mechanical gadgets such as housings, gates, spindles etc.

7. Vegetative Management

Desilting operation in canal beds-Normally loose materials from the embankment areas, deep cut areas and silt from catchment areas of level crossings and tank catchments etc. will come and get deposited in the canal beds and reservoir beds. This silt deposition will cause to reduce the flow rate and also to overtop the bunds. It is important to work out a program to remove silt with out interrupting the water issues in the canal net work.

The system B LB main canal is designed to convey 64 cumec of water through the canal at it's peak supply. The peak supply of this canal is sufficient to irrigate 32,000 ha. at the rate of 2 lts/sec. continuous supply of water. According to the present figures maximum possible extent that could be cultivated is about 21,000 ha. out of which only 14,000 Ha. is cultivated at present. Hence the total carrying capacity of the canal is not fully utilized. Hence under such circumstances 1 or 2 feet of silt accumulation is not a problem. On the other hand water is conveyed through the canal at a speed of 3 m/sec. Hence silt accumulation in the canal bed is very minimum as the flow is very high. Hence once in five or six years desilting operation in the main canal would be sufficient.

Usually, the distribution canals are kept open all seven days throughout out the season. The off season cultivation under year around irrigation did not exceed 1 % of the command area of a distribution canal during the last two years. Hence, it was possible to supply total requirement within a day. Until the off season cultivation exceeds 15 % of the total area, the distribution canal can be closed for almost five days per week. Hence, routine maintenance can be scheduled during the off season without any adverse effect on irrigation water supply. Alternatively, desilting in the branch and D-Canals could be accomplished during the rotation period. In that case a portion by portion of the canal could be cleaned without affecting the water issues. Hence, desilting in the Branch and D-Canals would not face a challenge to the year around operation as it could be carry out with out affecting the water issues in the field. Further, there is no cost difference in the desilting operation whether the system is operated in partial year or year round basis.

Replacement of concrete panels and repairing cracks-The concrete lining may be damaged, cracks can develop and/or weathering of the concrete lining could occur due to various reasons like uneven settlement, weathering due to heat or malfunctioning of weep valves. Repair of concrete lining require significant changes in procedures for year round operation compared to partial year operations. Equipment needed for these type of repairs has been identified. Even without acquiring new equipment, areas where canal lining needs placements can usually be isolated and dried up by partially lowering the water flow by using either sand bag temporary coffer dams or using fabricated equipment to isolate the area. Sometimes, temporary checks can be used if water deliveries are required on a portion of the canal being repaired. On the very special when the canal need to be dewatered, it should be done during low peak service and in coordination with the water users, probably the Maha season. Mr. Schaack's reported that in the Caochella Valley Water District (CVWD) using fabricated pieces of equipments which they called a "submarine" to work in canal beds. These fabricated pieces provide water tight condition on the lining dry working area for maintenance activities. For maintenance work in LB canal in System 'B' may need such fabricated steel shutters for maintenance work if the water issues is to be done on year round basis.

Cleaning of weep valves-Weep valves are necessary to provide hydrostatic balance to the concrete lining. If they are not functioning properly the concrete lining may crack due to hydrostatic pressure. Hence regular maintenance of weep valves are a must to avoid such hazards. It is observed that in some instances people use these weep valves to anchor themselves by driving a stick into weep valves for bathing purposes. This may be a cause for destroying these weep valves. Continuous stealing of weep valve lids has also become a problem and the maintenance crew has to replace them over and over.

Repairs to structures-There are different types of structures along the main canal, branch canals, distributory canals etc. which are constructed to serve different purposes. For instances regulatory structures are constructed to regulate the water in the main/branch/D-canal and release required quantity of water through a lateral canal during the low flow. Similarly under crossings, off take structures, syphons etc. are important canal structures. Under year round irrigation, maintenance of these structures are very important for long life span of the project.

Special attention should to be given for regulator No.8 and No.9 as there is no spillway arrangements are provided. Hence under flood condition main canal operations has to be dealt very carefully.

Maintenance of bund roads,side drains etc.-In order to operate and maintain an irrigation system at a satisfactory condition the right of way, O&M roads and side drains are to be properly maintained. At present the right of way of the canal system in some areas are encroached and the reservations too are cultivated by farmers and this leads to numerous irrigation difficulties.

Side drains are to be properly maintained to drain out drainage water. If those drainage are not properly maintained excess drainage water gets into canals and over top bunds. This may results to wash off bund roads, canal bunds etc.

The shallow drains on berms adjacent to the main canals are to be cleaned and graded to assure that the water drain out easily as pounding of this water may cause pressure on the lining and consequently cracking and displacements will occur. These ditches should be periodically maintained by removing the sediments and weeds.

Maintenance of Mechanical gadgets-Stealing of gates spares, housings nuts and bolts, gate plates etc. cause the biggest problem in the canal operations and maintenance. Regular greasing of mechanical gadgets, replacing the broken parts and wear and tear units has to be done at regular intervals.

Radial gates and/or other structures will need repair or painting at sometime. These can either be painted or minor repairs done in-place or hoisted from it's position. Major repairs could be done in the work shop. In such cases it is recommended by Schaack to have interchangeable equipments (gates) with the O&M staff for allowing immediate replacement spares.

Vegetative Management-Vegetation in the canals, laterals and ditches may affect the efficient and effective water deliveries in canals. According to the Schaack report 1991,there are some primary problems and they can be listed in the following forms.

1. Vegetation on the ditch banks which restricts or prohibits equipment access and maintenance work.

2. Vegetation on canal side slopes will reduce the canal capacity.

3. Algae or water weed growth can severely restrict the capacity.

Year round irrigation water issues in the LB main canal will result in additional water weed growth. It is observed that the growth of water weeds restrict the flow. Removal of water weeds is very essential for continuous supply of water in the canal. Hence it is suggested to introduce grass crap fish to eradicate water weed problem. Under year round water issues canal will not be dewatered, hence fish can be grown in canals without any problem. Periodic cutting of the grasses on the canal banks under preventive maintenance program is also very important.

5. O&M Management

The key element to efficient O&M program is the preparation of a well planned budget considering maintenance and improvement requirements. The budget should be based on specific needs and projected for several years in advance, as well as for next year. The following items should be considered in establishing future year budget.

1. Preventive maintenance program.

2. Recommendations of the Review of operation and Maintenance Program.

3. Annual on-site review by O & M personnel.

Success of implementation of the preventive maintenance program depends on the budget allocation. Due to financial difficulties of MASL, O & M allocations are dwindled year by year. This is aggravated due to present inflation prevailing in the country. The amount of work that can be done by the allocated amount is reduced day by day and consequently affect the O & M program. In some instances important repairs may have to be postponed due to budgetary constraints. Having a well prepared budget estimate will help to request for more funds for the maintenance.

6. Other Issues

The following four questions relate to the maintenance of the main canal. The report " Operation and Maintenance for year around irrigation of System 'B' by Jerry M. Schaack " published by the MARD project provides information that helps to answer the questions. With the additional information provided in this chapter, answers to the questions are provided with complete confidence.

1. Can MEA maintain the canal system without emptying the main canal for routine maintenance works annually?

During the years 1992, 1993 and 1994 the main canal was not dewatered for maintenance works. Further, the external inspection team that reviewed the O&M program in 1994 reported that MEA O&M staff had maintained the system satisfactorily. If O&M staff implement the recommendations of Mr. Schaack, they can maintain the system to without emptying the main canal for routine maintenance works annually.

2. Is it necessary to inspect the canal lining annually to ensure safety?

The answer is no. Mr.Schaack report gives the details.

3. Can minor repairs be done without emptying the main canal?

The answer is yes. Mr.Schaack report gives the details.

4. Could MEA could operate and maintain the main canal system on year around basis?

MEA operated and maintained the main canal during the years 1992, 1993 and 1994 without any problem. So, they will be able to continue to the O&M practices

Further, Mr. Schaack forwarded the following six main recommendations.

a. From an O & M view point, year around irrigation service is very feasible and should be implemented on System 'B'. A short term consultant should review System 'B' year around operation after its initiation to evaluate and advise on O & M procedures.

   Mr, Schaack inspected the irrigation system again in 1992 and confirmed that O&M practices are adequate and satisfactory.

b. An appropriate management team should go to the U.S. for 3-4 weeks to study year around O & M of irrigation systems.

   Four senior engineers of MEA visited US and studied the improved O&M practices required.

c. A preventive maintenance (PM) program should be developed and implemented using the general guidelines given in this report and its appended material.

   A preventive maintenance program was developed in 1994 and implementation is going on.

d. An inspection and monitoring program should be initiated as discussed in this report. A report titles "Review of O & M of System 'B' Irrigation Facilities" has been written as part of this consultancy to identify and discuss specific problems of System 'B' and other O & M personnel in review of O & M procedures for implementation of this program.

An external team of engineers inspected O&M practices in 1992 an 1994. Two reports are available with recommendations.

e. The surface drainage system should be designed and constructed to provide drainage to all irrigated lands and an investigation should be initiated to identify subsurface drainage requirements and most feasible methods.

Two Short Term Technical Assistance consultants conducted a feasibility study investigate and recommend solutions to drainage problems in System 'B'. The design guidelines for subsurface drains were developed and subsurface drains were tested at three locations in System 'B'. The findings are reported in three separate reports (Doering 1992, Gunawardena 1992 and Gunawardena 1993). The MEA now has required information to design and construct subsurface drains. A main drain improvement program was implemented in 1993 and 1994 by MEA.

f. A review of the O & M of System 'B' irrigation facilities should be accomplished every two years.

The MARD Project assisted MEA to conduct the proposed reviews in 1992 and 1994. The MEA has the capacity to arrange and conduct necessary reviews in future.

This shows that the recommendations have been implemented during the last three years. However minor recommendations related to the following topics have not implemented completely and needs attention.

a) Personnel

b) Equipment Requirements

c) Communications

d) Water Measurements

The readers are kindly requested to read the report of Mr, Schaack and report on " Review of operation and Maintenance of System 'B' Irrigation Facilities - Year 1994 to get more details on the above topics.
It can be concluded O&M staff of System 'B' can operate and maintain the irrigation system to provide a year around irrigation service.

CHAPTER 4

CROPPING PATTERNS

1. Introduction

The last two chapters provided information to establish that there is sufficient water in System 'B' and the irrigation system can be operated and maintained by the O&M staff of MEA for a year around irrigation service. In other words, irrigation water will be available to System ' farmers on demand at any time of the year. However, successful year around cultivation requires a range of crops that can be profitably cultivated in System 'B'. Further, soils, climate, and rainfall have a direct effect on crop production. This chapter looks in to crop recommendations and suitable cropping patterns for year around crop production.

2. Availability of Crops

The Department of Agriculture, Sri Lanka, in its publication "Agro technical Information" had recommended crops according to the agro-ecological regions in Sri Lanka. They have recommended more than 25 crops for Low Country Dry Zone. The Fig 2 shows the crops and suitable planting days for System 'B'. However, selection of a suitable cropping pattern requires knowledge of many factors. The most important factors are the net income to the farmer and the agronomic suitability of the crop combination. Other factors are the judicious selection of crops to prevent outbreaks of pests and diseases and optimization of the use of the factors of production (land, labour, capital and management) and nature's resources (rainfall, sunlight, soil nutrients, day length etc.). The MARD Project used a linear programming models to decide optimal cropping patterns (Dr. Gleason, Report on optimal crop combinations). Mr. Neil Bandara after studying the recommendations (Mr. Bandara, Report on feasibility study on year around cultivation in System 'B') selected a cropping pattern to be adopted in the Mahadamana trail. There are a range of crops that can be cultivated in System 'B' during any period of the year. But a cropping pattern for year around cultivation should extend at least to three years (Fig 4).

3. General Rules Regarding Crop Rotation

When practicing year around cultivation, crop rotations are done in the same field. However, matching the market requirements needs careful planing of crop combinations. The Crop Rotations can be developed to optimize the farm income considering limitations like labour, capital and land. It will also reduce the extent of risk to the farm family, improves the efficiency of resource usage and balances the family dietary system. Further, different crop combinations in the field helps to control outbreak of pests and diseases, improve the soil nutrient contents, and control weeds biologically.

There are many crops other than rice which are easily grown under irrigation and are important for the nutrition needs of the population. They could be listed as, pulses, maize, chillies, onions, fruits and various kinds of vegetables.

Further, a large quantities of pulses, chillies, onions, fruits etc. are still imported. There are crops like gherkins, baby corn and melons can be grown in System 'B' for the export market. Hence it is very important to consider the market and the price at the time of harvest in selection of crop combinations to suit the year round cultivation.

Following factors are to also be considered when deciding a cropping pattern.

a) Field duration.

Field duration is the time from planting to harvest, including nursery time, if applicable. The field duration of a crop is influenced by variety, season, mineral nutrition, and soil water status.

b) Rooting depth.

Rooting depth are classified as shallow (<30 cm) medium deep (30-60 cm), deep (60 -90 cm) and very deep (90 cm). Rooting depth play an important role as for vulnerability to water logging and for soil water availability.

c) Tolerance in water logging

This indicate the crops that grow in aquatic environments, crops which are some what tolerant to water logging (e.g. soybean), intolerant(e.g. butternut squash), and very sensitive(e.g. pigeon pea).(Morris, 1992).

The following types of mixing of crops can be incorporated in cropping patterns,

Mixed Cropping - In mixed cropping, many crops are grown in the field in the same season. Normally the crops are not cultivated in a particular sequence.

Inter Cropping - This is also a system of mixed cropping, however, a sequence is observed in planting the different crops. The different crops are normally row planted in a particular sequence, in order that the plants will optimize the use of the nature's resources.

Relay Cropping - This is again a system of mixed cropping, the difference being that 2 to 3 weeks before the harvest of a particular crop, another crop is introduced between rows of the former crop.

In all these systems of mixing crops in the field, certain important guidelines have to be followed for better crop sanitation, yields and profitability/marketability.

The principle in deciding a crop mixture for year round cultivation is that certain groups of crops which are susceptible or related to same pest or diseases should not follow one another in cropping sequence. All crops could be categorized in following groups.

a) Solanaceous crops- potato, chilli, capsicum, brinjal, tomato.

b) Crucifers crops - cabbage, mustard, radish, cauliflowers, broccoli, beet, kohlrabi,

c) Legumes crops - cowpea, greengram, soybean, groundnut, blackgram, sunhemp

d) Cucurbits crops - melon, gourds, pumpkin, squash, cucumber, zucchini

e) Bulbs - onions, shallots, leeks.

It is advised to include a legume at least once in each year to help supply nitrogen and organic matter to the soils. A short-aged legume crop, such as green gram, grown between high profits and high input crops will enrich the soil while providing profit a modest profit with low inputs. (Sellek and Gleason, 1992)

4. Optimal Times for Planting of Crops

In general, crops can be planted in system B during the periods and in the sequence indicated in Table shown below. Crops in Group A can be followed by any crop in group B and crops in group B can be followed by any crop in group C provided that related crops (those in the same group, as indicated above) do not follow one another.

PLANTING DATES FOR VARIOUS CROPS

Late Oct-Early Jan.	March- April	May-July
Group A	**Group B**	**Group C**
Potato	Greengram	Squash
Chilli	Big onion	Gourds
Capsicum	Red onion	Melons
Beetroot	Tomato	Cucumber
Carrot	Soybean	Brinjal
Groundnut	Okra	Pumpkin
Greengram	Red onion	Baby corn
Paddy	Paddy	Sweet corn
Bushbeans	Cowpea	Watermelon
Cowpea		Zucchini
Brinjal		Silverskin
Okra		Canterloupe
Cabbage		

Source : Sellek and Gleason, 1992

Time of planting and optimal planting periods are indicated in the Fig 2. This was developed from the information taken from the Regional Agricultural Training Center (RARC) Aralaganwila and Department of Agriculture Maha Illuppallama. (Sellek and Gleason, 1992).

4.1 Sequencing of Crop Compbinations

When deciding a cropping pattern to suit year round cultivation it is very important to avoid sequence of crops which will avoid soil-borne pathogens and nematodes which accumulate in root zone. This indicate successive cultivation of the same species or crops in the same family that are susceptible to a given strain of pathogens.

Hence as a general rule, successive cultivation of the same species should be avoided. For example, tomato would not be as susceptible to bacterial wilt as a second potato crop. Capsicum species are more resistant to potato bacterial wilt than tomato. Among field legumes, cowpea is susceptible to root rots, hence there should be at least one season between it another fields legume. Cabbage is extremely susceptible to club root fungus and should not follow other Brassica species. Okra and maize can follow any species without concern about soil born diseases. Paddy cultivation has no effect on bacterial wilt incidence. (Morris and Gleason,1992).

4.2. Crop Alternatives

The criteria for selecting appropriate crop combination depends mainly on economic return, crop water requirements, tolerance to occasional water logging, high incremental production under irrigation over rain fed condition, dry weather to assure quality of products etc. Agronomicaly acceptable crop rotations are listed in the table below.

Late Oct- Late Dec	March- April	May-August
Potato Brinjal	Big Onions Red Onions	Cowpea Squash Gourds Cucumber Okra Pumpkin
Potato Chilli Capsicum Brinjal	Greengram Cowpea Soybean Okra	Squash Gourds Cucumber Pumpkin
Paddy Okra	Big onion Red onion	Brinjal Greengram
Greengram Cowpea Soybean Groundnut	Big Onion Red Onion Paddy	Brinjal Okra Squash Pumpkin Cucumber
Cabbage Beet Carrot	Big onion Red onion Paddy Cowpea	Brinjal Okra Squash Pumpkin Cucumber

5. **Climate**

The climate of System B area is typical of the dry zone of Sri Lanka. This area comes under the region 3 (i.e. dry zone low country DL2 Agro Climatic Zone, Fig 3) with an annual rainfall of about 1750mm. The area is influenced by the North East Monsoon from November to March and south west monsoon from May to October. The North East monsoon brings most of the annual rainfall. The South West monsoon period is typically dry with strong winds. Rainfall in the inter monsoon period is caused by either convection or cyclonic storms. The rainfall fluctuate widely through out the year.

Monthly rainfall totals were had from Aralaganwila for the period of 1984 - 1991, using means and median as indicators of heavy rains during the October - January period. The Data do not show a Yala rainfall spike. (Table 2.2). It shows that except for a very low rainfall in June (Mean=14mm/month), rainfall means for each of the remaining months range from about 50 to 150 mm. As there is not much rainfall in Yala season there is a remarkable distinction between dry and wet seasons and however the rainfall distribution pattern negates the traditional concept that crop production should be limited to Maha and Yala seasons. Hence there is a almost 9 month dry period form mid January to mid October which can be considered as a continuous cropping season.

TABLE 4.1 MONTHLY MEAN AND MEDIAN OF TOTAL RAINFALL AND MEAN DAILY SUNSHINE HOURS FROM 1984 TO 1991

Month	Rainfall mm/month Mean	Rainfall mm/month Median	Sunshine Hours Hrs/days Mean	Sunshine Hours Hrs/days Median
January	285	272	5.4	5.5
February	131	51	7.3	7.8
March	150	145	6.8	7.3
April	101	58	7.5	6.9
May	74	69	7.0	7.8
June	14	01	7.2	7.1
July	93	103	7.2	7.2
August	89	78	7.3	6.9
September	133	150	7.4	7.3
October	172	160	6.8	7.1
November	224	211	5.3	5.2
December	289	201	4.7	4.6

Source : Regional Agricultural Research Center, Aralaganwila

The mean and median sunshine hours/day for each month are also listed in Table 4.1. Except for November to January when the number of sunshine hours/day is about 5, means and medians are both concentrated near 7 hours. Paddy yields responds to high solar radiation, particularly during the reproductive growth stage (especially the last month before maturity) (Morris and Gleason, 1992).

Weekly mean minimum temperature were fairly uniform within 22-250c except for November to February when they were about 2^0c lower. Weekly mean maximum temperatures from April to September ranged between 33 and 37^0c and those from November to February ranged between 28 and 31^0c. Weekly mean temperature changes during the months of March and October were pronounced. The mean daily evaporation appears to follow a typical sinusoidal pattern with highest means of 5.5.6.5. mm/days(Penman El_0) from May to September (when southwest winds are strongest and the sun is north of equator) and lowest means of 2.5-3.5 mm/day from November to January during the Maha season and when the sun if furthest south. (Jensen, 1989).

6. Suitability of Soils in System B for Year Round Cultivation

Extent available for cultivation on year around basis broadly depends on the extent of suitable soils for non rice crop cultivation. Twenty five types of soils are found in the project area (Acres, 1980) and which are falling within six major soil groups. This includes Reddish Brown Earth (RBE). Non Clacie Brown Soils (NCB). Low Humic Gley Soils (LHG). Recent Alluvial Soils(RAL). Old Alluvial Soils(OAL) and Solodized Solanetez(SS) etc. The soils in the upper catena mostly comprises moderately well drained RBE, NCB and upper levee soils. As they are well drained water never logged in the rainy season. Suitability of soils in System B must be considered in the light of the rainfall pattern and the kind and degree of soil limitation. During Yala, when rainfall frequency and intensity is low, factors such as PH, fertility and consistence become increasingly important because excess rainfall does not create a seasonal high water table. Irrigation helps to overcome rainfall deficiency. Drainage and permeability are still a factor, especially if poor irrigation management practices create an artificial water table: but this is of less concern in Yala than during Maha.

During Maha, when rainfall frequency and intensity is high, factors such a drainage, permeability and flooding are most important for determining suitability of soil for OFC production. Mr. P. M. Cauley, Soil Scientist, studied the characteristics of the soils and regrouped the soils into ten Groups according to soil limitations most significantly affecting suitability for non rice crop production. He has considered permeability, depth, drainage conditions and flooding which determine soil suitability for OFC production.

Mr. Cauley estimated that about 15 % of the soils in System 'B' are suitable for OFC cultivation during both seasons without drainage improvements. Further, he says, Soil Groups III and IV, which make up about 15 % of the area, raised beds are adequate to lower the water table and increase the rooting zone sufficiently to create good drainage conditions. There are about 35 % additional area that require intercepter drains in addition to raise beds to cultivate non rice crops during maha season.

Mr. Cauley recommended subsurface drains systems to improve drainage conditions of additional 27 % of soils belongs to Soil Groups VII and VIII. The remaining 8% is not suitable because of flooding or alkaline conditions. As illustrated in Cauley's report on soils of System B. 85% of soils are water legged during Maha season, of which the 50 % are drainable as summarized below.

a) About 15% are drainable using raised beds. (on farm drainage)

b) About 35% are drainable using a combination of on farm intercepter drainages with raised beds (on Farm drainage).

c) Balance 27% require main drain improvement in addition to on-farm subsurface drainages. Otherwise they would be difficult to drain because of lack of outlets and slow permeability.

It can be concluded considering the on farm drainage practices based on soil suitability, a realistic cropping goal would be 65% non rice crops, 35% paddy during Maha season.

The detail soil maps for System 'B' are not available to indicate the Soils Groups. Hence, it is not possible to indicate the farms which have suitable soils for OFC cultivation. The MARD Project attempted to initiate a detail soil survey. However, it was not carried out as anticipated. The soil maps will help to identify suitable farms for crop diversification programs. It is therefore recommended to implement Mr. Cauley's first recommendation; develop a detailed soil survey map (scale 1: 10,000) accompanied by a practical,easy to understand, layman's manuscript, describing important soil characteristics and outlining soil management and cropping practices.

7. On-farm Drainage Practices

It is a prime requirement to provide favorable moisture, oxygen and salt balancing in successful agriculture. Most crops require that the soils root zones remain unsaturated. If water table rises and remains in the root zones longer than 48 Hrs. agriculture production will be seriously affected. Yields of most crops decreases with shallow water tables due to insufficient aeration problems. Hence under the year round irrigation concept the drainage will play an important role.

The system B Mahaweli Project is an area where ground slope of most of the places is less than 3.5%. Soils in this area mostly consists of Non calcic brown (NCB) and old alluvial (OAL) soils which have more than 75% sand. As a result of high sand percentage, basic infiltration rate is very high and it's about 70 mm/hr. This is a higher value compared to 9 mm/hr. for Reddish Brown Soils (RBE). Therefore, rain or irrigation water can easily infiltrate into the soils thus raising the water table. Stratification of soil profile proves that there is a clayey material barrier. Upper layers consist of sandy textured soil while deeper layers have more clay. This deeper layers act as barrier to the vertical movement of water. (Gunawardene, 1992). As a result, poorly drained conditions will require improved drainage conditions for OFC cultivation.

At present most of the main, secondary and tertiary drainage are not properly functioning as the improvements to main drainage, construction of secondary drainage at certain places were not executed at the time of constructing the irrigation net work. This has caused drainage problems like water logging and flooding in certain areas.

Under year round irrigation concept water is conveyed through the canals most of the time and water table may be maintained at a higher elevation. If the drainage water does not drain out properly it will badly affect the cultivation. Such environment will not be suitable for growing of other field crops. Hence improvement to drainage system may play a vital role in year round cultivation.

Drainage improvements could be categorized into two.

1) Improvements to on-farm drainage
2) Improvements to main, secondary and tertiary drainage

The MARD project conducted a special study on on-farm drainage practices to form recommendations minimize crop damage due high water table. The recommendations from the information gathered from the investigations conducted in System 'B' to date are given below.

1) Device technique to remove excess rainfall as fast as possible.

   a) Reorienting the land to have a reasonable slope to facilitate surface drainage.

   b) Keeping the original land slope as far as possible for areas identified for OFC.

   c) Adopting alternative water application methods such as ridge and furrow instead of raised beds.

   d) Providing more opening in the bunds around the basin to facilitate quick removal of surface water.

   e) Laying out the OFC area in such a way to have a surface drainage ditch which could collect surface run off quickly and dispose them to the boundary drains.

2) Instructions to be given to the farmers and MEA extension staff to identify a suitable locations for the cultivation of OFC. A suitable area should have the following characteristics.

   a) Located at the headend of the field.

   b) The elevation difference between the land surface and the ditch bed of the outlet of the field should be more than 1m.

   c) The elevation difference of two meters should be maintained between turn out drain and land surface.

   d) If the bottom land near the drainage ditch is selected for OFC, the minimum elevation difference between the land surface and the water level in the drainage ditch should be 1m. and an interceptor should be constructed above the OFC area.

3) Construction of interceptors

   a) At the boundary to prevent subsurface flow from paddy area, if OFCs are grown with paddy.

   b) Between irrigation ditch and the field if seepage from irrigation ditch contributes heavily were logging condition.

   c) Try to prevent excess applications of irrigation water by practicing recommended water management techniques. Continuous farmer training and demonstration program on-farm water management will ease this situation. (Gunawardane, 1992).

Improvements to main, secondary and tertiary drains is very important to create outlets for on-farm drains to maintain the water table below root zone. The MARD Project assisted a program of clearing of main and secondary drainages.

7.1 On-farm Layout

Well set-out farm layout which includes the on farm ditch, farm drainage and correct lay out and levelling of liyaddes are important requirements for efficient use of irrigation water. The water that enters the farm is conveyed to all parts of the farm in the shortest possible time without causing any ponding up at the lowest point of the farms. For year around cultivation, selection of OFC areas should be done considering the recommendations given in the above section. Farmers should to be encouraged to develop their lands, wherever it is possible, to facilitate removal of surface and subsurface flows effectively. The MEA should provide technical know how to the farmers to form their land with intercepter drains at correct locations to suit the field conditions.

Cultivation of non rice crops needs good drainage conditions. As a result, farmers will adopt practices recommended to improve surface as well as subsurface removal of water. As explained in the chapter II, non rice crops use much less water compared to paddy, Hence, amount of water that could contribute to water logging will be less in relation to cultivating of paddy. Hence, year around irrigation practices will not contribute to water logging problems of System 'B'. However, operation of canal system during the close season may increase subsurface flow to some extent due seepage losses. As the main canal and the branch canals are lined, seepage losses will be negligible. Further the operation of the distribution and field canals will also be limited to day times as only OFC are cultivated. Hence, seepage losses cannot will not built up the ground water table. It can be concluded that year around cultivation practices will not contribute to the water logging problems.

CHAPTER 5

1. Introduction

Crop diversification is promoted to raise income level of farmers engaged in rice cultivation. Although farmers know that they earn more by cultivation of OFC, they prefer to grow rice which is a low risk crop when there is adequate water. But a large percentage of farmers in System 'G' and 'H' cultivate OFC as there is a water shortage for rice cultivation during Yala season. It is necessary to demonstrate to farmers that availability water is a blessing to grow OFC. This chapter describes the advantages of year around cropping over Yala season crop diversification and a process that could be used to convince farmers to cultivate non rice crops.

2. Necessity for Crop Diversification

One of the main objectives of the accelerated Mahaweli Development Program is to increase agricultural production to create employment and to increase farmer income with the effective use of the available land and water resources. With these basic objectives in view, settlement in System B is being executed by allocating irrigable land to selected peasant from the landless poor. The size of a farm given to an allottee, according to the land allotment policy of Mahaweli Development Program, is 1.0 ha. of irrigated low land and 0.2 ha. of unirrigated homestead. Development of new lands helps to solve unemployment problem in the country to a certain extent and also to enhance the domestic food production effort in the national point of view.

In System B, nearly 100 % of irrigated lands are cultivated with rice during Maha season and the Yala season cultivation is generally over 90 %. The homesteads are cultivated with other food crops such as cowpea chilies, maize, vegetables under rainfed conditions supplemented with well water. Rice is a marginal crop which it will not help overcome the poor living standard of subsistence level farmers. According to the results of Mahadamana trials net return per hectare per year was only Rs. 26,729.00. Hence average monthly income is only Rs. 2,300. But, growing of other field crops gives better returns as much as five times in the case of chillie and seven times in the case of big onions compared to paddy. Although profits are clearly visible farmers are reluctant to go for a large scale crop diversification. The following has been identified as constraints for crop diversification.

1. Marketing uncertainties
2. Labour shortages
3. Pest and diseases epidemics
4 Shortage of seeds
5. Interruption of irrigation water

6. Waterlogging of soils
7. High investment cost

It is essential to promote crop diversification mainly to raise living standard of rice farmers who have only one hectare of land for cultivation. Year around cultivation practices can definitely help to over come number of above constraints and has a few advantages over yala season crop diversification as described in the following sections.

3. Present Crop Diversification Policy

Dept of Agriculture promote crop diversification only during yala season in irrigated lands. But no one encourages farmers to grow OFC in irrigated fields during Maha season. A farmer who cultivates OFC during yala need to prepare his farm with raise beds and other drains which require much labour. Then next season he has to level his farm for paddy cultivation. This sift of cultivation for rice to OFC and again OFC to rice increase his land preparation cost. As a result he usually do not follow recommend land development patten to minimize his costs. Then his lands get water logged with a little rainfall and will damage crops. Since land development has been done to facilitate rice cultivation with levelled basins, it is difficult to convert land back to an upland farm. The recommend raised beds are basically a drainage system rather than an irrigation method for OFCs in levelled basins originally prepared for paddy. As this drainage system is not good enough to remove excess water, growing of OFCs during Maha season is not recommended. However, non rice crops like chillie, greengram and other pluses are encouraged to be grown on highlands as a rainfed crop during Maha season. It is a traditional practice (Chena Cultivation) of Sri Lanka to grow a range of crops on highlands as a rainfed crop. If OFC can be grown during Yala season, there is hardly any difference between upland cultivations and cultivation in paddy fields except drainage facilities during Maha Season. In upland farms, natural ground slope is not disturbed and as result, surface runoff from rain fall is easily removed. If drainage conditions are improved in OFC farms in irrigable areas, farmers can cultivate OFC both seasons and crop damages due to water logging can be minimized. The crop diversification can be more attractive to farmers if they can cultivate OFC during both seasons. The crops, like chillie, ground nuts, green gram and brinjal (Egg plant) recommended for Yala cultivation were grown on uplands under rainfed conditions before crop diversification programs were started in Sri Lanka. Hence, availability of irrigation water to an upland is a definite advantage as it overcomes possible crop damage due to lack of rainfall. The present policy of promotion of OFC cultivation during Yala season in irrigated lands should be extended to cover maha season too.

4. Maha Season OFC Cultivation

The next step that should be taken to promote crop diversification is encouraging and demonstrating cultivation of OFC during Maha season in irrigated lands. Then, drainage conditions available in upland farms should be created in the irrigated upland farms to avoid crop damage due to water logging. The drainage conditions in a upland farm are summarized as follows.

1. Easy removal of surface runoff as original land slope is not disturbed

2. No seepage water from canals to raise water table

3. No seepage and percolation from paddy fields to create water logging conditions

The above three conditions can be easily created by,

a). Development of lands to have a minimum of 1.5 % land slope and removal of bunds around basins (liyaddas) and

b). Construction of intercepter drains to block seepage water from paddy fields and canals.

The reports on " On-farm drainage investigations in Mahaweli System 'B'" and " On-farm drainages in Mahaweli System 'B' " give details about drainage problems and recommends appropriate on-farm irrigation and drainage systems. This shows cultivation of OFC can be done successfully in both Yala and Maha seasons.

The most important recommendation to initiate Maha season cultivation of OFC is to motivate farmers allocate a small area exclusively for OFCs. Then, advise him to prepare on on-farm drainage facilities as outlined in the chapter 4. Then the farmer will have an upland farm and a paddy farm. This is a better arrangement than to grow OFC and paddy in rotation in the same area. The farmer can enlarge the OFC area year by year.

4.1 Mid Season Cultivation

When, the farmer gets the experience of cultivation of OFC in both seasons, he should be encouraged to cultivate an additional season called Mid season at the end of yala season. When he is ready and able to cultivate three seasons concepts and recommendations of year around cultivation should be introduced. When a farmer practices a cultivation of during three seasons for two years, he would acquire knowledge to control pest and diseases epidemics. He could also save to raise capital required to extend his OFC area.

5. **Fulltime Employment at Farm**

The records of the labour use for various crops at Mahadamana trails showed one hectare of paddy cultivation requires 173 labour days. The land preparation and planting period absorbed 55 labour days or nearly 33 % of total labour days. The harvesting period absorbed 47 labour days. The farmer had to hire 83 labour days. During the crop development period the labor requirement was only 2 labour days per week. Hence, a farmer cultivating rice crop has only four weeks of fulltime employment. During the remaining period of the season he is employed only two days a week. On this basis the farmer has only two months of work at the farm for a season. Hence, a valuable resource is wasted almost by 66%. A cultivation of chillie requires 410 labour days and distribution is much more even than paddy. Only way available to create fulltime employment is cultivation of OFC in the paddy field. But the seasonal cultivation of OFC will also have peaks of labour distribution during planting and harvesting. It is possible to avoid peaks in the labour requirement by adopting staggered planting.

The staggered planting is possible only under year around irrigation service. When year around irrigation service is available, planting dates and areas can be adjusted to obtain a even distribution of labour throughout the year. Thus, it is possible to provide fulltime employment to the farmer and his family members.

In any industry, employees are fulltime employed. The agriculture in Sri Lanka can be developed to provide fulltime employment by operation of irrigation schemes on a year around basis. The System B is the only place that this concept can be implemented. If this become a success other major irrigation systems can also follow System 'B' practices.

6. **Market Oriented Production**

The seasonal production creates market gluts which suppress prices due to over supply sometimes almost to the production cost. It is necessary to provide storage facilities and costly post harvest technology. For example, vegetables has a steady market and a variety of vegetables can be grown in System 'B'. If marketing channel could be developed, System 'B' can produce to supply these markets on a continuous basis. If farmers are conscious about the price that they will at the time of selling there products, they can shift their planting dates to match specific markets windows. Without a year around irrigation service, farmers will not be able to practice planting with due regard to the price available at the time of selling their products.

Hence, year around irrigation will create conditions favorable for market oriented agriculture and fulltime employment for farmers. It is therefore recommended MEA to continue research and demonstration programs on year around cultivation and land development methods with assistance of RARC.

In order to meet the food demand for the present population and for the rapid growth of population in the country, a large portion of our local and foreign revenue is spent on import of essential food items. At present it is found that most of the productive lands in the country were already opened up for irrigation and settlement projects. If more jungle areas are cleared for agriculture it will adversely affect the ecology of the country. Hence it is very important to increase the intensity of cultivation of present agricultural lands thereby increasing the food production of the country to meet the demand.

When the reasons given above considered, effective use of resources like land , water climate, labour cam be ensured to a great extent by providing a year around irrigation service. MEA should develop and implement a program so that farmers can harvest to year around irrigation service.

CHAPTER 06

1. Conclusions and Recommendations

Advanced science and technology have been widely applied to increase food production in most of the developed countries in the world. Most of these countries are not blessed with the opportunity of growing crops throughout the year. We are in a country where food crops can be grown during the 365 days of the year provided that the water is not a constraint. The reports showed that System 'B' has suitable soils, sufficient water, favorable climate and suitable crops for cultivation through out the year.

According to the experienced gained and results obtained from Mahadamana trials and other special studies conducted in System 'B', following conclusions together with recommendations could be made in order to create conditions necessary for sustainable crop diversification program that will result improvements of living standards farmers.

The report published by **ACRES INTERNATIONAL LIMITED** on Studies of Operating Policy Options of Mahaweli Systems, showed that cropping intensity of 2.0 in the full project area could be supported with adequate reliability (ACRES ,1985). It can, therefore, be concluded that there is sufficient water for two seasons for paddy cultivation. Further, it was proved that cultivation of 746 Ha. of non rice crops saves enough water required to balance the canal water loss occurring during extended period of canal operation even under the present level of water use by farmers. It was therefore concluded that there was sufficient water available to System 'B' to provide water on year around basis.

The results of Mahadamana field trials showed that farmers would not waste water when properly educated and guided and amount of water use was almost at the recommended levels. This results provided an affirmative answer to the question;

> Will farmers waste more water when water is available on year around basis?

Mr. Jerry Schaack, a well qualified engineer from US studied the feasibility of operating the irrigation system on a year around basis. Mr. Schaack said in his report " I am confident that System 'B' can also be operated to provide year around irrigation water service in an effective and efficient manner. This very likely can be accomplished at about the same cost as partial year operation and with no decrease in system efficiency and with equal or better system integrity". All his main recommendations were implemented during the period from 1992 to 1995. With the information provided in the chapter 3, the followings conclusions are forwarded with complete confidence.

1. MEA can maintain the canal system without emptying the main canal for routine maintenance works annually.

2. It is not necessary to inspect the canal lining annually to ensure safety.

3. Minor repairs be done without emptying the main canal.

4. MEA O&M staff can operate and maintain the main canal system on year around basis.

The year around irrigation practices are necessary for a market driven crop diversification program. Unless the maintenance practices are improved and recommendations are implemented, MEA will have to close the main canal for repairs. Since main canal is in good condition now, MEA pays less attention to it. DRPM(Eng) should pay special attention and monitor the activities of O&M closely to see that WM staff adopt the Preventive Maintenance program. Further, MEA must introduce alternative methods for traditional methods avoid situations that demand O&M engineers to close the canal. The MEA engineers should endure to introduce the practices that they observed during their study tour in US.

It is suggested to pay continuous attention to improve the capacity of MEA water management staff to operate and maintain irrigation system to supply irrigation water on year around basis. If O&M staff implement the recommendations of Mr. Schaack, they can maintain the system without emptying the main canal for routine maintenance works annually. It is recommended to conduct the review of maintenance practices of main and branch canals at least once in every two years.

There are a range of crops that can be cultivated in System 'B' during any period of the year. The Department of Agriculture, Sri Lanka, have recommended more than 25 crops for Low Country Dry Zone. The table 4.1 shows the crops and suitable planting days for System 'B'. However, selection of a suitable cropping pattern requires knowledge of many factors. The most important factors are the net income to the farmer and the agronomic suitability of the crop combination. Other factors are the judicious selection of crops to prevent outbreaks of pests and diseases and optimization of the use of the factors of production (land, labour, capital and management) and nature's resources (rainfall, sunlight, soil nutrients, day length etc.).

A cropping pattern for year around cultivation should extend at least to three years. When deciding a cropping pattern to suit year round cultivation it is very important to avoid sequence of crops which will help soil-borne pathogens and nematodes to accumulate in root zone. This includes successive cultivation of the same species or crops in the same family that are susceptible to a given strain of pathogens. Hence as a general rule, successive cultivation of the same species should be avoided..

It is therefore recommended that a crop rotation for year round cultivation should not include groups of crops which are susceptible or related to same pest or diseases to follow another in cropping sequence. It is advised to include a legume at least once in each year to help supply nitrogen and organic matter to the soils. A short-aged legume crop, such as green gram, grown between high profits and high input crops will enrich the soil while providing profit a modest profit with low inputs.

Analysis of rainfall data showed that there is a almost 9 month dry period form mid January to mid October which can be considered as a continuous cropping season.

Diversification in paddy lands is constrained by higher ground water table caused by seepage water from paddy lands and irrigation canals. Further, rainfall is contributing to crop damage even during Yala season. Hence, improved land development methods are necessary to minimize crop damage. Present recommendations are adequate for diversification during yala season. However, for farmers doing diversification during Maha season or both seasons need to remove rainwater as soon as possible with minimum erosion of lands. It is necessary have a few farmers who are convinced about success of new on-farm drains before making a firm recommendations to other farmers. Therefore the Mahadamana trails need to be continued as demonstration area.

If farmers cultivate OFC during yala and paddy during Maha, their cost of cultivation go up mainly due to land preparation cost and they also get a lesser price for their products. For sustainable crop diversification program, farmers must cultivate OFCs during both seasons in a suitable locations of his field to suit markets. Further cultivation should be scheduled to suit to seasonal markets. Then the income of the farmers will increase due to produce higher price and less land development cost. This concept was developed and demonstrated at Mahadamana, Mahaweli extension staff can now propagate the message to the farmer through extension.

It was observed that there was an unequal distribution of water along the field canal specially during the land preparation and socking period. Also under normal circumstances head enders drew more water than tail enders which consequently lead to numerous water distribution problems. It is also necessary to stop water issues when adequate rainfall is experienced. This situation could be corrected if gated out-lets are provided to each paddy lot but it may be rather expensive. Hence the farmers must be encouraged to use wooden planks to cover farm inlets when rotational water issues are practiced and they should be provided with adequate training in water distribution and operation of field canals.

Mr. P. M. Cauley, Soil Scientist, studied the characteristics of the soils and regrouped the soils into ten Groups according to soil limitations most significantly affecting suitability for non rice crop production. It was established considering the on farm drainage practices based on soil suitability, a realistic cropping goal would be 65% non rice crops, 35% paddy during Maha season.

The detail soil maps for System 'B' are not available to indicate the Soils Groups. The soil maps will help to identify suitable farms for crop diversification programs. It is therefore recommended to implement Mr. Cauley's first recommendation; develop a detailed soil survey map (scale 1: 10,000) accompanied by a practical,easy to understand, layman's manuscript, describing important soil characteristics and outlining soil management and cropping practices.

Dept of Agriculture promote crop diversification only during yala season in irrigated lands. But no one encourages farmers to grow OFC in irrigated fields during Maha season. If drainage conditions are improved in OFC farms in irrigable areas, farmers can cultivate OFC both seasons and crop damages due to water logging can be minimized. The crop diversification can be more attractive to farmers if they can cultivate OFC during both seasons. Hence, it was recommended to extend the present policy of promotion of OFC cultivation during Yala season in irrigated lands to cover maha season too.

It was pointed out that the most important recommendation to initiate Maha season cultivation of OFC is to motivate farmers allocate a small area exclusively for OFCs. Then, the farmer can be advised to prepare on on-farm drainage facilities as outlined in the chapter 4. Then the farmer will have an upland farm and a paddy farm. This is a better arrangement than to grow OFC and paddy in rotation in the same area. The farmer can enlarge the OFC area year by year.

When, the farmer gets the experience of cultivation of OFC in both seasons, he should be encouraged to cultivate an additional season called Mid season at the end of yala season. When he is ready and able to cultivate three seasons the concepts and recommendations year around cultivation should be introduced.

When year around irrigation service is available, planting dates and areas can be adjusted to obtain a even distribution of labour throughout the year. Thus, it would become possible to provide fulltime employment to the farmer and his family members.
In any industry, employees are fulltime employed. The agriculture in Sri Lanka can be developed to provide fulltime employment by operation of irrigation schemes on a year around basis. The System B is the only place that this concept can be implemented. If this become a success other major irrigation systems can also follow System 'B' practices.

SUGGESTIONS FOR FUTURE RESEARCH

System B is very different compared to other Mahaweli areas, mainly due to topography and soils. There are not much adoptive research done in system B soils to decide on-farm water management recommendations. The O&M manual for system B prepared by CH2MHILL says (page 4-42) "adoptive research urgently required to determine appropriate channel and bed spacings for various project soils and crops". Further, Mid term MARD evaluation also recommended (Recommendation # 7, section B, Chapter II) a development and implementation of an applied research and development plan directed at turnout level water management technologies. It is recommended to continue the applied research program conducted jointly with RARC at least to refine our recommendations.

Undertaking of research on the following will also be useful for more comprehensive understanding on the feasibility of year round cultivation.

When increasing the intensity of cultivation under year round cultivation concept there is a tendency to increase the water table and restrict the cultivation of other field crop as most of these crops need good aeration in the root zone. This will be aggravated due to inadequate drainage facilities in the project area. On the other hand if proper drainage facilities are not provided there is a strong possibility of building up of soil salinity/alkanity etc. in the paddy fields. Hence research on soil behavior, building up of salinity and alkanity under year round water issues will be very useful.

ANNEX I

The water requirements include the field water requirement, the irrigation requirement and the amount of water needed at the head of the irrigation system i.e. the diversion requirement.

Related technical terms could be described as follows.

a) Evapotranspiration (ETP)

Evapotranspiration (ETP) = Evaporation + Transpiration.

b) Crop water Requirement (CWR)

Crop water Requirement (CWR) = Evapotranspiration + Percolation.

c) Field Application Efficiency (FAE)

This indicate how much effectively water is applied within the field. Using table 2a-5 of the O&M Manual as guide line FAE could be adjusted during the course of the cultivation season according to type of crop, cultivation phase/ crop development stage. and other factors.

d) Field water requirement (FWR)

Field water requirement is equal to the weekly crop water requirement divided by the field application efficiency.

Field water requirement = Crop water requirement/ field application efficiency.

e) Turnout water Requirement (TWR)

This indicate the turn out water requirement in cu m/day

TWR = FWR* Total cropped Area * 10

f) Irrigation Requirement = Field water requirement - Effective Rainfall

g) Diversion Requirement = Irrigation Requirement + Distribution losses

The duty of water in a season means the amount of irrigation water in meters or feet to be applied to meet the water requirement of a unit area. In applying water to crop, losses may occur at a number of points in the delivery system and distribution losses are therefore added to obtain the diversion requirement

In the case of paddy cultivation it is important to apply water at least once in seven days (May be at more frequent intervals) to saturate the root zone. Hence field water requirement should meet the crop evapotranspiration and percolation requirements. On the contrary OFC needs water only for crop evapotranspiration and infiltration. .

The following calculation estimate water requirement for non rice crop cultivation on year around basis. The water requirement for paddy cultivation for both seasons are computed and compared below to estimate the water saving arising out of year round cultivation.

Case a) 100% Diversified Cropping in respect of year round cultivation in one hectare farm.

<u>Assumptions</u>

1. No Paddy Cultivation is the farm.

2. Two Months rainy period. During this period no water is required.

3. Irrigation water is required for balance 10 months.

4. If the cultivation is staggered into five stages then always 20% of the land is in land preparation stage. As water is not required at land preparation stage for OFC cultivation 20% of water saving could be anticipated during this period.

5. Growth period of OFC plantations are 12 weeks.

6. Evapotranspiration in System 'B' Area = 6mm/day. for all the crops proposed.

7. Application Efficiency =70% (Ref table 2A-5 O&M Manual)

8. Water is applied for Evapotranspiration plants for metabolic activities and not to ensure ponding.
9. No of day for a months = 30 days

Calculation

Crop water req.(CWR) = Eva.Transpiration+ Percolation (P)

= 6 mm/day

Irrigation req. = CWR/0.7

= 8.57 mm/day

Total water requirement for 1 Ha. of a farm for one year period. = 8.57*80/100*10*30

= 2.057 m/year

Water Req. for 1 Ha. = 2.057*100*100

= $2.057*10^4$ cu.m/year

Case b) Paddy/Paddy cultivation

Assumption

1. Assume 4 1/2 month variety in Maha and 3 1/2 variety in Yala is grown.
2. Total cultivation period = 8 months
3. Land preparation and soaking = 2 months
4. Fallow period = 2 months
5. Water req. during land soaking and

   Preparation period = 350 mm.

   as per the O&M Manual for System 'B' (CH2M Hill,1987)
6. Percentage of cultivation = 100%
7. Evapotranspiration = 6 mm/day
8. Percolation rate = 3 mm/day
9. Application Efficiency (AE) = 60 %

   As per O&M Manual (CH2 M Hill,1987)
10. No of days for a month = 30 days

Calculations

Crop water requirement = ET + P

= 5.5 mm/day + 3mm/day

= 8.5 mm/day

Field water requirement = CWR/AE
= 8.5/0.6

= 14.16 mm/day

Water req. for cultivation of paddy for a year (Two seasons) = 350 *2 + 7*30*14.16

= 3.67 m/year

Effective rainfall = 0.6 m/year

Net water requirement = 3.07 m/ year

Water req, for 1Ha.of allotment = 3.07*100*100cu.m/year

= 3.07 $*10^4$ cu.m/year.

As per the analyses above it shows that there is a 33% saving of water if 100% OFC is grown on year round basis.

Case c) 50% crop diversification on year round basis and 50% paddy/paddy for two season

Water requirement for 1 Ha. of allotment = 1/2*(2.057 + 3.07)$*10^4$

-do- = 2.563$*10^4$ cu.m/year.

The above analyses shows that there is 14% of water saving over the cultivation of paddy/paddy for two seasons.

This shows that there is a considerable saving in water by growing OFC. The results obtained from computer program CROPWAT 5.3 developed by FAO for estimation of crop water requirements also proved the assumptions are correct. (Gunawardana, 1990)

However the seasonal water duties as per CIDA report published in 1985 for system B is 1960 mm for Yala season and 1300 mm for Maha season. In actual practice the water duty is higher at present and the following are some reasons.

Chapter two of the O&M manual for system B gives the procedure to be adopted for preparation of Turn Out irrigation schedules and this procedure is followed by the water management staff of

M.E.A. at Welikande. This Chapter describes the preparation of water schedules for the irrigation of OFC.

During the rotational water issues, the total flow that is 28 lts/Sec. is divided between two farm lot at a time for a period of 12 hrs. at the rate of 14 lts/sec. This rotation is ideal for paddy cultivation as the water table is to be brought to ground level at a minimum time.

But it is found that the water distribution to the farmers in a T.O area is unequal and head enders are getting more water than the tail enders (De Silva, 1991) due to lack of training. Hence rotational irrigation issues cannot be practiced effectively and contributes to increased water use.

Duration of irrigation is determined by the amount of water req. to wet the root zones and the irrigation application efficiency base in the size of the basin and the stream size. The depth of irrigation recommended for System 'B' for different frequencies given below are based on the irrigation requirement to wet the root zone. The duration of irrigation is calculated assuming an efficiency of 50% with a stream of 4 lts/sec.

Irrigation Interval	**Depth of Application**	**Duration for 80 m2 basin**	**60 m2 basin**
2	15	10	08
3	20	14	10
4	25	17	13
5	30	20	15
6	35	24	18

If a farmer has cultivated 0.4 Ha. (1 Acre) and needs 4 days irrigation interval he needs water for 5 hours to irrigate approximately 50 Nos. of 80 m^2 basins. Thus only 3 basins could be irrigated at time with a stream of 4 l/s for a duration of 17 minutes (Wicramarathne, 1991).

But farmers do not respond to this rotation in some instances and they prefer to have a rotation to suit their conditions and requirements. On the other hand when OFC are grown in the rice based system, adaptation of the recommended rotation becomes difficult. Hence it has become necessary to provide 28 l/s discharge at the head of the canal overcome inefficenies of on-farm water distribution.

Main canal losses

Maximum area under main canl	= 24,000 Ha
Average discharge of the canal	= 36 cu.m / sec
assumed losses (4 %)	= 1.44 cu.m / sec
	= 124416 cu.m/ day
Total losses for two months	= 7,464,960 cu.m

Analysis of Mahadamana data

Maximum water use at Mahadammana	= 1.44 m/ha
Distribution losses	= 30 %
Corrected water use	= 1. 8 m /ha
Average water use at Mahadamana	= 1.3 m/ha.
Distribution losses	= 0.39 m/ha or 30 %
Corrected water duty	= 1.69 m/ha
Recommended water duty	= 0.7*2.0 + 0.3*1.03
	= 1.71 m/ha
Water saving	= 1.71 - 1.69 =.0.02 m/ha

TABLE A1-1 WATER DUT IN SYSTEM 'B'

91 YALA SEASON

BLOCK	AREA ha.	VOLUME ha.m.	DUTY m
Damminna	1071.60	3076.37	2.87
Wijayabpura	1915.00	5603.67	2.93
Ellewewa	1995.03	6079.96	3.05
Dimbulagala	1792.31	5568.73	3.11
Sevanapitiya	1905.80	4680.28	2.46
Senapura	1348.40	3654.37	2.71
TOTAL	10028.14	28663.38	2.86

91/1992 MAHA SEASON

BLOCK	AREA ha.	VOLUME ha.m.	DUTY m
Damminna	998.75	3330.61	3.33
Wijayapura	2047.20	3590.05	1.75
Ellewewa	2105.41	4796.66	2.28
Dimbulagala	1854.50	4778.98	2.58
Sevenapitiya	2278.10	3565.97	1.57
Senapura	1549.65	3196.44	2.07
Asselapura	1573.14	1404.25	2.45
TOTAL	12406.75	24662.96	2.29

SOURCE - System 'B', Water Management Division

TABLE A1-2 QUANTITY OF WATER ISSUES FOR DIFFERENT TYPES OF CROPS GROWN IN MAHADAMANA TRIALS - 1991 YALA SEASON

Field No.	Red onion m	Big onion m	Grean Gram m	Soya Bean m	Chillie m	Mean Total Duty(m)
01	0.75	0.72	0.75	0.50	0.45	0.63
02	0.69	0.71	0.71	0.47	0.41	0.60
03	0.72	0.78	0.72	0.45	0.43	0.62
04	-	-	-	-	-	-
05	0.78	0.81	0.74	0.45	0.50	0.66
06	0.80	0.83	0.79	0.48	0.51	0.68
07	0.75	0.79	0.71	0.42	0.49	0.63
08	0.72	0.84	0.69	0.51	0.42	0.64
09	0.80	0.83	0.72	0.49	0.49	0.67
10	0.75	0.84	0.79	0.48	0.50	0.67
Mean Duty in OFC area of the Turnout FC 66						0.64

TABLE A1-3 QUANTITY OF WATER ISSUES FOR DIFFERENT TYPES OF CROPS GROWN IN MAHADAMANA TRIALS - 1991/92 MAHA SEASON

Field No.	Chillie m	Potato m	Ground m	Cabbage m	Soya Bean m	Mean Total Duty(m)
01	0.33	0.75	0.92	0.71	0.45	0.63
02	0.38	0.80	0.85	0.75	0.43	0.64
03	0.35	0.79	0.82	0.73	0.45	0.63
04	-	-	-	-	-	-
05	0.37	0.75	0.85	0.78	0.44	0.64
06	0.38	0.81	0.87	0.73	0.43	0.64
07	-	-	-	-	-	-
08	0.37	0.82	0.89	0.78	0.45	0.66
09	0.35	0.79	0.95	0.72	0.43	0.65
10	0.38	0.82	0.91	0.74	0.47	0.66
Mean Duty in OFC area of the Turnout FC FC66						0.64

TABLE A1-2 WATER ISSUES IN MAHADAMANA TRIALS

1992 MID SEASON

Period From:92.02.15 To:92.04.30

Plot No.	Total Discharge in (L)	Total Discharge cum.	Height in m.
01	8,500,000	8,500	0.85
02	87,500,000	8,750	0.87
03	8,050,000	8,050	0.80
04	-	-	-
05	79500,000	7,950	0.79
06	77,500,000	7,750	0.77
07	-	-	-
08	81,500,000	8,150	0.81
09	8,250,000	8.250	0.82
10	8,200,000	8,200	0.82
	Average Duty		0.82