Appendix 8 - 1

## MANUAL ON LAND CONSOLIDATION WORK (DEWAHUWA)

Preface:

This manual is based on the results of the land consolidation work which has been carried on at the Dewahuwa Special Project for the last 5 years (from 1971 upto 1975).

As land consolidation work is in itself varied according to nature, its contents and procedure, to make a manual of the work and to make it of use for other projects, the initial conditions in the manual must be clarified.

Therefore, in this manual, the following initial conditions are to be adopted, based on the results at Dewahuwa.

i.e.
1). Border line between each allotment is left as it is.
2). Land re-arrangement aims at effective use of 6 HP two wheel tractors.
3). Main jobs, e.g. land grading are done with bulldozers.

1. Selection of jobs:

Since the effect of land consolidation work and the procedure to get its results are distinguished as follows, the necessary tasks for a project must be selected from them according to the condition of each project.

i.e.

Improvement of the productivity of land -

- Land re-arrangement to enable effective transplanting etc.
- Unification of inlets liyadda to liyadda to enable effective use of water etc.
- Underdrainage and soil dressing, if they are necessary.

Improvement of the proudctivity of labour input -

- Extension of liyadda size to enable effective use of agro-machinery etc.
- Reinforcement of field road to enable effective transportation of necessary materials etc.

Improvement of the conservation of land -

- Extension of liyadda size to modify land gradient etc.
- Strengthening of border and inlets liyadda to liyadda to stabilize land permanently.

2. Standards of each task:

2-1 Pre-survey

- Draw a plan scaled about 1/100 with 1 ft. contour line by using a level and a plane table.
- Level survey is to be done in each 50 ft. at sloped area and in each 80 ft. at flat area roughly in grating wise, and each point must be lotted in the plan by checking each location using the plane table.
- Efficiency of the pre-survey per unit work is about 15AC/day/troop. Here one troop consistes of one surveyor, 1 assistant and 3 labourers.

2-2 Allocation of field lot

- Considering ploughing efficiency with 2 wheel tractor and transplanting efficiency with manual labour liyadda size is to be 1/4 AC at sloped area to 1/2 AC at flat area in standard.
- Although, the ideal shape for each liyadda should be rectangular from the practical point of forming, yet due to increase in cost of soil work entrailed, adherence to this shape may be avoided.
- Particularly at sloped area, arrange each liyadda so that the long edge of each liyadda is along the contour line.
- Minimum length of short edge is to be 30 ft. and maximum length of long edge is to be 300 ft, in each liyadda.
- Difference of height between neighbouring liyaddas is to be a minimum of 0.5 ft. mainly at flat area and to be a maximum of 3 ft. mainly at sloped area.
- Both cutting height and banking height should be a maximum of 2 ft.

2-3 Land grading work

- One troop of heavy machinery is to consist of 2 to 3 bulldozers which are 90 H and 11 to 12.3 ton weight each, and out of these bulldozers one with lipper for hard soil breaking or one swamp-typed bulldozer for the work in marshy land should be included in case of necessity. Incidentally land grading work by one machine alone should be avoided in case of some mechanical trouble as it will be quite difficult to rescue the tractor from the field.
- One way distance to grade soil by a heavy machine is to be a maximum of 150 ft.
- Although, efficiency of machinery work fluctuates largely according to field condition $30M^3$/hr. of grading capacity and 20 hrs./AC of

work duty are generally the standard.
Accordingly when a troop consists of 2 machines and they work 10 hrs./day each, efficiency for land grading meets 1 AC/day/troop.

2-4 Top soil treatment

. In any land consolidation work, top soil treatment is to be recommended from technical view point, but since the cost is rather expensive, it is better in a case when soil fertility is completely different, i.e. top soil and subsoil.

(Note: at Dewahuwa top soil treatment has never been carried out because top soil maturity itself was rather poor).

. When top soil treatment is carried out in a project 0.5 ft. of top soil in depth is to be treated and this soil is once to be put on the proposed liyadda border, then after land grading work and rough levelling work,it is to be scattered on the whole of the liyadda surface again.
. When top soil treatment is not carried out, spraying of V 1 mixed fertilizer at the rate of 0.5 to 1 bag (12.5 kg. to 25 kg.) per AC is effective to prevent temporary depression of soil fertility just after the land consolidation work.

2-5 Levelling

. Levelling is one of the most important jobs in land consolidation work. The levelling error of elevation in any point in the liyadda must be within ± 2 inches against the average height of the liyadda.
. There are two ways to establish the levelling scheme, i.e. by dried condition and by inundated condition. In the former, elevations of about 9 to 12 points in each liyadda are to be checked by a level before and after levelling by bulldozers, and to be repeated until the error of each point reduces to less than ±2 inches.
Against it in the latter, i.e. the inundated method, repeated checkiing of elevations at many points is unnecessary because in the inundated condition (2 to 4 inches depth of water) uneven condition of the liyadda surface is so noticeable that an operator of the bulldozer can correct it easily without the help of level.
. Generally, the dried method is little effective, i.e. about 6 hrs./AC by machine and the inundated method has effeciency of about 4 hrs/AC. Therefore, if it is possible to make inundated condition by filling irrigated or rainfed water to the liyadda and also possible to use a

swamp-typed bulldozer, the inundated method is better than the dried method.

2-6 Border making and installation of inlets

. Border is to be earth-made one, which is banked and compacted by means of heavy machinery. Since border making is done by heavy machinery, the size of border comes to be rather big with top width of banked soil about 2 ft. and banked height about 2 ft. However, this enlarged size may be useful to prevent crab-holes.

. Soil compaction for border is to be carried out by using 35 H and 3 ton weight bulldozer and supplemented by manual labour, if necessary. Efficiency of machinery for this job is about 3.5 hrs/AC.

. Inlets liyadda to liyadda are to be concrete-made size 8" by 8". Field mix of concrete is to be 1:3:6. Incidentally, about 4" sized cut-wall is also to be installed at front and back end of concrete flume.

. Soil compacting at base and sides of concrete flume is also essential job to inlet work.

. As to design of border and inlets,,see Fig. 4.2.3.3. in the Final Report.

2-7 Field channel and drainage

. At flat area installation of a channel and a drainage along short edges in both sides of a liyadda is recommended so that irrigated water can be supplied directly from the field channel to each liyadda and also can be drained directly from each liyadda to the field drainage.

. But, particularly, at sloped area, this lay-out must be carefully adopted, because it might cause increased water loss which is drained from field channel to main drainage directly without being used in each liyadda if water management by farmers is slack.

. Accordingly, which method is better for a project should be considered carefully in connection with construction cost.

(Note (Note: Considering the construction cost and the sloped condition of the area, the liyadda to liyadda irrigation method was unaltered at Dewahuwa).

2-8 Field Road

. One field road in each of two allotents is to be installed between the two in order to enable effective transportation of necessary materials to any allotment.

- The size of field read is to be about 10 ft. wide with 4" depth gravel as course base.

  Banking and soil compacting for field road must be carried out with land grading work simultaneously.

2-9 Other jobs

- At ill-drained field underdrainage work is necessary. 2 ft. depth and 50 ft. distance trenches are to be excavated towards main drainage and rubbish like brushwood or broken brick is to be buried. After that excavated soil is to be replaced and to be compacted as it was.
- If top soil fertility is extremely unsuitable for paddy cultivation, soil dressing by using humus, e.g. from bottom of neighbouring tank etc. to liyaddas is effective.

  Layer thickness of humus is to be about 1 inch.

3. Maintenance of Heavy Machinery

As mentioned earlier, this manual is meant initially for proceeding with land consolidation work performed mainly by heavy machinery. Therefore, maintenance of heavy machinery is a vital necessity in order to carry out the work smoothly.

Here, the standard for maintenance of heavy machinery is shown, as follows:-

3-1 Instructions before operating

- Open the fuel tank valve and inspect fuel on the palm. If the fuel contains grit, mud or water, drain out till fuel is apparently clean
- Check water level in radiator and correct it, if necessary.
- Check engine oil level and correct it, if necessary.
- Check oil level of the transmission case and correct it.
- Check hydraulic oil level.
- After starting the engine, keep the fuel control lever in half opened position and idle the engine for about five minutes, and again check engine oil whether the oil level is correct and if the oil contains water.
- Then, go round the machine and check mounting bolts and nuts for tightness.
- Check the engine oil pressure gauge, water temperature gauge, and ammeter.

- Check exhaust gas colour and sound of engine.

3-2 Instructions while operating

- Scraping should be done by engaging the first gear, because the machine is so designed, otherwise overheating would result.
- But hauling and levelling can be carried out in the second or third gears.
- Operators must be attentive to faulty engine sounds and must manipulate gears so as to keep the r.p.m. constant.

3-3 Instructions after operating

- Idle the engine for about five minutes.
- Clean the machine.
- Replenish fuel.

3-4 Overheating

Overheating causes varioustroubles such as leakage of water into cylinders. To prevent the engine from overheating, the following measures are recommended:

- To operate machine at proper speed use proper gear so as to avoid overloading.
- Washing the radiator and using clean water.
- Keeping fan belt tension properly.
- Keeping the inside of the cooling system clean by adding rediator cleaner.

3-5 Special instructions of maintenance

- To clean the air cleaner every two or three days and change the element once in two months.
- To change the engine oil and the oil filter element every month.
- To check whether metal powders stick to the magnetic oil drain cock and inside the oil filter element.

4. Particulars of the construction cost of the land consolidation work per acre is based on each of the standards mentioned earlier, it may be, as follows:-

| | | | | | | |
|---|---|---|---|---|---|---|
| Main job by heavy machinery | Wages | 10 Persons | x Rs. | 8. = | Rs. 80 | |
| | Salary | .. | .. | | " 250. | for operators & a mechanic |
| | Diesel Oil | 50 Gallons | x Rs. | 5. = | " 250. | |
| | Others | .. | .. | | " 30. | for pre-survey etc. |
| Concrete inlets. | Wages | 8 Persons | x Rs. | 8. = | " 65. | |
| | Concrete | 0.25 Cuces | x Rs. | 360. = | " 90. | |
| Road & Others | .. | .. | .. | | " 35. | |
| | | | | | Rs.800./AC | |

. Here, it must be noted that in the Rs.800/AC, depreciation for machinery is excluded and the salary for permanent employees, e.g. operators and a mechanic, is included.

Thus, if a project can implement the land consolidation work in a year and earn rather large acreage for its performance, the unit price for the work would be discounted to less than Rs.800/-, because the share of the salary would become less in terms of acre basis.

Appendix 8 - 2

# MANUAL AND MAINTENANCE STANDARD OF AGRICULTURAL MACHINERY

SRI LANKA - JAPAN RURAL DEVELOPMENT PROJECT, D E W A H U W A. OCT. 1975


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# MANUAL AND MAINTENANCE STANDARD OF AGRICULTURAL MACHINERY
## - DEWAHUWA -

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## INTRODUCTION.

A role of agricultural machinery in raising agricultural productivity is a very important one as a agricultural sector is modernized. Nobody will deny, referring to the example in most of the developed countries, that mechanization in agriculture was a driving force in modernization of agriculture as a whole, by which traditional villages cast off into modern villages.

Agricultural machinery, being a driving force to a mechanized agriculture, should be properly maintained and kept always in best condition, and properly used in order to attain a most economical and effective result in their works, and to attain a longest durability.

We hope that this manual will give essence of maintenance, regulation and preservance of agricultural machinery to people who are engaged in this field, and that it may play an important role of help for mechanized farming in Sri Lanka.

## CHAPTER I.

### HOW TO USE ENGINE PROPERLY.

1. OIL FILL-UP TO THE CRANK CASE.

   At the time of oiling the engine should first be set horizontally, and oil be filled up to the indicator line just above the oil gauge. Oil should be properly chosen according to the prescribed viscosity.

2. OIL FILL-UP TO THE AIR CLEANER.

   The same quality of oil as that of engine oil should be precisely filled up to the oil level indicator line.

3. COOLING WATER.

Use clean water, fill up, and close the cap firmly.

4. FUEL SUPPLY.

Fuel should be supplied through the filter net without fail, always be careful that water is sometimes mixed in the fuel.

5. FUEL FILTER CHECK.

Check carefully the fuel filter, and if there collect dust and water, at the bottom of filter, clean up completely.

6. CHECK OF THE PULLEY TIGHTENING NUT IN THE MAIN PULLEY.

Check, and if the pulley tightening nut is loose, fasten it tightly.

7. CHECK OF THE TENSION OF THE BELT.

Check and confirm the tension of the belt; push down in the central part of the belt with your finger, it bending should not be excess 20 m/m.

8. ENGINE START.

Put the control lever in the starting position, push the decompression lever, turn the handle, and confirm the sound of fuel jetting. If there is no jetting sound of fuel, loose the air breathing bolts which are installed on to the fuel filter and fuel pump, by turning handle and let fuel jet up untill bubbles disappear. And then tighten the air breathing bolts, push the decompression lever and start engine by 3 - 4 times of inertia.

9. WARNING UP

When engine starts, put back the control lever to the idling position, and keep engine warm up for about 5 minutes.

10. ENGINE STOP.

To stop engine, you have only to put the control lever to the "stop" position. At this time strictly refrain from hasty movement of the control lever up and down, and from moving the decompression lever.

## MAINTENANCE BEFORE STORAGE

1. After work, clean off dust and mud clung to each part of the machine and wash with water before you put in the hanger.

11. In case of long term storing

    a) Draw off the old engine oil from the crank-case and air cleaner, and put new oil.

    b) Carry out for 5 - 10 minutes an idling operation unloaded so that fuel and oil may go to every parts of the engine.

    c) After (b) take off all the fuel from the tank. Turn the starting handle and keep engine in compressed condition and confirm the valves are completely closed. This is in order to avoid rust from the valve seats, and you put the machine in the hanger.

    d) Apply cloth with the machine oil all over the machine. It may prevent from being rusted.

# CHAPTER II.

## OPERATION AND HANDLING OF 2-WHEEL TRACTORS

1. Oil fill up to the main gear case.

   At the time of oiling to the main gear ease, the tractor to be kept horizontally on the stand which is provided under the engine mounted chassis.

   And the gear oil "#90" be filled up to the oil level mark of indicator. The gear oil should be properly chosen according to the prescribed viscosity.

2. Oil fill up to the rotary case.

   Keep the tractor in the horizontal position as above, and fill up the prescribed oil up to the indicated mark.

3. Lubrication for "Sub-chain case" or (Counter-chain case)

   Greese has been filled into the sub-chain case prior to delivery from factory, but high quality greese should be applied after every 50 hours' use.

4. Main Clutch Lever.

It has three "controlling positions". The first is "ON". The main clutch lever is shifted to "on" position when the clutch is engaged, and the power is transmitted through the main clutch to various parts of the tractor.

The second is "OFF". When the lever is shifted to this position, the drive force from engine is cut off within the main clutch. You should keep the main clutch lever to "off" position before starting engine so that the drive force may not be transmitted to various parts of the tractor.

The third is "Brakes". When the lever is shifted to "brake" position wheels are braked.

Note;

The main clutch lever should be gently operated towards "on" position. If the main clutch lever is shifted hastily to "on" when you are operating the tractor, it may start out suddenly or engine may stall.

5. Speed change lever.

With this lever, the speed can be changed from first to third, and reverse.

The speed change lever should be set at "neutral" position when you start tractor engine.

6. Sub-speed change lever.

There are two speed positions, "high" and "low".

Note:

You should not shift it "high speed" position at the time of reverse when operating on the field. That is very high speed and dangerous.

Refrain from using this speed for any works other than trailer work.

7. Rotary tiller and its speed change lever.

It has two speeds and neutral position. When the lever shifted to "high" position, the revolution of the rotary is fast and soil is pulverized fine. When the lever is shifted to "low" position, the revolution of the rotary is slow and the soil is pulverized coarsely.

Note:

In case it is difficult to shift the lever as mentioned in Paragraph 5, 6, 7, disengage the main clutch lever once, and then try again. It will be shifted easily.

8. Steering clutch lever.

This lever provided by the handle grips of right and left, transmits or cuts the power to the wheels of right and left. For instance, if you grip the right lever, the drive force is cut off in the right wheel, and the tractor turns to the right.

Caution:

When operating up or down steep slope, or driving a trailer refrain from using the steering clutch. You should steer by handle only.

If you steer by gripping this lever under the situation of a steep slope or trailer driving, the tractor turns to the right or left hastily. This is very dangerous.

9. Accelerating lever.

This lever regulates the engine revolutions and power. You should keep the acceleration lever at "start" position when you start tractor engine.

10. Rear wheel Light adjusting handle.

This handle is far the purpose of adjusting the tilling depth while

in field operation.
When the handle is turned to the right, the tilling depth becomes deep, and when turned to the left, the tilling depth becomes shallow.

11. Rear wheel pipe fitting handle.

The above mentioned the rear wheel hight adjusting handle is for making a slight adjustment in the tilling depth is required. But when deeper adjustment than that, you can get any depth by adjustment this handle.

12. Lubrication:

(a) For various wires.

A few drops of engine oil should be applied to the lubricating holes which are provided on the various wires, such as the steering clutch wires and accelerating wires etc.

(b) Moving and sliding parts.

Before every work, you should apply engine oil to various moving and sliding parts. They can be operated with ease and would not become rusted by lubrication with a few drops of engine oil.

13. Air inflating of tires.

The air pressure of tires should be 1.1 to 1.5 $kg/cm^2$ and the same pressure in both left and right tires must be kept.
When the pressure of right and left tires are diffierent, the tractor will not go straight forward. Keep the both tires in the same pressure.

14. Tread adjustment and tire change.

Set the magic bar on the rotary shaft or protrudent hook of the rear hitch, and lift up the handle. Then the magic bar acts as a support, and one wheel is lifted up from ground.
Remove the wheel tube pin and make tread adjustments or change tires.

Note:

When using the magic bar on a concrete floor or hard ground, be careful so that the tip of the magic bar may not slip.

15. Removal and attachment of rotary tilling Unit.

Remove the set belts or set nob of the sub-chain case (or counter-chain case). Loosen the rotary hitch bolts setting the rotary and rear hitch, and then pull out the front side of the sub-chain case from the main gear case at the connecting part.

(In case of model KL-781, pull out the sides of the counter-chain case from the rotary tilling unit and main gear case at the connecting parts).

How to attach the rotary tilling unit, the way of which is in the reverse order to the above.

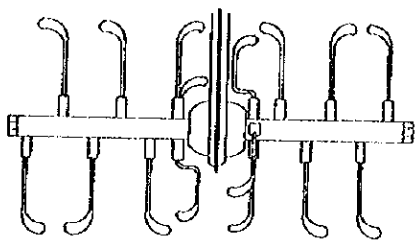
Note:

After removal, be sure to cover the connecting part of the main gear case with a rubber cap. (Model K-550 only).

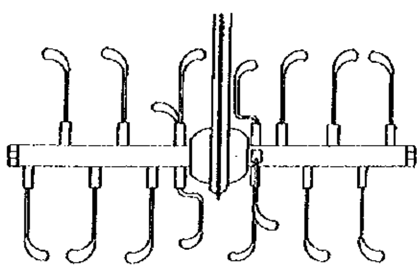
16. How to attach the tilling blades.

The ways of the blade setting are as follows:

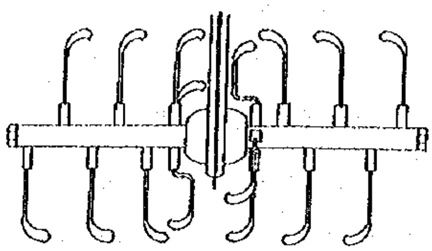
(a) Plain tilling



(b) Out-ward tilling

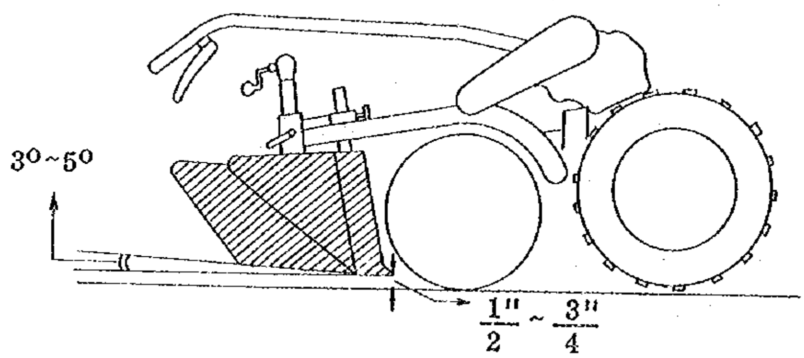


(c) In-ward tilling



17. How to attach ridger and adjustment.

Tilt the tractor forward, insert the shaft of the ridger through the bradkot of the ridger from underneath the rotary tilling cover, and then firmly tighten the ridger setting balt in a correct position. The adjustment of the ridger angle and the hight of ridger as shown in the following figures.



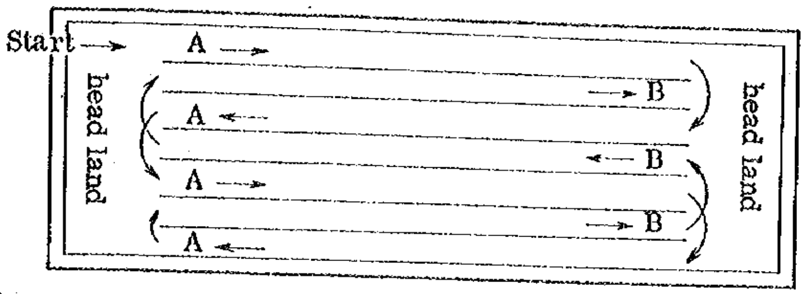

18. Rotary tilling, especially plain tilling.

There are many ways in the rotary tilling, but "every other space tilling method" is the most efficient way. It is the easiest and most popular.

(a) First till along the band of the partition. Next till the whole field leaving space narrower than the width of the rotary tiller.

(b) After you finish the above till the space which is left untilled by on the return way. In this case, the wheel will pass over the tilled place, so that tilling depth will be uniform.

(c) Finaly, till the head lands which are left untilled, and then the way is as follows:




19. Ridging.

The tip of the ridger should be set 1/2" - 3/4" high above the straight extended line of the tangest between the circumference of rotary and the circumference of the wheel.

When the ridger is raised higher than this standard position, the ridging becomes shallow. And when lowered, the ridging becomes deep.

(a) Till by "every other space tilling method" as paragraph 18 - a first. Next, attach the ridge and till the untilled parts, if the soil condition is good. It saves time for ridging.

(b) But, if the soil is bard it should be ridged after the tilling to over.

20. Cleaning after use and storage.

Be sure to wash off dirt which may have been clung to the various parts. After washing, be sure to wipe off the water and then apply engine oil to the various parts. It may prevent from being rusted if the machine would be stored for a long term.

CHAPTER III. PERIODICAL CHECKING POINT AND MAINTENANCE

remarks:

o refill-up # check.

x change + # clean & check, if defected it should be replaced.

| Item | Checking time | | | | | Descriptions |
|---|---|---|---|---|---|---|
| | daily | every 50h. | every 100h. | every 100h. | after seasonal work | |
| Cooling water | # o | | | | | Check water level and refill up to the desinated level. |
| Crank-case oil | # o | x | | | | Check oil level, the gauge is provided at the rear of engine and if oil level is lower than the central part of the upper and lower notched mark, it should be refilled up to the upper notched mark. If oil is dirty and viscosity has gone it should be replaced with new oil. Engine oil must be changed to new oil every 50 hours. |
| Fuel filter | | | + # | | + # | Remove the filter every 100 hours of operation, clean impurities on the inside and rinse the filter and filter strainer well with light oil. If strainer is damaged replace with a new filter. |
| Nozzle | | | | + # | + # | Check and clean thoroughly, if there is tendency that out-put has decreased. If the needle is not smoothly moving up and down, it must be replaced with a new nozzle. |

| Item | Checking time | | | | | Descriptions |
|---|---|---|---|---|---|---|
| | daily | every 50h. | every 100h. | every 100h. | after seaso-nal work | |
| Oil piping | | # | | | # | Check oil leakage from the piping and the screw of various parts whether loose or not after over 50 hours' use. |
| Fuel tank | | | | | + | Clean the interior of the fuel tank after operation of every seasonal work. |
| Air cleaner | #<br># | # | | | + #<br>+ # | When used in ordinary places, clean with kerosene or light oil.<br>When used in specially dirty places, clean every day, if the oil in side the air cleaner is dirty, replace with new oil. |
| Grinding of intake and exhaust valves, and valve seats. | | | | + # | + # | Be sure to clean and check, if it defected it should be regrind properly. And then the valve clearance should be made as following figure when engine is cold and the stroke is set at the top deadcenter of compression position.<br>ISEKI KD-70 & KD-90 ............0.28 m/m<br>KUBOTA ER-50 & ER-90<br>YANMAR ES & ESC ) .......0.2 m/m |
| Valve clearance, intake & exhaust | | | # | | | Check valve clearance after every 100 hours' use, if it is not correct, clearance should be adjusted properly. The standard valve clearance should be followed when engine is cold and the strok is set at the top deadcenter of compression position. |

<table>
<tr><th rowspan="2">Item</th><th colspan="5">Checking time</th><th rowspan="2">Descriptions</th></tr>
<tr><th>daily</th><th>every 50h.</th><th>every 100h.</th><th>every 100h.</th><th>after seaso-nal work</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>* ISEKI ED-70 & KD-90 ..... 0.28 m/m. ) Intake and<br>* KUBOTA ER-50, ER-90.... 0.2 m/m. ) exhaust valve<br>* YAMMAR ES & ESC ....... 0.2 m/m. ) clearance both<br>) are same.</td></tr>
<tr><td>Injection pump</td><td></td><td></td><td></td><td></td><td>#</td><td>Check and clean, if the pump is not properly working or out of order, replace with a new pump ass'y.</td></tr>
<tr><td>Piston rings</td><td></td><td></td><td></td><td></td><td>#</td><td>Check if there are seizing and wear off of the piston rings. measure the gap between the ends of the ring with a feeler gauge keeping the ring in the cylinder bore. If the gap is over 1.5 m/m. the ring should be replaced with a new one.</td></tr>
<tr><td>Bolt and nuts, bearings</td><td></td><td></td><td></td><td></td><td>#</td><td>Check and confirm that all are tight.<br>Tightening torque of bolts and nuts, excluding special bolts & nuts.<br>bolt size / torque kg/cm / Nut size / torque kg/cm<br>M 5 / 30 - 40 / M 5 / 60 - 70<br>M 6 / 60 - 80 / M 6 / 100 - 130<br>M 8 / 130 - 180 / M 8 / 250 - 350<br>M10 / 200 - 300 / M10 / 350 - 700<br>M12 / 500 - 600 / M12 / 900 - 1100<br>M14 / 700 - 800 / M14 / 1300 - 1500</td></tr>
</table>

| Item | Checking time | | | | | Descriptions |
|---|---|---|---|---|---|---|
| | daily | every 50h. | every 100h. | every 100h. | after seasonal work | |
| Belt tensioning | # | | | | | Check the bolt tensioning by pushing down the central part of the belt with your finger. If it bends by 10 m/m to 20 m/m, it is correct. |
| Set bolts for rotary time | # | | | | | Check it before every work, be sure to tighten the bolts nuts securely. |
| Lubrication:<br>Main gear case<br>rotary case | | #<br>#<br># | | | | Check oil level every 50 hours' use. If it is lower that the described line, refill with new oil of the same kind. If oil is very dirty or after one year's use, replace with new oil.<br>Q'ty of filling oil:<br>Model — Q'ty<br>*main gear case: KL-7S1 — 4 liters; KR-850 — 5.3 "; K -550 — 4.7 "<br>*rotary case: KL-781 — 0.5 "; KR-850 — 2 "; K -550 — 1.5 " |
| Counter chain case | | # x | | | #+x | Check and apply with new grease. |
| Wires, moving joints | | # | | | ÷ | Check and apply engine oil if necessary. Remove all kinds of wires and clean with clean kerosene or light oil after season is over. |

| Item | Checking time | | | | | Descriptions |
|---|---|---|---|---|---|---|
| | daily | every 50h. | every 100h. | every 100h. | after seasonal work | |
| Bolts & Nuts | # | | | | | Check all the bolts & nuts. If it is loosened you must tight it securely before starting work. |
| Cleaning | + | | | | | Clean mud and dust with clean water after every work. |
| Storage | | | | | + | When machine is to be stored for a long time, be sure to apply new oil after it is cleaned well with water, and close the valve by putting the position at the compressed position. Be sure to drain the cooling water (water cooled engine only) |
| Tire | | | | | | Check inflation of tires before use. If pressure is not enough or the inflations of the right and left are different, make the both have the proper and same pressure. |

| TROUBLES | POSSIBLE CAUSES | CORRECTIVE ACTION |
|---|---|---|
| A. Engine does not start in spite that cranking-up is easy | Speed lever is not in the "start" position. | Set the speed lever at correct "start" position. |
| | No fuel in the tank or there is air in the fuel line. | Fill-up fuel in the tank, and then loosen the air breather bolts which are provided on the fuel filter and fuel pump, wait until disappear bubbles in the flowing fuel, and then tighten the air breathing bolts. |
| a-1. It has no noise of the fuel injection or the noise does not come regularly when you turn up the starter handle several times by hand. | The injection nozzle is not properly working or fuel pump has a defect. | Clean the injection nozzle with light oil nicely. In case of defect of parts replace with new parts. |
| | | Check the injection pump and if it has defect, replace with new parts. |
| a-2. Fuel has water in the tank. | | Drain off all the fuel from the tank and clean nicely, and then refill with pure fuel. |
| a-3. Compression pressure is not enough or less than required when you turn the cranking handle by your hand. | Improver vlave clearance. | Adjust it properly. |
| | Engine-oil is defected. | Replace with new oil. |
| | Valve seats are defected. | Regrind and correct them. |
| | Improper valve timing. | Adjust it properly. |
| | Engine head tightening nuts are losened or head gasket packing is defected. | Tighten the nuts securely or replace with new part. |

| TROUBLES | POSSIBLE CAUSES | CORRECTIVE ACTION |
|---|---|---|
| | Piston rings are worn out or broken. | Replace with new parts. |
| | Valve spring is broken. | Replace with new part. |
| | Mesh of air filter is clogged. | Clean with light oil nicely. |
| a-4. Governor trouble | Governor is not in proper action. | Correct it properly. |
| B. In case cranking up is heavy with the decompression lever | Engine oil is not proper or defected. | Change oil with correct viscosity. |
| | It is seizing on to the moving joints. | Clean and correct it, if it is defected, replace with new parts. |
| | Improper tappet clearance or Valves are touching the piston when cranking up. | Adjust it properly. |
| | Gear is engaged with another. | Take off the engaged gear. |
| | The moving part has cought something. | Take off the strange material. |
| C. Engine has suddenly stopped itself | Fuel is just finished. | Fill up fuel. |
| | Fuel line has bubbles. | Take off the bubbles according to the method in paragraph A. |
| | Fuel is not a proper kind or water is mixed in the fuel, | Take out all the fuel from the tank and clean nicely in the fuel tank. then fill up proper kind of fuel. |
| | Over loading. | Reduce the load. |
| | Valve springs break down. | Replace with new parts. |

| TROUBLES | POSSIBLE CAUSES | CORRECTIVE ACTION |
| --- | --- | --- |
| c-1. Cranking up is heavy inspite of off-clutch. | Engine is over heated & seizing on moving part. | Check up the several moving part, if it is defected by over heating replace with new parts. |
| | | In case of air cooled engine: check the net of cooling air inlet, if it clog by dust, clean out it nicely. |
| | | In case of water cooled engine: check up cooling water level, if water level is less than described line, refill up clean water to described line. |
| | Valves are seized or valve guide is broken. | Check up and defected should be replaced with new parts. |
| c-2. Cranking up is easy at the of off position of clutch | Transmission or Rotavator has trouble | Check up and correct it. |
| D. Engine stops when at the slow rotation | Over loaded. | Reduce loading. |
| | Improper valve clearance. | Adjust it properly. |
| | Governer is not properly working. | Correct it, if some parts are defected replace with new ones. |
| | Water is mixed in the fuel. | As paragraph A-2. |
| | It is caused as paragraph A-3. | As paragraph A-3. |
| E. In case of abnormal sound of explosion. | Fuel filter is clogged with dust. | Clean nicely and operate. |
| | Fuel pipe is clogged with dust. | As paragraph A. |

| TROUBLES | POSSIBLE CAUSES | CORRECTIVE ACTION |
|---|---|---|
| | Governor mechanism is not properly working. | Check up and makt it properly. |
| F. Out put power of Engine is not sufficient. | Fuel is not a proper kind. | It should be changed to proper kind. |
| | Engine oil is not a proper kind or defected. | Replace with new oil of proper kind. |
| f-1. Over heating. | The cooling air inlet mesh is clogged with dust. | Clean it nicely. |
| | The cooling fan is broken down. | Replace with new parts. |
| | Fan belt is loosened or broken down. | Should be tightened properly or replace with new parts. |
| | Governor mechanism has improper working. | Check and correct it properly. |
| G. Engine is hunching | Governor spring is defected. | Replace with new parts. |
| | Injection timing is not correct. | Correct it properly. |
| | Valve mechanism has improper functioning. | Check and correct it properly. |
| H. Engine has irregular knocking sound. | Injection pump is improperly functioning. | Check and correct it properly. |
| | Injection nozzle is improperly functioning or carbon clings to the nozzle | Check up the nozzle opening pressure and should make 140 $kg/cm^2$ or, clean off carbon nicely. |

| TROUBLES | POSSIBLE CAUSES | CORRECT ACTION |
|---|---|---|
| h-1. You hear different knocking sounds when engine rotates. with inertia after you suddenly take back the acceleration lever from the high acceleration position. | Moving parts are defected. | Dis-assemble and repair it or replace with new parts. |
| I. Fuel comsumption is too much | Fuel pipe jointing nuts are loosened. | Tighten it securely. |
| | Fuel tank or fuel pipe has a crack same as paragraph A-3. | The crank should be repaired as paragraph A-3. |
| | Air cleaner is clogged with dust. | Clean it up nicely. |
| | Over loading. | Reduce to normal loading. |
| | Governor mechanism is not properly functioning. | Check and correct it. |
| J. Oil comsumption is too much. | Oil is leaking from Gasket packings. | Retighten the tightening bolts, or roplace the gasket packing with new parts. |
| | Oil pipe is cracked. | Repair or replace with new parts. |
| | Oil pipe setting bolt is loosened. | Tighten it securely. |
| | Oil seal is defected. | Replace it with new parts. |
| | Oil viscosity is improper. | Replace with new oil. |
| j-1. The exhaust smoke has white colour too much. | Piston ring or cylinder is vorn off, and then the lubricating oil is burning. | Replace with new parts, or cylinder should be bord and then choose an over sized piston and piston ring. |

| TROUBLES | POSSIBLE CAUSES | CORRECT ACTION |
| --- | --- | --- |
| K. Engine is over rotation | Adjusting screw is not at correct position. | Set to correct position and make it to the designated r. p. m. |
| | Smoke set lever does not return properly. | Check, and make it properly function. |
| L. Engine rotation does not return to the idling revolutions when the accelerator is returned. | Accelerator cable is rusted. | Clean it or replace with new parts. |
| M. Oil or smoke is coming out from the breather | Engine oil level is not correct. | Fill up to the described line. |
| | Some parts in motion are seized etc. | Replace with new parts. |
| | Piston-rings are worn out. | Replace with new parts. |
| N. Smoke comes out in a bad colour | | |
| n-1. Excessively bluish | Oil viscosity is too low. | Refill with new oil. |
| | Compression pressure is not enough. | As paragraph A-3. |
| | Valve mechanism is defected. | Check and correct it. |
| | Piston ring is worn out. | Replace with new parts. |
| | Injection timing is improper. | Adjust it properly. |

| TROUBLES | POSSIBLE CAUSES | CORRECT ACTION |
|---|---|---|
| n-2. Excessively blackish | Fuel is not proper kind. | Drain and refill with a proper kind. |
| | Smoke set-lever is defected. | Repair it. |
| | Injection timing is not correct. | Adjust it properly. |
| | Injection nozzle is not properly functioning. | Repair or replace with new parts. |

# STUDY ON WATER USE IN THE DRY ZONE



October 1974

By T. Mase

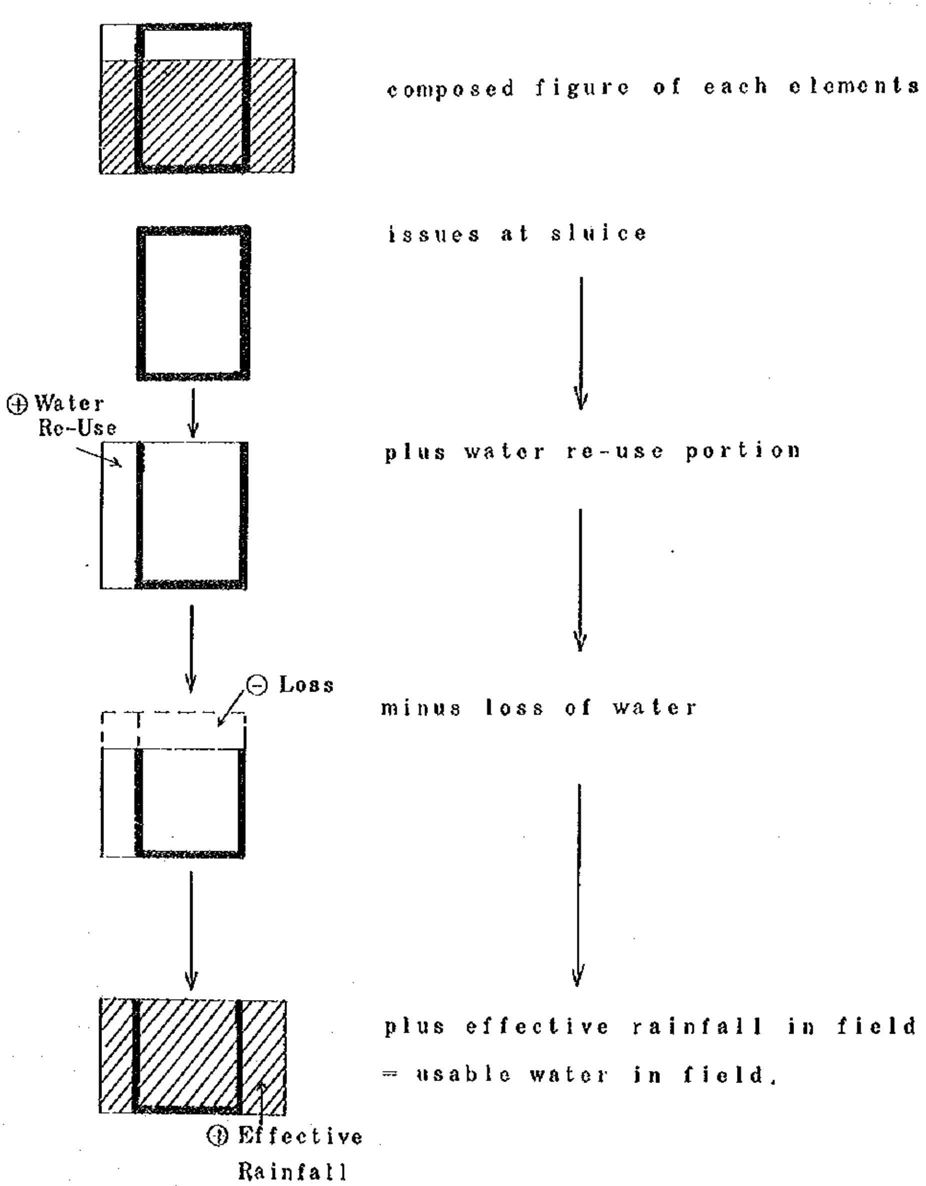
## 1. Preface

It is generally said that the consumptive use of water in a paddy field of the Dry Zone is about 4 to 6 Ac. ft., but one does not know how this inference was reached, or whether what is meant is water issued at sluice or water required in field. To get precise values on water-use is very important not only with regard to planning of proposed irrigation schemes but also to reasonable water allocation in existing irrigation schemes. In order to gain sufficient values which can be used for these purposes, we must obtain a lot of data by means of broad-scaled and carefully measured investigation in the future. However, going on this supposition, our Japanese irrigation engineers have tried tentatively a method of approach to final conclusions on water in the paddy field based on our inspection tours in the Dry Zone and other data. We are glad that this trial report would prove helpful for the sake of future studies in this country.

## 2. Elements composing Water-Use

The words of "Gross duty of water" and "Nett duty of water" are used often, but herein we would like to define that water-use is composed of elements shown in Fig.-1 and pursue consequently "Issues at sluice" and "Usable water in field". As "Usable water in field" means final quantity of water which is offset in many factors throughout from sluice to field, in total quantity of each scheme it is to be met equally to total quantity of "Water required in field" by adopting suitable cultivation pattern or reasonable cultivation acreage. Here, "Water required in field" can be called to necessary quantity of water physiologically for paddy plant, as shown in the next section.

Fig-1



### 3. "Water Required in Field"

As the study on "water required in field" has been done in full detail from physiological point mainly by Maha Illupallama Agrarian Research Institute, it seems that further studies on the water required in field are not so essential from the stand point of irrigation engineering. Therefore, we will describe here only a concept of component elements of it, and we will introduce a result of tentative calculation on it by Maha Illupallama.

As shown in Fig.-2, water consumption in field consists of the following 5 elements:-

(1) evaporation from soil surface

(2) percolation to under-soil

(3) transpiration from paddy plant

(4) seepage from surrounding ridge

(5) groundwater runoff

Of the above mentioned elements (1) to (3) are indispensable water consumption physiologically but (4) and (5) mean an absolutely unnecessary waste of water. Thus the water required in field coincides to (1) to (3), and we deal with (4) and (5) as loss of water in this report.

Meanwhile, this evaporation, percolation and transpiration come to change with conditions of meteorology, soil, height of groundwater and yield of paddy of each area. For example, suppose an area sited in a low place of the Wet Zone, consists of alluvial soil with low permeability, and gets low yield of paddy crops like 30 bushel/AC. In this area we can suppose following results,

(1) low degree of evaporation from field surface due to many rainy or cloudy days

(2) low degree of percolation through soil due to low coefficient of of permeability and high groundwater

(3) low degree of transpiration from paddy plants due to poor growth.

Consequently we can say that in the above mentioned area the water required in field will be reduced.

Fig-2

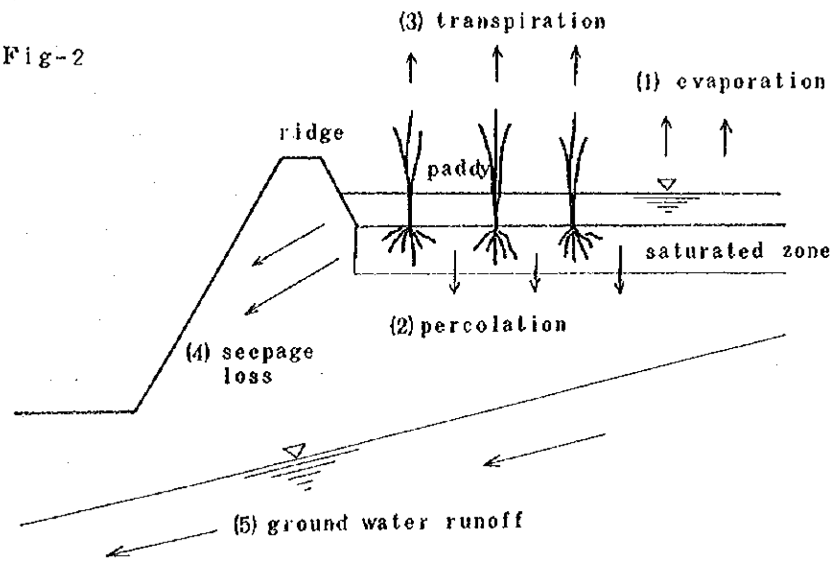


Table - 1, as an example of the opposite case, shows a tentative calculation of the water required in field done by Maha Illupallama.

Table - 1. Tentative Calculation on "Water Required in Field" According to Maha Illupallama

| Period | Description | Maha | Yala |
|---|---|---|---|
| Preparation of field | Water required for tilling, puddling, levelling and maintaining | 6.7" | 7.1" |
| From sowing to transplanting | evapotranspiration | 0.13" x 20 days 2.6" | 0.26" x 20 days 5.7" |
| From transplanting to harvest | evaporation | 0.13" x 100 days x 0.54 7.0" | 0.26" x 110 days x 0.54 15.1" |
| | Transpiration | 0.134 x 70 bushel/AC 9.4" | 0.178 x 70 bushel /AC 12.4" |
| From sowing to harvest | Percolation | 0.28" x 120 days 33.6" | 0.28" x 130 days 36.4" |
| | Total | 59.3" = 4.9 ft. | 76.2" = 6.4 ft. |

That is to say that water of 4.9 ft./AC in Maha cultivation and 6.4 ft./AC in Yala cultivation is required in field in order to gain 70 bushels/AC yields at Maha Illupallama area.

## 4. Main Points of this Report

As stated above, there may be a noticeable difference in the water required in field between the Wet Zone and the Dry Zone because of different conditions of climate, etc. But if one concentrates one's study only on the Dry Zone, it seems that there may not be a big difference between each area and that the water required in field of each area may be adjusted to approximate that of Maha Illupallama. Thus the most influential factors which make each irrigation scheme in the Dry Zone different in consumptive water seem not the water required in field but other subjects, i.e., water re-use ratio, loss ratio, and effective rainfall ratio in field. Besides these factors are assumed to be influenced by scale and topographical condition of each irrigation scheme. Therefore the main points of this report will be the above mentioned factors. In the following section we will show the results of our calculation in Table - 2 on water use of each irrigation scheme and subsequently explain calculation ground of each item.

| Item No. | Description | Dimension | Dewahuwa | Rajangana | Padawiya | Minneriya | Elahera | Gal Oya | Uda Walawe | Mahakanadarama |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Irrigated acreage | AC | 2340 | 17400 | 14300 | 15000 | 7500 | 121000 | 30000 | 6000 |
| 2 | Cultivation pattern | - | one time paddy | two times of paddy & others | two times of paddy | two times of paddy | two times of paddy | two times of paddy & others | two times of paddy & others | two times of paddy |
| 3 | Acreage in terms of paddy | Ac | 2340 | 14900 | 14300 | 15000 | 7500 | 116000 | 25000 | 6000 |
| 4 | Irrigation procedure | - | Tank No.1 | Tank No.2 | Tank No.1 | Tank No.1 Supply Ch.1 | Anicut No.1 stream supply | Tank 21 Nos. | Tank 2 Nos. | Tank No.1 |
| 5 | Total catchment areas of tanks | Sq.Mls. | 26 | 357 | 208 | 96.6 | - | 685 | 519 | 126 |
| 6 | Total storage capacity of tanks | 1000 AC.FT. | 8.8 | 87 | 81 | 110 | - | 1050 | 232 | 34 |
| 7 | F.S.L. areas of reservoirs | AC | 750 | 6000 | 6900 | 4500 | - | 38400 | 11300 | 1500 |
| 8 | Rainfall in S.D.Y. | Ins. | 52.5 | 43.8 | 54.6 | 55.5 | 55.5 | 67.6 | 45.7 | 44.2 |
| 9 | Yield from Catchment | 1000 AC.FT. | 16.0 | 183.5 | 133.2 | 62.9 | - | 543.3 | 278.3 | 65.3 |
| 10 | Evaporation loss from tank surface | 1000 AC.FT. | 1.2 | 9.5 | 10.9 | 7.1 | - | 60.7 | 17.9 | 2.4 |
| 11 | Useful yield at tank | 1000 AC.FT. | 14.8 | 1740 | 122.3 | 55.8 | - | 482.6 | 260.4 | 62.9 |
| 12 | Inflow from other catchment | 1000 AC.FT. | - | 34.2 | - | 89.9 | 100.4 | - | - | - |
| 13 | Total available for irrigation | 1000 AC.FT. | 14.8 | 208.2 | 122.3 | 145.7 | 100.4 | 482.6 | 260.4 | 62.9 |
| 14 | Issues at sluice, per-acre-basis | FT./AC. | (6.3) | (14.0) | (8.6) | (9.7) | (13.4) | (4.2) | (10.4) | (10.5) |
| 15 | Shape co-efficient of each scheme | - | 0.42 | 0.45 | 0.55 | 0.57 | 0.43 | 0.75 | 0.45 | 0.52 |
| 16 | Water re-use ratio | % | 11 | 18 | 24 | 28 | 17 | 67 | 25 | 17 |
| 17 | Total quantity of water re-use | 1000 AC.FT. | 1.6 | 37.5 | 29.4 | 63.4 | 17.1 | 323.3 | 65.1 | 10.7 |
| 18 | Loss ratio including conveyance & field | % | 40 | 37 | 31 | 29 | 39 | 22 | 37 | 32 |
| 19 | Total quantity of water loss | 1000 AC.FT. | 5.9 | 77.0 | 37.9 | 65.7 | 45.3 | 106.2 | 96.3 | 20.1 |
| 20 | Effective rainfall in field | Ins. | 11.0 | 14.1 | 21.45 | 22.6 | 16.7 | 36.2 | 14.7 | 16.4 |
| 21 | Total quantity of effective rainfall | 1000 AC.FT. | 2.1 | 20.4 | 25.6 | 28.3 | 10.4 | 365.0 | 36.8 | 8.2 |
| 22 | Usable water in field | 1000 AC.FT. | 12.6 | 189.1 | 139.4 | 171.7 | 82.6 | 1064.7 | 266.0 | 61.7 |
| 23 | Usable water in field, per-acre-basis | FT/AC | (5.4) | (12.7) | (9.7) | (11.4) | (11.0) | (9.2) | (10.6) | (10.3) |

## 6. Explanatory Note of Each Item

Item 1. Irrigated Acreage (AC).

This has been decided as a result of investigations made during an inspection tour. But that of Uda Walawe was adopted according to the existing R.B. acreage, because tank water has been issued only to R.B. so far.

Item 2. Cultivation Pattern.

It is described approximately in order to adjust to the following values, i.e. effective rainfall in field, etc. Because if there is no cultivation in Yala like in Dewahuwa, we cannot use any amount of effective rainfall in field during Yala season.

Item 3. Acreage in Term of Paddy (AC).

There may be a remarkable difference in water consumption between paddy and other crops. Meanwhile, this report is made by unifying the whole of calculation into paddy cultivation. Therefore acreage of other crops has been converted into acreage of paddy cultivation by means of assuming water consumption ratio of each crop as follows.

Rajangana: Out of 17400 AC, 3800 AC is lift-irrigated area for chillies, onions and other subsidiary crops, and water consumption in average for the above crops may be $\frac{30" + 18"}{2} = 24" = 1/3$ of paddy case

$\therefore$ acreage in term of paddy $= (17400 - 3800) + \frac{3800}{3} = 14900$ AC

Gal Oya and Uda Walawe: As same as the above, the water consumption for sugar cane may be about 1/2 that of paddy. Then, acreage in term of paddy for Gal Oya $= (121,000 - 10,000) + \frac{10,000}{2} = 116,000$ AC.

acreage in term of paddy for Uda Walawe

$= (30,000 - 10,000) + \frac{10,000}{2} = 25,000$ AC.

Item 4. Irrigation procedure.

Each scheme is irrigated respectively with one tank, many tanks, an anicut, a diverted channel, or stream flows as shown in Item 4 column.

Item 5. Total catchment areas of tanks (sq. Mls.).

For example, Gal Oya Scheme has 21 tanks from which catchment area water can be expected to be used in the Scheme. Therefore the total catchment areas of tanks are written in Item 5 column.

Item 6. Total storage capacity of tanks (1000 AC. ft.)

As same to Item 5, total capacity is written in Item 6 column.

Item 7. F.S.L. areas of reservoirs (AC).

In order to use this value in Item 10 - evaporation loss from tank surface - F.S.L. areas of reservoirs are written in Item 7 column.

Item 8. Rainfall in S.D.Y. (Ins.)

S.D.Y. means Standard Dry Year. During the last few years the characteristic droughty condition of the Dry Zone has prevailed, so it is intended to study water-use of each scheme in this report under the Standard Dry Year. Here 75% quantity of rainfall will be adopted of last average records as annual rainfall of S.D.Y.

Incidentally the rainfall records of following stations have been used for each scheme.

| Name of Scheme | Name of Station | Name of Scheme | Name of Station |
|---|---|---|---|
| Dewahuwa —— | Galewela | Uda Walawe —— | Embilipitiya Tank |
| Gal Oya —— | Gal Oya anicut | Rajangana —— | Maha Illuppallama |
| Mahakanadarawa—— | Mihintale | Elahera —— | Minneriya |
| Padawiya —— | Kebitigollewa | Minneriya —— | Minneriya |

Item 9. Yield from catchment area (1000 AC. ft.)

= (5) x (8) x 22%

where (5) : Item 5

(8) : Item 8

22% : runoff co-efficient of catchment area.

By means of the investigation in Dewahuwa Tank the supposed runoff co-efficient at 25% from October to March and as 15% from April to August, and on the other hand, by rainfall records of each area the supposed rainfall of both seasons, mentioned above, as 70% and 30% respectively.

Therefore, the annual runoff co-efficient

= 70% x 25% + 30% x 15% = 22%.

Accordingly it is assumed that there is no spill-over of tank water in the Standard Dry Year.

Incidentally about 80% of yield from catchment area is gained during Maha Season (from October to March) according to the above mentioned calculation.

Item 10. Evaporation loss from tank surface (1000 AC.ft.)

The annual evaporation loss from tank reservoirs seems to be fairly large. In Japan this loss is assumed to meet about 5% of tank storage.

It is supposed this value to 4 mm/day = 0.16"/day = 0.013 ft/day in annual average by means of results of investigation by an evaporation pan measurement and of the data of Maha Illuppallama. On the other hand, although acreage of tank reservoir is different in each season, it is supposed its acreage in annual average is to 1/3 of full water surface.

Thus annual evaporation loss from tank reservoirs will come to
0.013 ft/day x 365 days x 1/3 of tank acreage.

The results of the above calculation in % compared with tank yield are as follows.

| Name of Scheme | Evapo-loss in % | Name of Scheme | Evapo-loss in % |
|---|---|---|---|
| Dewahuwa | 7.5 | Uda Walawe | 6.4 |
| Gal Oya | 11.2 | Rajangana | 5.2 |
| Mahakanadarawa | 3.7 | Elahera | - |
| Padawiya | 8.2 | Minneriya | 11.3 |

Average 7.6% each scheme.

Item 11. Useful yield at tank (1000 AC.ft.) = (9) - (10).

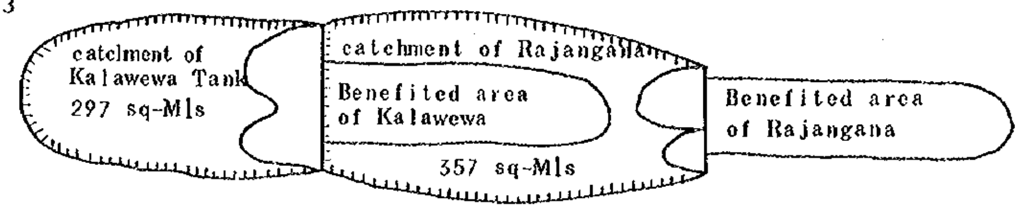
Item 12. Inflow from other catchment (1000 AC.ft.).

Three schemes, i.e. Rajangana, Minneriya and Elahera, only.

Rajangana:

As shown in Fig.-3, the benefited area of Rajangana scheme may obtain wasted-water from the benefited area of Kalawawa sited on the upper-stream of Rajangana in addition to the water from its own catchment.

Fig.-3



i.e. yield from catchment of Kalawewa tank

= 297 Sq. Mls. x rainfall in S.D.Y. 43.8" x runoff 22% = 152.6(1000 AC.ft.)

A quantity, which is deducted 10.0 of evapo-loss from the above 152.6 and is multiplied 24% of water re-use ratio, may be used at Rajangana Scheme.

∴ (152.6 - 10.0) x 24% = 34.2 (1000 AC.ft.)

The water re-use ratio will be explained later.

Elahera. Minneriya:

As shown in Fig.-4, three irrigation schemes, as mentioned below, are irrigated by four irrigation methods given.

The Name of Irrigated Scheme

(1) Giritale - 5400 AC

(2) Elahera - 7500 AC

(3) Minneriya - 15000 AC

The Irrigation Method

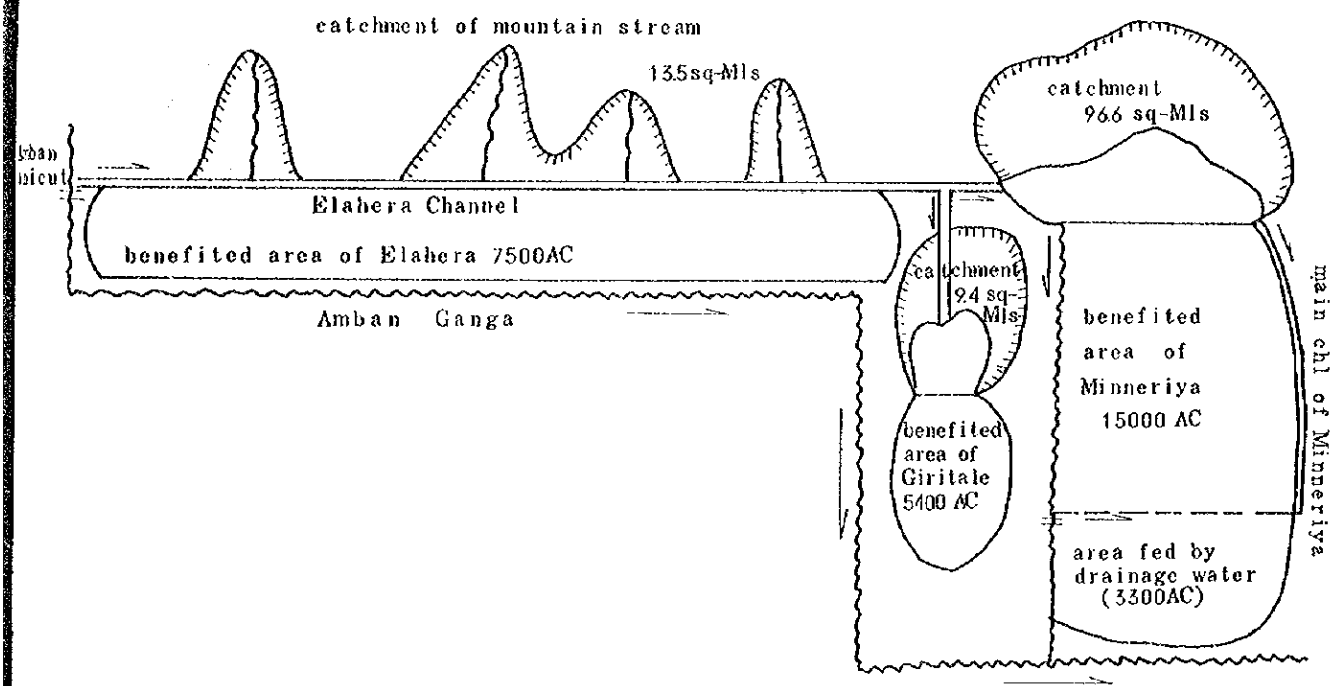
(1) Amban anicut

(2) Giritale tank

(3) Minneriya tank

(4) Stream flow

Fig-4



The above stated scheme is rather complicated, but according to investigations made at field office, the following method of irrigation may have been carried out.

Premise - At first: subsidiary water supply from Amban anicut to Giritale area must be done.

Next: subsidiary water supply from Amban anicut to Elahera and Minneriya must be done to be about same in water-use for both schemes.

The water received from Amban anicut during the last one year was 322.5 (1000 AC.ft.), but this amount seems to be about 20% higher than usual years because of the severe drought in the last Maha season. Therefore 322.5 x 0.8 = 260 (1000 AC.ft.) is adopted for available water from Amban anicut.

The quantity of water expected from each irrigation method is as follows:-

| | Catchment | Rainfall in S.D.Y. | Runoff co-eff | Evapoloss from tank | Useful Yield |
|---|---|---|---|---|---|
| Giritale tank | (9.4 sq.mls. x | 55.5" | x 22%) | - 1.58 x 800 AC | = 4.7 (1000 AC.ft.) |
| Minneriya tank | (96.6 sq.mls. x | 55.5" | x 22%) | - 1.58 x 4500 | = 55.8 |
| Mountain stream | (13.5 sq.mls. x | 55.5" | x 22%) | x usable ratio 20% | = 2.7 |

The annual water requirement in Giritable is not known, so 13ft/AC is assumed. Then the subsidiary water supply from Amban anicut to Giritale area will be -

5400 AC x 13 ft/AC - its own yield 4.7 (1000 AC.ft.) = 65.5 (1000 AC.ft.)

Accordingly, the balance of (260 - 65.5) = 194.5 (1000 AC.ft.) will be issued to Elahera and Minneriya so as to make both schemes about equal in water-use as follows.

$$\frac{\{\text{supplied water from Amban anicut } (x) + \text{yield of mountain stream } (2.7) + \text{rainfall } (10.4)\} \times \{1.0 - \text{loss ratio } (0.39)\} \times \{1.0 + \text{re-use ratio } (0.17)\}}{\text{irrigated acreage of Elahera } (7500)}$$

$$= \frac{\{\text{supplied water from Amban anicut } (194.5 - x) + \text{yield of Minneriya tank } (55.8) + \text{rainfall } (28.3)\} \times \{1.0 - \text{loss ratio } (0.29)\} \times \{1.0 + \text{re-use ratio } (0.38)\}}{\text{irrigated acreage of Minneriya } (15000)}$$

As the result of the calculation, 100.4 (1000 AC.ft.) to Elahera and 89.9 (1000 AC.ft.) to Minneriya will be supplied from Amban anicut.

Item 13. Total available for irrigation (1000 AC.ft.)
= (11) + (12)

Item 14. Issues at sluice, per acre basis (FT/AC)
= (13) ÷ (3)

Item 15. Shape co-efficient of each scheme

As general observation, one may assume that water re-use ratio (A), loss ratio (B), and effective rainfall ratio (C) are the function of topographical slope (D).

That is -

$$A = \frac{1}{f(D)}$$

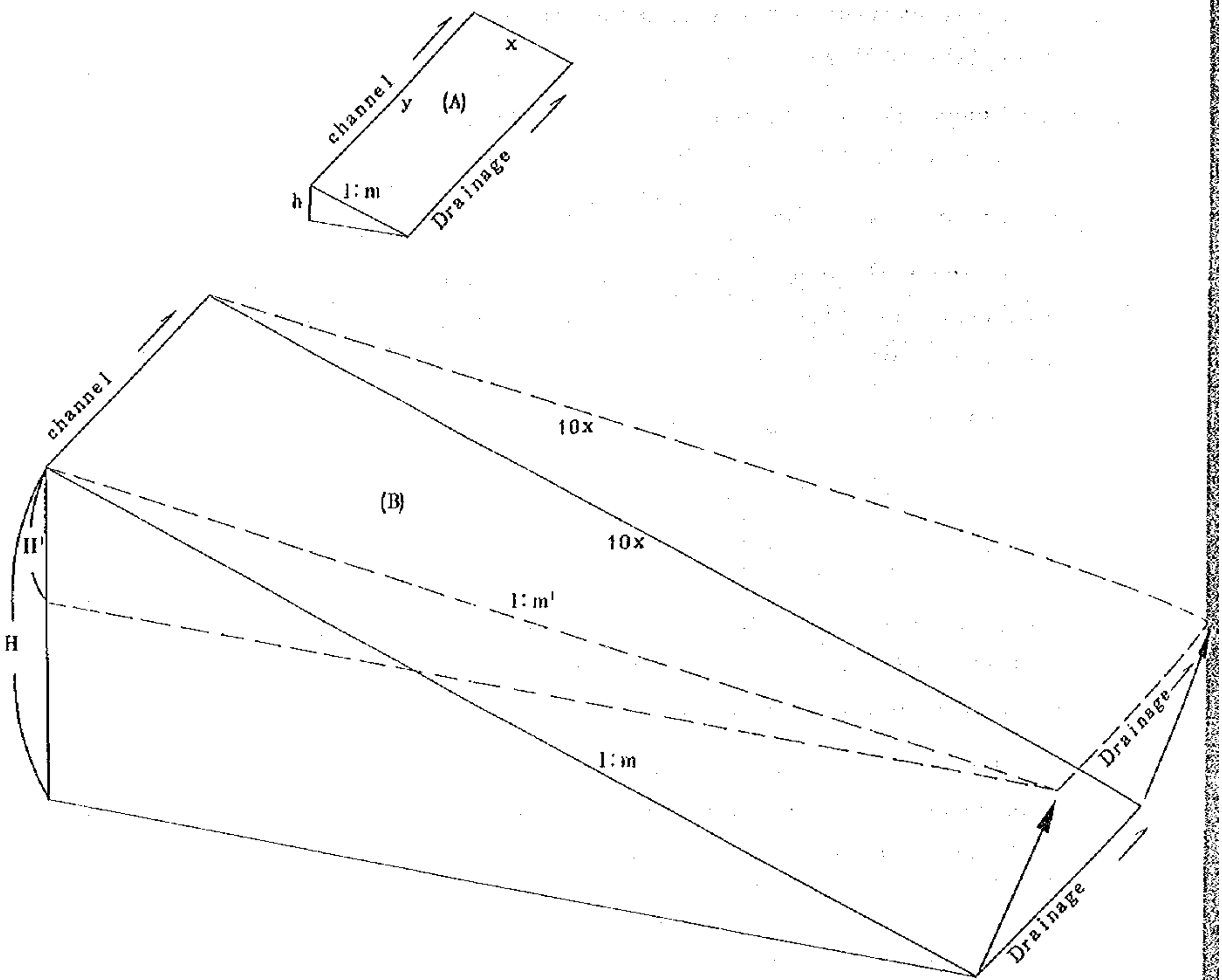
$$B = f(D)$$

$$C = \frac{1}{f(D)}$$

Accordingly, if the topographical conditions including slope gradient, elevations of channel and drainage, etc., are known, it might be possible to infer the above mentioned ratios.

But so far it has not been possible to get such data from each irrigation scheme, so each ratio has been surmised from the shape co-efficient as shown in the following (A) and (B) in Fig.-5.

Fig-5




y is the length of an edge which goes along contour lines or a channel and a drainage.

x or 10 x are the length of edges which go across contour lines.

If the slope gradient m of both is the same, the difference of elevation between the channel and the drainage in both will come to

$$H = 10\ h$$

It means that if h is 30 ft., H is equal to 300 ft., and conversely, that if H is 30 ft., h will meet to only 3 ft. But one can suppose that with an elevation of 300 ft., and a long slope will give rise to severe erosion on the surface of the paddy field, and simultaneously, one can suppose that 3 ft., is so small as the difference in height between the channel and the drainage that one cannot control the water in the paddy field.

Thus the above example shows that the difference between h and H is not so big in comparison with the difference between x and 10 x in the existing schemes -

$$\text{i.e. } H < 10\, h$$

and this inference means that the slope gradient of (B) scheme is not equal to that of (A) scheme but more gradual.

From the above description it is assumed that a ratio of

$$\frac{\text{length across contour}}{\text{length along contour}}$$

means not only a flat shape but a vertical tendency at "the existing schemes".

In this way the shape co-efficient is adopted as follows:-

$$\text{Shape co-eff} = \sqrt{\frac{\text{length across main channel of scheme}}{\text{length along main channel of scheme}}}$$

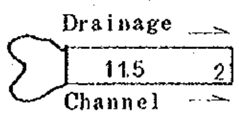
where, $\sqrt{\phantom{x}}$ does not have any reasonable base, but it is supposed that a vertical tendency cannot be simple proportional to the above ratio. So the relation between them is modified by using $\sqrt{\phantom{x}}$

The concrete calculations led by the shape co-eff from the one inch-one mile map are shown respectively as follows:-

Fig.-6 (on same scale)

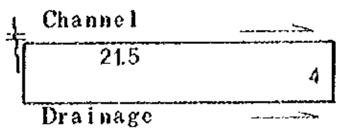
Dewahuwa

$$\sqrt{\frac{2}{11.5}} = 0.42$$



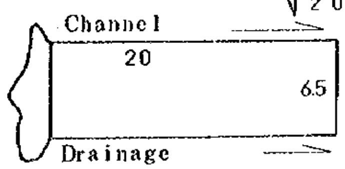

Elahera

$$\sqrt{\frac{4}{21.5}} = 0.43$$



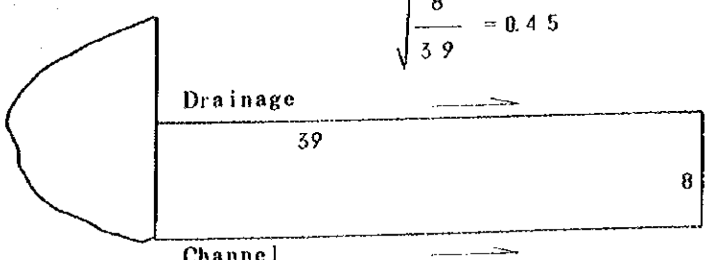

Minneriya

$$\sqrt{\frac{6.5}{20}} = 0.57$$

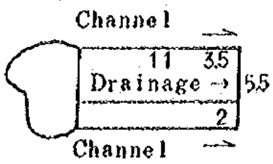



Uda Walawe

$$\sqrt{\frac{8}{39}} = 0.45$$

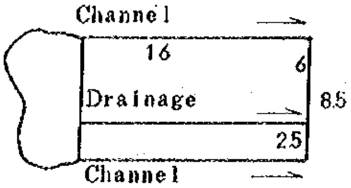


Mahakanadarama




$$\frac{3.5}{11} = 0.32, \quad \frac{2.0}{11} = 0.18 \rightarrow \sqrt{\frac{11\times3.5\times0.32+11\times2.0\times0.18}{11\times5.5}} = 0.52$$

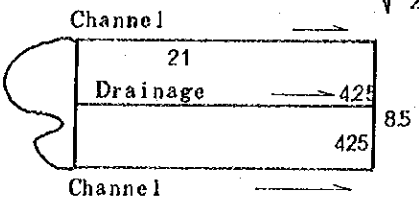
Padawiya




$$\frac{6}{16} = 0.38, \quad \frac{2.5}{16} = 0.15 \rightarrow \sqrt{\frac{16\times6\times0.38+16\times2.5\times0.15}{16\times8.15}} = 0.55$$

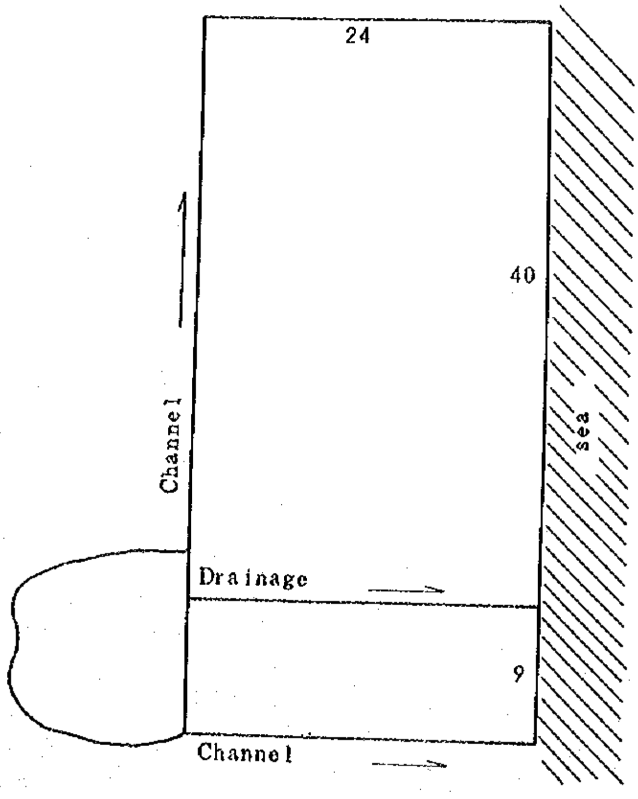
Rajangana

$$\sqrt{\frac{4.25}{21}} = 0.45$$




Gal Oya

$$\frac{24}{40} = 0.60, \quad \frac{9}{24} = 0.37 \rightarrow \sqrt{\frac{40\times24\times0.60+24\times9\times0.37}{24\times49}} = 0.75$$



Item 16. Water re-use ratio (%).

As shown in Fig.-4, out of 15000 AC's benefit of Minneriya Scheme, 3300 AC of the lower portion is irrigated completely by drainage. Accordingly one may say that the water re-use ratio of Minneriya is as follows:-

the quantity of wasted water in the upstream

= the quantity of required water in the downstream

then re-use ratio $= \frac{3300}{15000 - 3300} = 28\%$

Based on this ratio of Minneriya, it is assumed that the water re-use ratio of each scheme is according to the following formula -

$$28\% \times \frac{\text{shape co-eff of each scheme}}{\text{shape co-eff of Minneriya } 0.57} \times \sqrt{\frac{\text{length across contour of each scheme}}{\text{length across contour if Minneriya } 6.5}}$$

Where is used the factor of length across contour from Fig.-6, it is inferred that about this length the longer the more an opportunity of water re-use will become. But this opportunity may not simply be proportional to the above length. So the relation between them is modified by using $\sqrt{\quad}$ . As an example calculation of the above formula as used in Dewahuwa -

$$28\% \times \frac{0.42}{0.57} \times \sqrt{\frac{2}{6.5}} = 11\%$$

Item 17. Total quantity of water re-use (1000 AC.ft.) = (13) x (16)

Item 18. Loss ratio including conveyance & field (%)

See Fig.-2. In the figure, seepage loss (4) and ground-water runoff (5) are horizontal water-flow caused by the topographical slope of each scheme and are unnecessary water for paddy growth.

Generally the water losses in irrigation schemes are classified into

(a) channel-loss, and

(b) field-loss

But this classification is not so clear because both losses are similarly caused by the topo-slope. Therefore, both have been put together in this report.

According to the investigation made at Dewahuwa, a quantity of water flow measured in the main drainage at the end point of the scheme fluctuates more or less 50% of the quantity of the issued water from the tank-sluice. And of this flow, some portion may be due to an inflow from other catchment areas.

Then it is assumed that about 40% of the issued water from the tank will flow into the main drainage through channels and the paddy field. Of course, this refers to the loss ratio in Dewahuwa.

Accordingly, the following formula is adopted to decide the loss ratio of each scheme -

$$40\% \times \frac{\text{Shape co-eff of Dewahuwa } 0.42}{\text{Shape co-eff of each scheme}}$$

Item 19. Total quantity of water loss (1000 AC.ft.) = (13) x (18)

Item 20. Effective rainfall in field (Ins.)

According to the study on the water-use for Maha cultivation by a method of a balance calculation between demand and supply in each group of ten days, 11.0 inches of Maha rainfall can be used effectively in field. This amount means 30% of Maha rainfall of Dewahuwa.

Then it is assumed the effective rainfall of each scheme based on this 30% of Dewahuwa by means of adjustment using shape co-efficient as follows:-

$$30\% \times \frac{\text{Shape co-eff of each scheme}}{\text{Shape co-eff of Dewahuwa } 0.42} \times \text{rainfall of each scheme in S.D.Y.}$$

For instance, in Gal Oya

$$30\% \times \frac{0.75}{0.42} \times 67.6 = 36.2 \text{ Ins.}$$

Item 21. Total quantity of effective rainfall (1000 AC.ft.)
= (1) x (20)

Item 22. Usable water in field (1000 AC.ft.)

= (13) total available for irrigation.
+(17) total quantity of water re-use.
-(19) total quantity of water loss.
+(21) total quantity of effective rainfall.

This is the final value gained through addition and deduction as shown above.

Item 23. Usable water in field, per-acre-basis (FT/AC)
(22) ÷ (3)

## 7. Analysis

Upto this point "A method to determine annual water use in irrigation schemes of the Dry Zone" has been shown in Table-2 and its explanatory note. Then subsequently the analysis on it should be shown here. But each item in Table-2 is based on many assumptions and inferences, so any analysis on it will have to wait till broadscaled and carefully measure investigations are done later.

Therefore, only a summary on each value, which has been gained from Table-2, may be written as follows.

## 8. Summary on Table-2

Usable water in field, per-acre-basis, in Table-2 is also shown in Fig.-7 in comparison with "Water required in field" of Maha Illuppallama. If the water required in field of each scheme is nearly the same as the one for Maha Illuppallama, then Fig.-7 means all the schemes have the water more or less for both Maha and Yala cultivation, except Dewahuwa, which has the water only for Maha cultivation. Subsequently, each component, which is stated from "issues at sluice" (No.14) to "usable water in field" (No.23) is shown respectively in Table-3. Herein a very remarkable feature can be seen in the Gal Oya Scheme. That is to say that the total ratio of each component of Gal Oya 191% is in excess of the water quantity fed by its tanks and that the effective rainfall ratio 76%, too, is nearly tank-fed quantity. It means that the condition of Gal Oya on the water-use is rather similar to that of the Wet Zone.

Table-3. Each ratio comparing with issues at sluice.

| | Rajan-gana | Minne-riya | Ela-hera | Uda-walawe | Maha-kanda rama | Pada-wiya | Gal-Oya | Dewa-huwa | Ave-rage | Average excluding Gal Oya |
|---|---|---|---|---|---|---|---|---|---|---|
| Water Re-Use ratio | 18 | 28 | 17 | 25 | 17 | 24 | 67 | 11 | 26% | 20% |
| Water Loss ratio | -37 | -29 | -39 | -37 | -32 | -31 | -22 | -40 | -33% | -35% |
| Effect-ive Rainfall ratio | 10 | 19 | 10 | 14 | 13 | 21 | 76 | 14 | 22% | 15% |
| Total | -9 | 18 | -12 | - | -2 | 14 | 121 | -15 | 15% | ± 0% |

Therefore if each ratio of Gal Oya is excluded from the average of the schemes sited in the Dry Zone, then the average excluding Gal Oya will be changed as shown in the extreme right of Table - 3. Consequently, it may be possible to say that on a relation between "issues at sluice" and "usable water in field" is as follows:-

| |
|---|
| In the Dry Zone on an average |
| "issues at sluice" ÷ "usable water in field" |
| ∵ Water Re-Use ratio 20% |
| - Water loss ratio 35% |
| + Effective Rainfall ratio 15% = 0 |

Incidentally, the following assumptions may be permitted:-

( issues at sluice > usable water in field for schemes which have relatively
( steep topo-condition.
( issues at sluice < usable water in field for schemes which have relatively
( gradual topo-condition.

Fig-7 Usable Water in Field (annually)

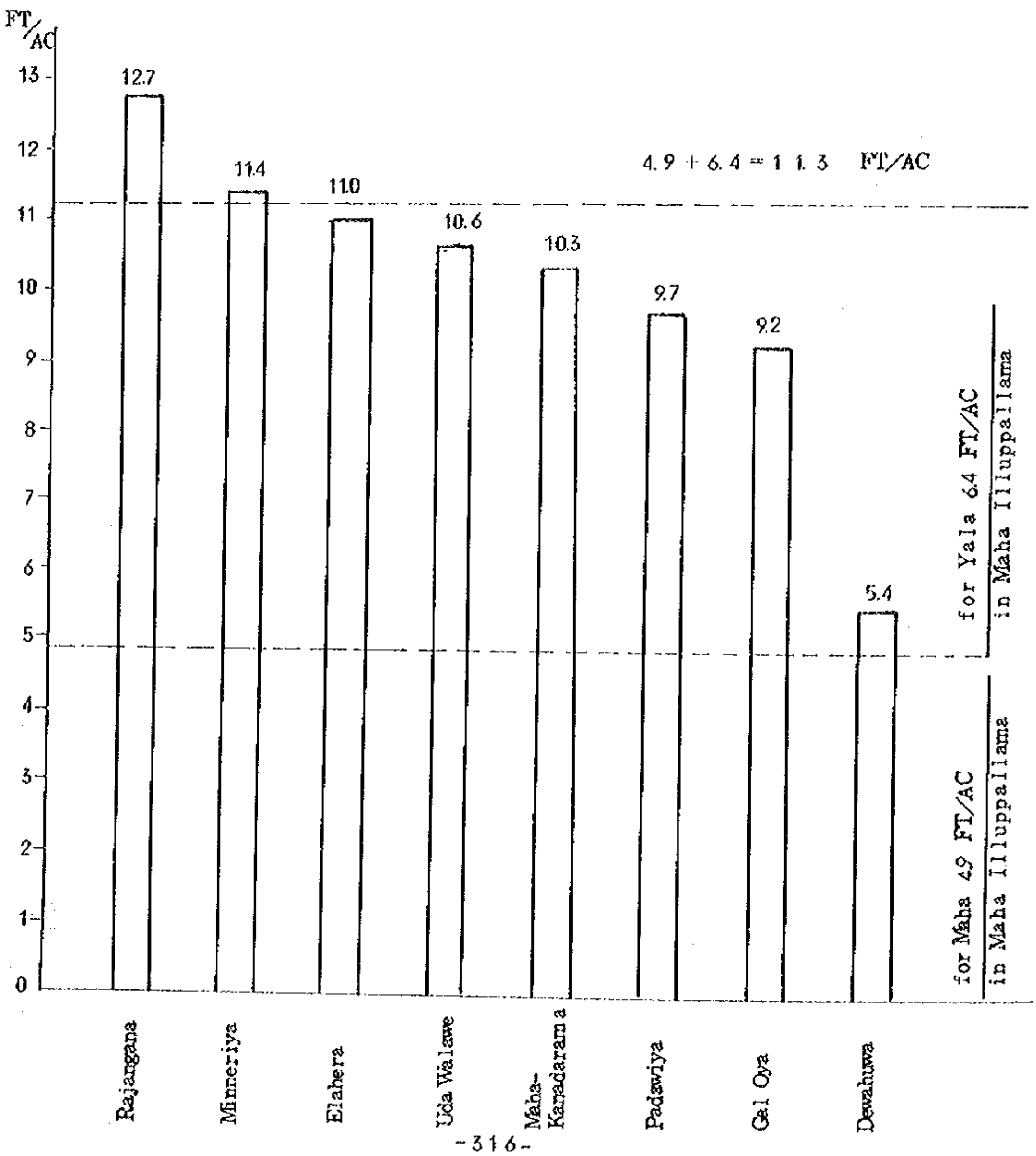
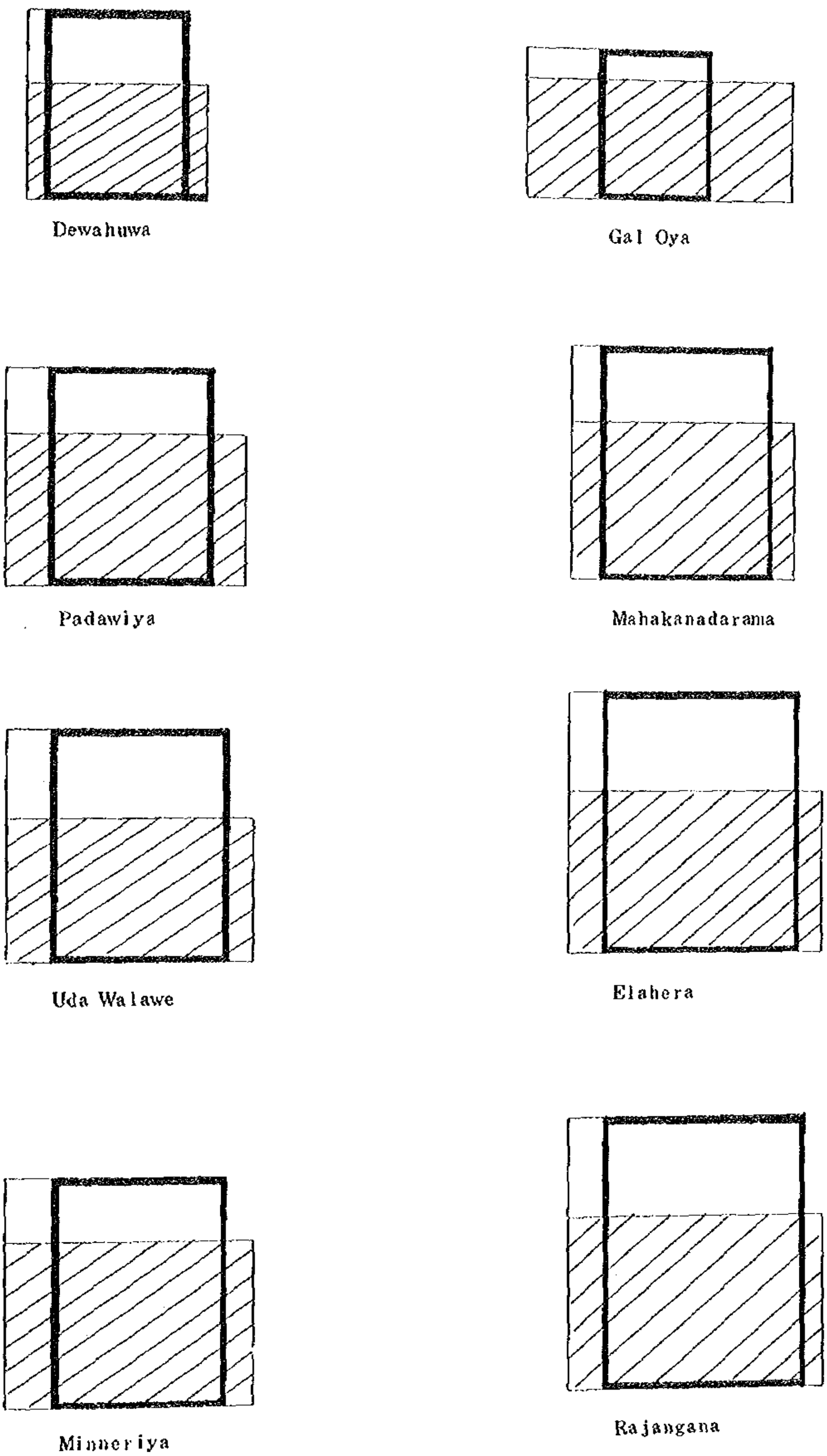


Fig-8 Figures Composed of Water-Use in Each Scheme (on same scale)



More over the figures thus composed of the water-use in each scheme are show in Fig.8.

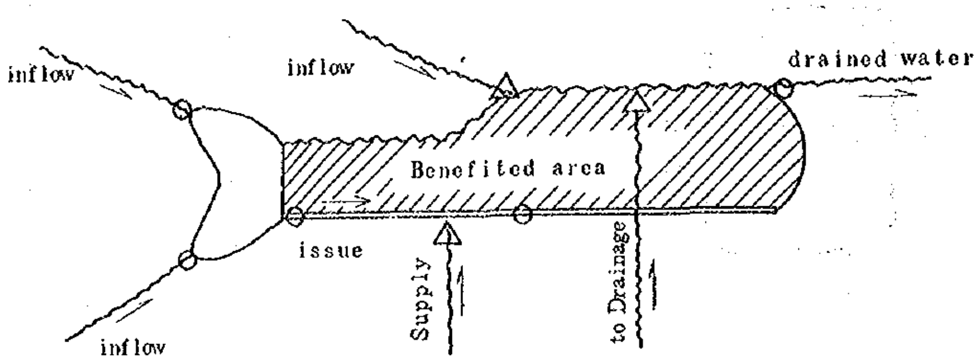
## 9. Subjects to be Studied in the Future

In order to gain more accurate results on water use in the Dry Zone and to use them effectively for optimum planning and management of irrigation schemes, the following studies will have to be done -

(1) To know the past records on both rainfall and acreage of cultivation over a long duration as much as possible, and to analyse the relation between them.

(2) To investigate the water balance in broad-scaled area. For example, in Dewahuwa, as shown in Fig. 09.

Fig.-9 Water Balance in Dewahuwa




o marked quantities of water can be measured by measuring devices but Δ marked ones cannot be measured due to lack of devices. So, to get accurate results about the water balance of Dewahuwa Scheme those marked Δ must be measured by some method in the future.

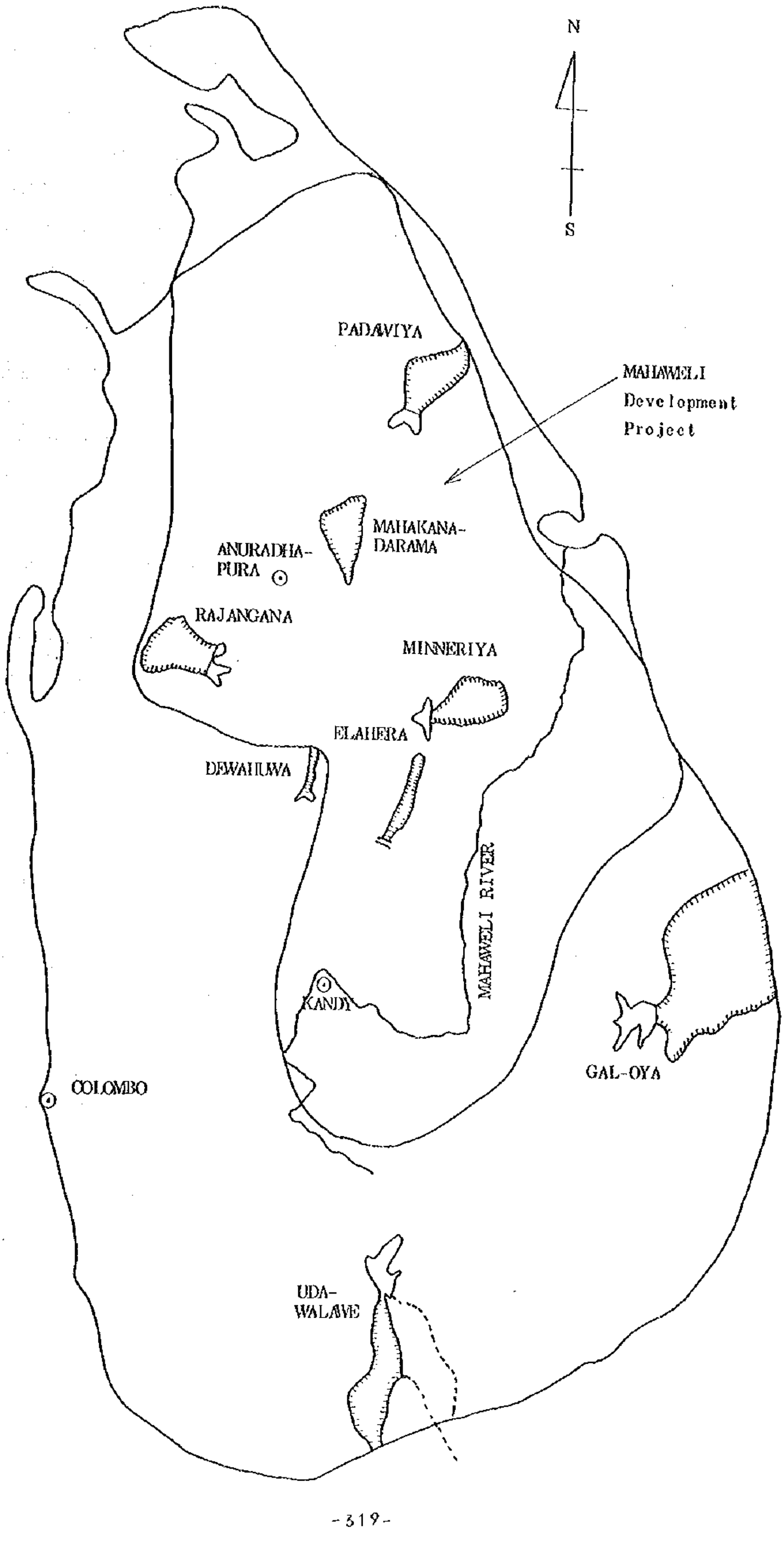
(3) To investigate the water balance in small-scaled area including the study on soil moisture, groundwater level, and paddy growth.

(4) As a result of the above mentioned study, several facts on water use will have to be clarified.

Accordingly the optimum method of water use in the Dry Zone may be proposed mainly from the stand point of irrigation.

Of course, the topo-condition of each scheme cannot be changed, but by understanding the facts on water condition of each scheme, one will be able to point out the method of improvement aiming at optimum water use.

Fig-10


N
S
PADAVIYA
MAHAWELI
Development
Project
MAHAKANA-
DARAMA
ANURADHA-
PURA
RAJANGANA
MINNERIYA
ELAHERA
DEWAHUWA
MAHAWELI RIVER
KANDY
GAL-OYA
COLOMBO
UDA-
WALAWE

Appendix 8 - 4

## STUDY ON DUTY OF WATER IN DEWAHUWA

### Introduction

In Dewahuwa, the phenomenon of severe water shortage was seen again in most of the fields in the Maha of 74/75, in spite of the great effort at water management made by the Project staff, especially the irrigation T.A.s.

The reasons for this, apart from the unusual climate condition of prolonged drought are the following:

1. The renovation of infrastructure, mainly land consolidation is still of very low standard in the whole Dewahuwa area including middle and down stream parts which is outside the direct project area, but irrigated by the Dewahuwa Tanka (as well as the project area).

2. Water management by farmers themselves (including administrative and socio-economic conditions under which they carry it out has not yet progressed especially in the branch and field channels and in the fields where the water management is not done directly by government officers. In short, we have not yet sufficiently established the conditions presented in the Feasibility Report ("F.R.").

### I. Idea shown in F.R.

In the "F.R." the duty of water is shown assuming that conditions of the modernised cultivation through the process of ploughing by two wheel tractors, row transplanting, weeding by machines or agro-chemicals, water management and so on --- have been established among farmers organized through a "mental revolution" after completing the infrastructural renovation. And this should be an advisible method of agriculture for paddy cultivation in future in the dry zone of the Island. And it is the main purpose of the Dewahuwa project to show its practicality here in Dewahuwa.

However, with the four years' experience since the beginning of the project, we have realized that (i) it is impossible to establish the above mentioned system in the whole of the Dewahuwa area (not only in the upstream project area) and (ii) that some standard figures for the planning of water use do not match with actual conditions here.

Therefore now we have studied again the planning on water use from the beginning consulting reports of Maha-Illuppallama and other institutes.

## II. Meaning of Irrigation water

Generally the following formulaes are used concerning "duty of water"

Net duty of water = Water requirement at field
- effective rainfall at field

Gross duty of water = $\frac{\text{Net duty of water}}{1 - \text{loss rate}}$

In the "F.R." and "D.R." the same diffinition is used too. But these terms are after used vaguely.

Therefore we want to clarify distinctly the meaning of "irrigation water" here. First we must distinguish between,

A. "the required amount of water in a field" and

b. "the required amount of water to be issued from the Tank sluice in the whole irrigation scheme.

### A) The required amount of water to cultivate paddy in a field

Here, we call this "required quantity of water at field", and this consists of,

i) necessary water to grow rice plants (water for growth)

ii) necessary water for preparation of cultivation such as ploughing (water for preparation)

iii) necessary water for secondary purpose such as weeding (water for weeding)

iv) percolation and evaporation (percolation & evaporation loss)

From the 4 factors shown above, "water for preparation" differs much depending on soil texture, climatic condition and method of ploughing.

We do not take into account water for weeding, particularly because in this project, weedisides and instruments are included in the calculation. (But only between 1st and 2nd ploughing, standing water is estimated here for the purpose).

### B) The necessary quantity of water to be issued from the Tank sluice for the whole area

This is necessary amount of enough water to issue required amount of water in entry field. Here we call this irrigation water or "gross duty of water".

These elements are difficult to be distinguished clearly, and usually it is calculated as mentioned before.

The loss in the formula consists of following two factors:

i) Conveyance loss in a narrow meaning and the quantity of water re-use which differ depending on the natural conditions such as topography, shape soil texture and ground water level, and standard conditions of infrastructural consolidation of the area.

ii) Other than physical factors shown in i), necessary quantity of water for operating the whole system, which depends on the ability of management of farmers and other responsible persons.

In other words, this is an unavoidable amount of supplementary water such as surplus water to keep the necessary water head to distribute or ineffective discharge caused by time lag and so on.

## III. Water requirement in the field

The quantity of water required in the field also depends on socio-economic conditions combined with natural conditions such as ploughing methods (Power; by men, by cattle, by machine; and with water or without water). Cultivation methods (varieties, transplanting or broadcasting) as well as natural conditions such as climate, geography, soil, ground water conditions.

### A) General

1. Water for growing paddy

i. Fundamental theory from institutes reports,
Many reports about water for growing paddy have been written in South Asian countries and Japan. Judging from these reports, it will be possible to say that a definite opinion has been established on this matter. Here we confirm it.

a) The basic method of water control is to keep shallow water continuously.
Naturally the most important point is how much water we can save here in the dry zone of Sri Lanka where water is very precious.

But Fig. 1 shows that most of the cases of saving water show a lower yield than the cases of shallow continuous standing water, except in the case where very complicated operation is done including treatment of stopping water in certain periods.

Taking the system as a whole there is scarce benefit in enlarging the irrigable area by saving water.

Fig. 2 shows the relation between used amount of water and yield in the case of keeping standing water; at 100% of soil moisture, and at 70% of soil moisture.

Roughly we can say that the more water we use, the more yield we get in lineal relation except in the case of complicated operation similarly to Fig. 1 unless we give marshy conditions.

Fig. 3 shows the relation between water level and yield. Compared to the case where water level is the same as soil surface, yield is less in the case where the water level is lower than soil surface, and the yield is higher in the case of standing water. About 2 inches of standing water gives the best yield.

b) Paddy is destroyed by stopping water in a certain period

In Fig. 4, effect of treatment by cutting water in several stages of growth of paddy is shown.

Cutting water in the stage around heading gives a deadly blow while cutting water during ineffective tillering period gives a negligible damage or gives even rather benificial results.

In Fig. 5, the effect by treatment of non-standing water in different stages of growth of paddy is shown. Naturally, the earlier and the longer the period is, the greater the effect but on the other hand the treatment of 20 days without water from the 30th day and the 50th day of growth gives rather good results.

ii. Practically advisiable method

From the above mentioned reports, generally speaking, it will be said that the best method of irrigation is to keep shallow standing water throughout the period, except in the ineffective tillering period, (to be dried up). In other ways, regardless of consuming more water or less water or less water it will result in less yield without exception.

A rotation system, which we adopted for these few years as the last resort in Dewahuwa, because of severe drought compelled to alternate deep water supply and no water at all. So it can hardly be said to be an advisiable method at least from the physiclogical point of view of paddy.

Dr. Murakami pointed out from his experience at Maha Illuppallama that paddy soil in the dry zone of Sri Lanka has so poor a water holding capacity and available moisture that once soil is dried up, the moisture content becomes very little and therefore rotation issue or cutting water treatment should be carefully planned.

2. Water for preparation

It seems a big debatable question yet as to whether it is always necessary to issue water for ploughing in the dry zone. However, the followings can be said qualitatively at present: A 4 wheel or 2-wheel tractor of high power can work even when soil is a little too hard or a little too soft. But for a 2-wheel tractor of 5 - 7 ps, that is a main power in Dewahuwa, it is necessary that soil is softened enough with rain or issued water. Therefore under the present situation in which any reliable long term weather forcast can not be got, it seems advisable to rely on issued water mainly and to close the main sluice only when there is enough rain (for the day). Otherwise we can not carry out the ploughing work on schedule and as the result of this more water will be used.

Based on this idea, it is proposed to issue water for preparation during the 1st and 2nd ploughing period in principle. (the treatment of effective rain will be mentioned later). First we want to consider the required amount of water for ploughing according to Dr. Murakami's empirical formula,

$Y = -0.31X_1 + X_2 + 9.9$ (cm) --- for the soil at Maha Illuppallama

$Y = -0.34X_1 + X_2 + 7.2$ (cm) --- for the soil at Paranthan (sandy)

here: $X_1$ : quantity of water in gramme included in 100 gr. of dried soil of 0 - 3 inch under the soil surface.

$X_2$ : sum of standing water, percolation and evaporation in water depth in centimeter.

Y : required amount of water in water depth to plough the soil within 8 inches under the soil surface.

Influence of the numbers of ploughing day.

Here is an example given to see the effect of the difference in the number of necessary days for ploughing per acre.

supposed: $X_1$ = 10 gr.

standing water = 5 cm

sum of evaporation and percolation = 1 cm/day

ploughing days; case A --- 1 day/acre

case B --- 4 days/acre

case A; $X_2$ = 5 cm = 1 cm/day x 1 day = 6 cm

$Y_A$ = 6 cm + 9.9 cm - 3.1 cm = 12.8 cm (0.42')

case B; $X_2$ = 5 cm + 1 cm x 4 days = 9 cm

$Y_B$ = 9 cm + 9.9 cm - 3.1 cm = 15.8 cm (0.52')

The number of necessary days for ploughing, which is a big factor in deciding the necessary amount of water as shown in the above example, depends largely on the manner and the capacity of ploughing, and the capacity of inlet discharge.

In the above example, the difference of net water requirement in the two cases, in the whole Dewahuwa area results in,

0.52' x 2340 ac $\sim$ 0.42' x 2340 ac = 1220 acft $\sim$ 980 acft.

When the loss rate is supposed to be 0.3, the difference in the quantity between the two cases above becomes 340 ac.ft. of issue from the Tank sluice. This is only net calculated quantity, and if the period is lengthened, the ineffective quantity of water supplied to unnecessary fields becomes large and far more significant than calculated.

B) Required amount of water at the field in planning

Here, the required amount of water in the field of Dewahuwa is studied, based on the above mentioned general experimental phenomena, and depending on the results as got in Dewahuwa.

1. Required amount of water for preparation (ploughing)

Farmers now spend 2 months for first and second ploughing in the whole Dewahuwa area. It means they plough 78 ac. per day on an average, (including 1st and 2nd ploughing). It is supposed to supply water from the tank during the period in principle. Though the actual present condition of ploughing is not known well, and presupposing of conditions for the future is far more difficult, it is based as in the following table, on the report on 72/73 Maha water use. Large sized liyads are premised for tractor operation.

Table 1 Presumed conditions of ploughing in the future

| Case | Area | Nos. | Ability | | Acreage to be ploughed & necessary days | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | per 1 set | total | 1st plough | | 2nd plough | | |
| | | | | | ac | day | ac | day | |
| | upper-stream | 30 | 1 ac/day | 30 ac/day | 600 | 20 | 240 | 8 | |
| | down-stream | 15 | " | 15 | 400 | 27 | 500 | 33 | |
| | sub-total | 50 | " | 45 | 1000 | (27) | 740 | (33) | average 870 ac |
| | upper-stream | 160 | 0.5 ac/4 nos day | 20 ac/day | 170 | 7 | 530 | 21 | |
| | down-stream | 296 | " | 37 | 1170 | 31 | 1070 | 29 | |
| | sub-total | 600 | " | 57 | 1340 | (31) | 1600 | (29) | average 1470 ac |
| | Total | | | 102 | 2340 | (31) | 2340 | (33) | |

Note: *4 wheel tractors are converted to 2 wheel tractors.

* Number of tractors means actually used ones including rented ones from outside.

i. In case of tractor

* One 2-wheel tractor spends 10 days net for 1st and 2nd ploughing of one allotment (5 ac.)

In the formula, $Y = -0.31 X_1 + X_2 + 9.9$ (cm)

$X_2 = X_2' + X_2''$

$X_2$ = Standing water

$X_2'' = d^{\text{cm/day}} \times n$ days

d; percolation and evaporation per day

Then, $(9.9 + X_2'' - 0.31\ X_1)$ shows the necessary quantity at the beginning, and d x n is the total quantity to be supplied during the period. $X_1$ differs much due to the soil texture and condition at the time. Here following Dr. Murakami's example, we adopt the following figures:

$X_2' = 5$ cm (2")

$X_1 \fallingdotseq 24$ gr and $9.9 - 0.31\ X_1 = 2.5$ cm (1")

percolation; 8mm/day, evaporation; 2mm/day and $X_2 = 1$ cm

Then 3" (75mm) of water is thought to be reasonable requirement including 2" (50 mm) of standing water, just before the 1st ploughing.

During the ploughing period and the interval between 1st and 2nd ploughing, the water supply of 10 mm/day, which consists of 8 mm of percolation and 2mm of evaporation, is thought to be necessary.

Water supply should be started from the day previous to the day of ploughing.

6 days of interval is reasonable between 1st and 2nd ploughing judging from the present condition. Depending on these and supposing that the supply of 75 mm per day is possible we have formulated table 2.

Table 2 Schedule of ploughing and water use in one allotment per 5 acres

| day / field | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | mm 75 | 1st 10 | ploughing 10 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 2nd | ploughing | | 〃 | 〃 | . |
| 2 | | 75 | 1st 10 | p. 10 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 2nd | p. | | 〃 | |
| 3 | | | 75 | 1st 10 | p. | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 2nd | p. | | |
| 4 | | | | 75 | 1st 10 | p. 10 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 2nd | p. | |
| 5 | | | | | 75 | 1st 10 | p. 10 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 2nd | p. |
| ℓ/S | 2.31 | 3.97 | 4.44 | 4.92 | 5.38 | 2.34 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | |
| m³ | 304 | 343 | 381 | 425 | 465 | 202 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 〃 | 4342 |
| Ac.ft. | .25 | .28 | .34 | .38 | .16 | | | | | | | | | | | | | 3.52 |

If interval of 6 days is not kept the quantity will be decreased by 1214 $m^3$ (0.98 Ac.ft.) and total necessity becomes 155 mm in depth. This figure is smaller than the figure given in "F.R." (170 mm)

Further more if we can do 1st and 2nd ploughing by a set of 2 tractors without interval, the period is shortened by 10 days and the quantity decrease by 2024 $m^3$ and total necessity becomes 2318 $m^3$ (115 mm).

This will be taken place in the whole area, with supposed loss of 30%

$$2024\ m^3 \times \frac{2340}{5} \times \frac{1}{1-0.3} = 950 \times 103\ m^3\ (770\ \text{Ac.ft.}) \times \frac{1}{1-03} =$$

1100 Ac.ft.

This water should be called water for weed prevention as mentioned before. And in the future it might possible to be saved by a good combination of works.

But here it should be estimated as water for preparation supposing that the present situation will continue because we must say it is very difficult to expect that the series of works of 1st and 2nd plough and trans-planting be carried out right on schedule continuously without any loss of time in the whole area.

The designed capacity of existing inlet is 4.16 l/sec (0.147 cusec), while the maximum necessary amount of water to one allotment is 5.38 l/s on the 5th day, but as a matter of fact, most of the inlets have a capacity of more than 5.38 l/s, as shown in Fig. 10 and in the previous report.

Therefore it is proposed to supply 5.38 l/s of water in the first 5 days and 2.34 l/s in the latter 12 days. Then total quantity will be 4750 $m^3$ (3.85 Ac.ft.) or 235 mm (0.77 ft.) in depth. If we stop the water during the 6 days of interval of plough, not only do we not kill the weeds but also we lack again 75 mm of water simultaneously in a wide area, so this is not a wise method.

The decrease of quantity from 5.38 l/s to 2.34 l/s has to be practised by shortening the hours or so.

ii. In case of cattle

The average ploughing capacity is 0.5 ac/day with 4 cattle. Therefore it takes 20 days to finish 1st and 2nd ploughing of 1 allotment (5 ac.) with 4 cattle. Similarly as in the case of tractor, 5.35 l/sec of water is supplied for 5 days from the previous day of starting ploughing.

We can suppose the work will continue after this till the end of the 2nd ploughing without interval, because they use their own cattle mainly in this case. Then 2.34 l/sec of water is to be supplied for 16 days.

And this will be in total : 5.38 l/s x 5 days + 2.34 l/s x 16 days = 5559 $m^3$ (4.51 Ac.ft.)

This is 275 mm (0.90') in water depth.

If farmers can store and regulate water in their own allotment, we can shorten the term. But according to the present situation, it is dangerous to make a plan depending on this.

iii. Average required amount of water in the total area.

If we suppose that 870 Ac. of paddy field are ploughed with tractors and 1470 Ac. are done with cattle, as shown in Table 1, average required amount of water will be,

(235 mm x 870 ac + 275 mm x 1470 ac) ÷ 2340 ac = 260 (0.85')

The necessary days will be; 17 x 870 + 21 x 1470 ÷ 2340 = 19.5 = 20 days.

In conclusion it is proposed to supply 5.38 l/s throughout 5 days, 2.34 l/s for 15 days and in the total 5357 $m^3$ (4.34 Ac.ft.) or 265 mm (0.87 ft.) in depth in 20 days as the water for preparation (ploughing) in the plan of the whole area.

2. Necessary amount of water for growing paddy plants

Here "necessary amount of water for growing paddy" means the sum of transpiration from the surface of the leaves, evaporation from the surface of paddy field and vertical and horizontal percolation, that is "consumptive use of water" during the term of growth".

"Water for stopping weed" is not considered here, because we are supposed to use other methods of weeding.

Shallow standing water is expected for the whole season except 10 days of water cut.

i. Transpiration

"Required water", that is necessary amount of water shown in (cc) unit to produce 1 gr. of dried materials of paddy and plant, is based rather on term of growth than on varieties and soil texture.

And the "total weight of dried materials" is proportionate to transpiration, but the relation between the "weight of dried ears materials" and transpiration is shown in a quadratic equation. (see Fig. 9)

The target of unit yield in Deqahuwa is 90 bushels per acre. In this case, supposing that moisture content in paddy is 12%, rate of weight between dried ears materials and total dried materials is 0.44 judging from Fig. 9, the total dried materials on target is calculated as follows,

90 bushes/ac. x 21.5 kg/bushel ÷ 4.047 (10a/ac.)
x (1-0.12) ÷ 0.44 = 956 kg/10a
(Here "a" means "are")

"Required water" for 4 month varieties is Maha will be as follows from Fig. 8.

2.27 x 100 days + 115.5 = 340 (cc)
Then total transpiration in water depth will be,
340 cc x 956 kg/10a) = 325 mm
The optimum point in the quadratic equation shown in Fig. 9 is,
(dried ears; 44 gr., water; 30 kg.)

Considering that this was given from the not experiment, we will give an allowance of 10%, then the transpiration will be,

30 kg/0.044 kg. x 90 days x 21.5 kg/bu. x (1-0. 12)
÷ 4.047 (10a/ac) x 1.1 = 316 mm

And 309 mm is adopted in "F.R.". These figures can be said to be much the same, so, here we will adopt 309 mm after all.

ii. Evaporation

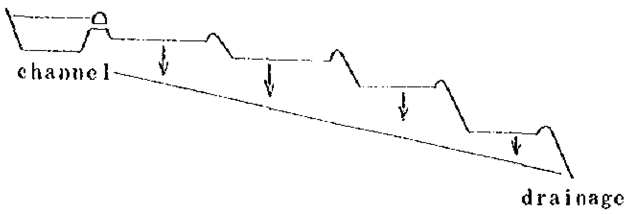
Evaporation from the pan is 4.0 mm/day on an average according to Messrs. Otani, and Mase's observation at Dewahuwa. Supposing that E/EM (rate of the evaporation from the field and from the evaporation pan) is 0.60 from Fig. 7, evaporation from the field will be in total, 4.0 mm x 90 days* x 0.60 = 216 mm   0.71 feet

* 10 days of water out among 100 days in the main field is considered.

iii. Percolation

The above mentioned two items have not severe regional differences, but the figure of the percolation varies much depending on the local conditions.

Dr. Murakami found out that the vertical percolation was 7 mm/day at Maha Illuppallama, and 2-3 mm/day at the impervious field, and that the horizontal percolation (i.e. seepage from borders) becomes some times 2-5 times as much as vertical percolation depending on topographical and other conditions. But wehen liyadas are arranged along the slope, which are often seen, most of the water runs from the upper-most liyad to the lowest, without being consumed so much, and so this quantity will be much reduced for a whole allotment.




In this project area, topographic conditions and other conditions seen to vary so greatly that it will be dangerous to adopt an average figures for the whole area in planning, because the extra water in the surplus side gets lost and can not be used in the field with a shortage an shown in the previous report. (The 2nd investigation team got a few data showing very high percolation.) Therefore if possible, the whole area should be separated into several blocks with the same conditions after practising investigation.

From the observation which was carried out in the pilot farm during the period when water consumption seemed to be at the highest in 73/74 Maha, though the term was very short, we can say that consumptive use will be roughly as follows in the consolidated fields under a good management;

| | | |
|---|---|---|
| percolation (vertical) | 6 mm/day | |
| " (horizontal) | 2 " | |
| evapo- transpiration | 12 " | |
| total water requirement (water consumption) | 20 " | |

The observation was done in a liyad where the percolation seemed a little higher than average because it located in a little higher part. And from the observation in a small liyad without paddy plants, we found out that the sum of evaporation and vertical percolation became about 12 mm/day. Then we can get the following table.

| | | | |
|---|---|---|---|
| percolation | (from a field without paddy plant) | 6 mm/day | |
| " | ( " with paddy ) | 4 " | ($\frac{EM}{E}$=0.66) |
| vertical percolation | ( " ) | 6 " | |
| horizontal " | ( " ) | 2 " | |
| transpiration | ( " ) | 8 " | |
| water consumption | ( = water requirement ) | 20 " | |

Horizontal percolation is very high in an unconsolidated field under a poor management.

Actual average capacity of inlets for an allotment (5 ac. each) in tract 3 is about 8.5 l/sec (0.3 cusec) from which roughly 40% is supposed to be used to saturate the earth and 60% is for standing water, which is lost in about 2 days. Then water consumption in an allotment will be,

$$2^{days} \times 0.6 \times 8.5^{l/s} \times 86400^{s/day} \div (5^{ac.} \times 4047^{m^2/ac.}) \div 2 \text{ days} = 21.8 \text{ mm/day}$$

Then the excessive horizontal percolation will be

21.8 - 20.0 = 1.8 mm/day

This becomes for the entire season in the whole area,

$$0.0018^{m} \times 3.28^{ft/m} \times 2340^{ac.} \times 90^{\ days} = 1244 \text{ ac.ft.}$$

Supposing that the conveyance loss is 30%, then the amount of water to be issued from the tank is,

$1244 \div (1 - 0.3) = 1775$ ac.ft.

Here we suppose by experience that percolation will be 8 mm in the whole upstream area, and 40% of the downstream area, and the rest will be 10 mm/day, after the project term.

Then average percolation in the whole area will be,

$$(770^{ac.} + 1570^{ac.} \times 0.4) \times 8^{mm} + 1570^{ac.} \times 0.6 \times 10^{mm}$$

$$\div 2340^{ac.} = 8.7 \text{ mm/day}$$

The total for the season becomes,

8.7 mm x 90 days = 783 mm

Water supply of 27 mm is possible after the water cut of 10 days during the invalid tillering stage, supposing that more than 25 mm which is requested before the plough.

3. Total required amount of water in the field

Here is a table of the total required amount of water in an average field, for the whole term summarized from the above mentioned observations.

| | | | |
|---|---|---|---|
| till the end of 2nd ploughing | 20 days | 265 mm | 0.87 ft. |
| transpiration | 340 cc. x 910[*1] kg./10a. | 309 | 1.01 |
| evaporation | 4 mm x 90 days x 0.6 | 218 | 0.72 |
| percolation | 8.7 mm x 90 days | 783 | |
| after water cut | | 27[*2] | 0.09 |
| total | | 1602 | (5.3 ft.) |

*1 in "F.R."    *2 treated as percolation

4. Water requirement in every stage of growth

Up to here, total amount of required water is treated as an average in the whole season, but water requirement changes at every stage of growth.

Here it is roughly studied monthly according to Fig. 7, and checking up relation between inlet capacity and distribution method.

19-1 The figure in table 4 is only the sum of each of the elements of water requirement amended seasonally in one field.

In the whole area, the work spread over 2 months, so, strictly speaking it is not the proper way to adopt the same values of evaporation and transpiration in the different areas. But here it is treated as an average value for convenience.

In calculation, the total sum, maximum water requirement in the most necessary stage, and ET/EM in Fig. 7 have been taken into consideration. Percolation after the "water cut" is supposed to increase a little.

19-2 Table 4

Table 4 Water requirement and necessary discharge to allotment in each stage of growth

| Month | 1st Month | | | | | | 2nd Month | | 3rd Month | | | | | | 4th Month | | | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Day | 1 – 5 | | 6 – 20 | | 21 – 30 | | 31 – 60 | | 61 – 70 | | 71 – 75 | | 76 – 90 | | 91 – 105 | | 105 – 120 | | | |
| Period (days) | 5 | | 15 | | 10 | | 30 | | 10 | | 5 | | 15 | | 15 | | 15 | | 120 | |
| Water for preparation | mm/day 23 | mm 115 | mm/day 10 | mm 150 | | | | | | | mm/day 5.4 | mm 27 | | | | | | | mm/day | mm 292 |
| evaporation | | | | | 2.3 | 23 | 2.0 | 60 | 0 | 0 | 3.0 | 15 | 3.0 | 45 | 3.0 | 45 | 2.0 | 30 | 2.4 | 218 |
| transpiration | | | | | 0.3 | 3 | 1.2 | 36 | | | 4.5 | 22.5 | 4.5 | 67.5 | 7.0 | 105 | 5.0 | 75 | 3.0 | 309 |
| evapo-transpiration | | | | | 2.6 | 26 | 3.2 | 96 | | | 7.5 | 37.5 | 7.5 | 112.5 | 10.0 | 150 | 7.0 | 105 | 5.9 | 527 |
| percolation | | | | | 8.6 | 86 | 8.6 | 258 | | | 8.8 | 44 | 8.8 | 132 | 8.7 | 130.5 | 8.8 | 132.5 | 8.7 | 783 |
| Total | 23 | 115 | 10 | 150 | 11.2 | 112 | 11.8 | 354 | 0 | 0 | 21.7 | 108.5 | 16.3 | 244.5 | 18.7 | 280.5 | 15.8 | 237.5 | | 1602 |
| discharge l/sec | 5.38 | | 2.34 | | 2.62 | | 2.76 | | | | 5.08 | | 3.52 | | 4.38 | | 3.70 | | | |
| quantity $m^3$ | 2327 | | 3035 | | 2266 | | 7163 | | | | 2195 | | 4947 | | 5676 | | 4806 | | 32416 | |
| " Ac.Ft. | 1.89 | | 2.46 | | 1.84 | | 5.81 | | | | 1.78 | | 4.00 | | 4.60 | | 3.90 | | 26.28 | |
| rate of proportion to the Maximum | 1 | | 0.43 | | 0.49 | | 0.51 | | | | 0.94 | | 0.71 | | 0.81 | | 0.69 | | | |

Note : Replenishing quantity for evapo-transpiration in the water-cut period is not estimated.

In the above table, discharge after the "water cut" is given supposing an increased quantity is supplied in 5 days.

If the maximum discharge of 5.38 l/s is continuously supplied, then necessary days to recover the standing water will be 4 days from following calculation.

$$\underset{mm}{(0.0163}\ \underset{days}{n} + \underset{mm}{0.027)} \times \underset{Ac}{5} \times \underset{m^3/Ac}{4047} = \underset{m^3/s}{0.00538} \times \underset{sec/day}{86400} \times \underset{days}{n}$$

$$n = 4.05 \text{ days}$$

By designed discharge of 4.16 l/s, it becomes 18.5 days.
From this, we can say that after the 10 days' "water cut", if 27 mm of additional supply is necessary due to dried up condition of soil, 4 days to 18 days of time is necessary to recover the standing water and some times recovering is very difficult depending on soil and inlet capacity.

The above table gives the required amount of water, in an allotment unit (5 ac.). This unit of required period in the above table, in every allotment is spread over 2 months in the whole area. And this tendency is inevitably supposed to continue in future too, without radical change.

Here for practical purposes, we have arranged this unit into 5 blocks with a 10 days period, and the acreage is divided in the proportion of 4 : 3 : 2 : 2 : 1, because the acreage is larger in the earlier stage. Then we get the table 5. Here transplanting is expected in the whole area.

20. Here the following requirements are estimated;

$$\text{In 1st 10 days; } (\underset{mm.}{115} + \underset{mm.}{10} \times \underset{day}{5}) \div \underset{day}{10} = \underset{mm/day}{16.5}$$

$$\text{7th 10 days; } (108.5 + 16.3 \times 5) \div 10 = 19.0 \text{ "}$$

$$\text{10th 10 days; } (18.7 \times 5 + 15.8 \times 5) \div 10 = 17.25 \text{ "}$$

From the table, we can say that the total required amount of water consumptive use in the field is 12,300 acft. (5.26 acft/ac.), and max. required amount of water on a 10 days average becomes 130.5 acft/day (65.3 cusec). Supposing 30% of the irrigation loss max. discharge of the channel becomes 65.3 ÷ 0.7 = 93.3 cusec.

21. The indicated tendency towards the maximum in the table is a little different from actual issue. We may point out the reasons for this as,

i) Irrigation efficiency in the ploughing period is very low due to "dried up condition of channel", and "water goes into unnecessary fields".

ii) We cannot issue enough at the time of the really required maximum.

iii) The peak point of the farmers' work may come earlier than in this table.

The table is expected to be amended after further study.

Table 5 Water requirement in each blocks of Dewahuwa

| Block / Day | A 780 Ac | | B 585 Ac | | C 390 Ac | | D 390 Ac | | E 195 Ac | | Total 2340 Ac | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | mm/day | AcFt | mm/day | AcFt | mm/day | AcFt | mm/day | AcFt | mm/day | AcFt | cusec | AcFt |
| 1 - 10 | ※1 16.5 | 422 | | | | | | | | | 21.1 | 422 |
| 11 - 20 | 10.0 | 256 | 16.5 | 317 | | | | | | | 28.6 | 573 |
| 21 - 30 | 11.2 | 289 | 10.0 | 192 | 16.5 | 211 | | | | | 34.5 | 690 |
| 31 - 40 | 11.8 | 302 | 11.2 | 215 | 10.0 | 128 | 16.5 | 211 | | | 42.8 | 856 |
| 41 - 50 | 〃 | 〃 | 11.8 | 226 | 11.2 | 143 | 10.0 | 128 | 16.5 | 106 | 45.3 | 905 |
| 51 - 60 | 〃 | 〃 | 〃 | 〃 | 11.8 | 151 | 11.2 | 143 | 10.0 | 64 | 44.3 | 886 |
| 61 - 70 | 0 | 0 | 〃 | 〃 | 〃 | 〃 | 11.8 | 151 | 11.2 | 72 | 30.0 | 600 |
| 71 - 80 | ※2 19.0 | 486 | 0 | 0 | 〃 | 〃 | 〃 | 〃 | 11.8 | 75 | 43.2 | 863 |
| 81 - 90 | 16.3 | 417 | 19.0 | 365 | 0 | 0 | 〃 | 〃 | 〃 | 〃 | 50.4 | 1005 |
| 91 - 100 | 18.7 | 479 | 16.3 | 313 | 19.0 | 243 | 0 | 0 | 〃 | 〃 | 55.5 | 1110 |
| 101 - 110 | ※3 17.25 | 441 | 18.7 | 354 | 16.3 | 209 | 19.0 | 243 | 0 | 0 | 62.6 | 1252 |
| 111 - 120 | 15.8 | 404 | 17.25 | 331 | 18.7 | 239 | 16.3 | 209 | 19.0 | 122 | 65.3 | 1305 |
| 121 - 130 | | | 15.8 | 303 | 17.25 | 221 | 18.7 | 239 | 16.3 | 104 | 43.4 | 867 |
| 131 - 140 | | | | | 15.8 | 202 | 17.25 | 221 | 18.7 | 120 | 27.2 | 543 |
| 141 - 150 | | | | | | | 15.8 | 202 | 17.25 | 110 | 15.6 | 312 |
| 151 - 160 | | | | | | | | | 15.8 | 101 | 5.1 | 101 |
| Total | | 4098 | | 3073 | | | | | | | | 12293 |

※1 (23×5+10×5)÷10=16.5

※2 (21.7×5+16.3×5)÷10=19.0

※3 (18.7×5+15.8×5)÷10=17.25

5. Effective rainfall

As shown in the report on water use in "72/73 Maha", the rainfall of regional and short time type is evident here. Therefore it is actually impossible for farmers to go to their fields to control the water condition every time it rains, because the forcast of rain can not be got and because their fields are separated by more than a mile from their houses. (The pattern of rainfall is referred to in detail in Mr. Masa's report)

Continuous irrigation keeping shallow standing water is advisable from the physiological point of view of paddy, as mentioned before, and channel system is also designed expecting continuous plot to plot irrigation. Therefore we can not expect much of effective rainfall on the field, because we can not store water so deep on each liyad.

It is proposed to expect 80% of the following quantity:

| | | |
|---|---|---|
| for every one day rain exceeding water requirement per day | ----- | equivalent amount of water saved by stopping issue <u>one day</u> |
| for every continuous rain exceeding water requirement each day | ------ | equivalent amount of water saved by stopping issue for <u>these days</u> |

Rain corresponding to this condition happened only 4 days in '74 Maha. In 72/73 Maha which is looked upon as a standard year for the planning, effective rainfall is calculated as follows:

22. It was proposed to stop the issue 1 - 2 days in the ploughing period and 0.5 day in the other stages, whenever there is a rainfall that exceeds the water requirement per day.

Table 6 Effective rainfall in 72/73 Maha

| Date | 1-10 | 11-20 | 21-30 | 31-40 | 41-50 | 51-60 | 61-70 | 71-80 | 81-99 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| (1) No. of days | 3 | 5 | 3 | 4 | 1 | 3 | 1 | 5 | 3 | 28 |
| (2) acft/day | 42.2 | 57.3 | 69.0 | 85.6 | 90.5 | 88.6 | 60.0 | 86.3 | 100.8 | - |
| (3) (1) × (2) | 126.6 | 286.5 | 207.0 | 342.4 | 90.5 | 265.8 | 60.0 | 431.5 | 302.4 | 2112.9 acft. |
| (4) (3) × 0.8 | 101.3 | 229.2 | 165.6 | 273.9 | 72.4 | 212.6 | 48.0 | 345.2 | 241.9 | 1690 acft. |

From this table, total effective rain fall is estimated as 1700 Acft. (0.73 Ac.Ft/Ac.)

6. Net duty of water

Here net duty of water is calculated by usual way of subtracting effective rainfall from total requirement amount of water in the field. Therefore, it will be as follows.

12,300 - 1,700 = 10,600 acft. (4.53 Ac.Ft/Ac.)

This net duty of water is almost the same as the figure got by simply accumulated net required amount of water of all the fields.

In addition to required amount of water due to the difference of inlet capacities, natural conditions such as soil texture, and time lag of field works ; this is also rather necessary water for operation unlike waste of water of farmers, is not taken into consideration. In the next paragraph, gross duty of water is studied, including the above mentioned water.

## IV. Gross duty of water (Necessary amount of water to be issued from the tank)

(In general)

1. Necessary water for operation

In "F.R." gross duty of water is decided, taking the conveyance loss as 40% in the following formula,

$$\text{gross duty} = \frac{\text{net duty}}{(1 - \text{conveyance loss})}$$

However, it is a matter that demands special attention that only natural phenomenon like seepage loss from the channel is generally counted as conveyance loss and that others, if any, are apt to be regarded as waste of water caused by farmers' faults.

In fact, natural conditions of field are not uniform, and actual intake capacity varies greatly as shown in Fig. 10, and that most of the allotments can automatically get excessive water in general whenever there is enough water.

Unification of varieties of paddy, methods of cultivation, or grouping of works which were suggested in "F.R." could not have been realized.

Therefore water is liable to enter into unnecessary places and hardly reaches the necessary places, and it is difficult to supply proper amount of water according to stages of growth of paddy to every field.

These matters are mainly caused by administrative and socio-economic reasons, and therefore, in general, this water should be included in to the "necessary water loss for operation". (Tentative figure for this loss is shown later.)

2. Conveyance loss

As already shown in "water management in 73/74 Maha", conveyance loss has been remarkably reduced owing to improvement to the outlet-gates.

Generally speaking, unlike the conveyance channel in a diversion scheme, both main and lateral channels are in the project area, so that most of seepage water from the channels is utilized directly or indirectly in the project area.

The problem which actually bothers persons concerned is rather the delay of arrival of water to the tail end parts of each tract in the early stages of each issue time, due to the rotation issue, and the drop in conveyance capacity of channels due to growing of grass in channels.

Tentative plan

<u>Main channel loss.</u>

Taking in general the facts shown above into consideration, here the practical situation regarding amount of loss is studied.

The conveyance loss in the main channel in a normal circumstance was marked as 21.6% of planned discharge in 72/73 Maha report.

In 73/74 report, the decrease of loss was marked as 7% due to the improvement to outlets.

Therefore now conveyance loss in the main channel in a normal stage can be considered as;

$$21.6 - 7 \fallingdotseq 15\%$$

In addition to this, the amount of 3 days' average discharge, that is about 3% of the total is reasonably estimated as the operation loss which is at the beginning of issue and so on. Then total loss in the main channel becomes 18%. However, about 1/2 of the former (15%) is supposed to enter the field to be used. And here this is called "re-use" .. (7.5%).

Branch channel losses.

We have no observed data for branch channel loss, so as in the main channel, 15% of branch channel discharge is considered to be normal conveyance loss. And 5% to be operation loss due to the unequality of intake capacity, etc.

Then the total branch channel loss becomes 20% of branch channel discharge.

However, branch channels exist close to fields, so, 80% of the former that is 12% of the branch channel discharge is supposed to enter the field and to be re-used.

Field loss.

If we allow for the worst case, we must take into account the quantity considering that we supply in the whole term, total amount of each outlet capacity. The number of issue days is;

160 (full term) - 28 (effective rainy days) - 10
(water cut) = 122 days
Supposing the capacity is 8.5 l/s; loss is 30%, then
one day : 8.5 l/s x 2340/5 x 86400 sec/1-0.3 = 398 Ac.Ft.
in the whole term : 398 Ac.Ft. x 122 = 48,500 Ac.Ft.
(20.8 Ac.Ft/Ac.)

But main channel capacity is 190 Ac.Ft/day and annual run off into the tank is 16,000 Ac.Ft. in S.D.Y. (So naturally we can not supply this quantity.)

Next, several figures of rate of seasonal change in water requirement in table 4 is divided into practically three broad groups using, 1, 0, 0.8 and 0.5 and include the quantity of water to be added.

The total quantity is equivalent to 6.4% of consumptive use in the whole term in table 5.

The fifference between the quantity of water taken to an ordinary place and to the pilot farm under good management is 22%. A greater part of this quantity is due to the structure of inlet.

We can not do anything but expect farmers to reduce the quantity by adjusting or shortening the hours of issue, and therefore we have to expect much difficulty. Then 15% of the necessary quantity at the field, that is about double 6.4% shown before, is proposed as the field loss. Surplus water flows down directly to drainage channels. Irrigable acreage under anicuts at drainage channels is small. So, the quantity of water re-use is supposed to be included in the quantity of re-use calculated at the main and branch channels. Therefore here we do not count the water re-use. Water balance in illustration.

We can get the following illustration of water balance in Dewahuwa in S.D.Y. Maha, from figures so far studied.

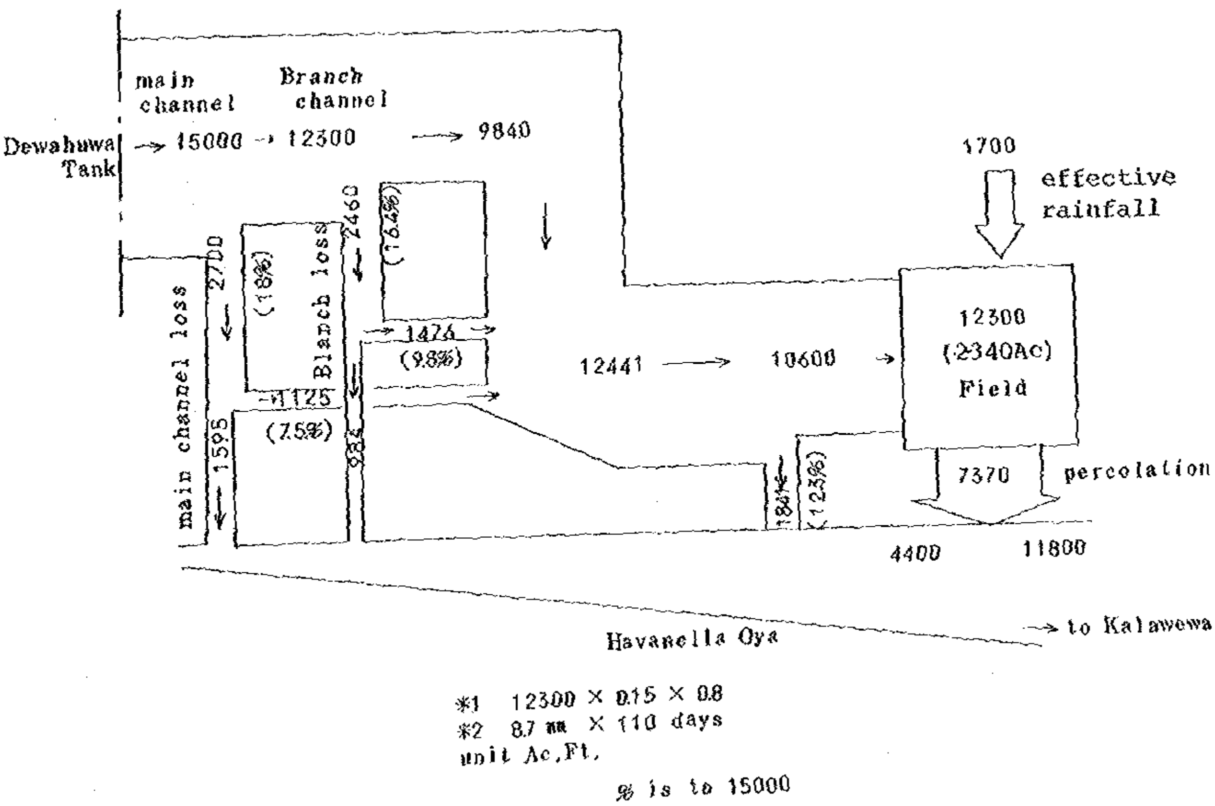



Fig. 11 The illustration of balance in Dewahuwa in S.D.Y. Maha.

Losses can be summarized as follows:

| Loss | of Tank issue | (for operation) | re-use |
|---|---|---|---|
| Main channel | 18% | 3% | 9% |
| Branch channel | 16 | 4 | 7 |
| Field | 12 | (mostly) | 0 |
| Total | 46 | 7 | 16 |

Irrigation loss: 46 - 16 = 30%

That is:

We propose that the necessary amount of water to be issued from the Tank in a Maha of S.D.Y. after the project term in

Dewahuwa should be 15000 Ac.Ft;
Irrigation efficiency (= 1-loss) will be 70%;
Effective rainfall in Ac.Ft. will be 1700; and consumptive use of water in the field will be 12300 Ac.Ft., under fairly good management.

## V. Conclusion

1. In the dry zone there is not so much a regional difference of evapo-transpiration, that is about 500 mm (1.64 ft) in case we cultivate 4-month varieties in Maha, although the above evapo-transpiration, in other words, water to be consumed for the growth of paddy plants in the fields, varies much or less according to kinds of varieties and target of yield per unit area you aim at.

2. The factor that gives a big difference in deciding the planned water are,

(i) As for the water requirement in the field it is not shown by the above mentioned "water for growth" but by the following two factors.

(a) percolation which varies very much according to soil and topographical conditions of the particular region.

(b) Water for preparation (mainly for ploughing) which varies much according to ways of working.

(ii) As for the gross duty of water in an irrigation scheme as a whole:

(a) physical conveyance loss

(b) loss which should be called loss for operation and which is indispensable to give a secured quantity in the fields. And this varies very much according to the local administrative socio-economical conditions as well as natural conditions.

(c) A large portion of (a) can be used in the field if the channels run through the area --- "water re-use".

According to topographical conditions, in some schemes fairly good part of loss water can be re-used. From the wide point of view 100% of loss can be re-used in the downstream of the same basin in this country. But, in the scheme located in the uppermost stream of a basin as Dewahuwa, the possibility of re-use is low and consequently total loss rate becomes large.

3. There are many assumptions in this report specially (ii)-b,c to be seen above. And further observation is expected.

4. Duty of water varies naturally from place to place. Therefore, following items are expected to be carried out in planning a new project.

(i) Study of irrigation method based on the study of cultivation method.

(ii) Survey of water requirement especially study of percolation etc.

5. In Dewahuwa, we should adopt the following figures for planning:

Dam discharge - 15000 Ac.Ft. (6.41 Ac.Ft/Ac.)
(gross duty of water)

Irrigation efficiency ; 70%

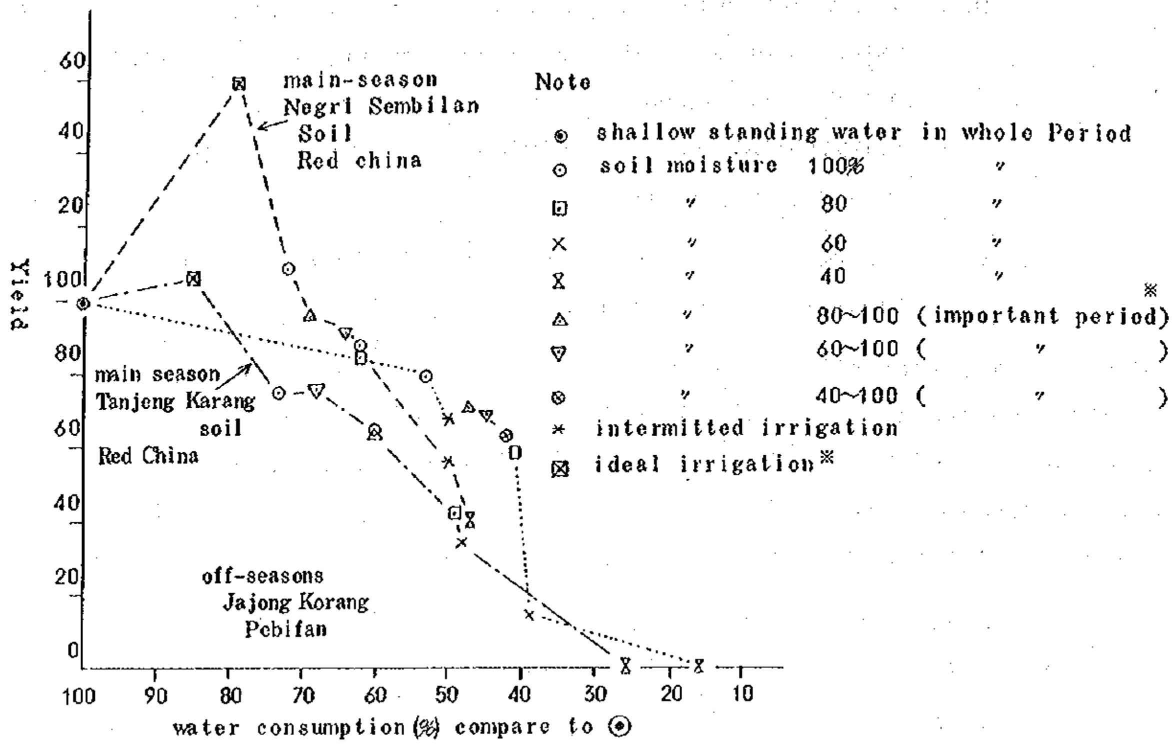



Fig.1 Yield & Water Consumption (I) (Malaya)
(Dr. Matsushita)

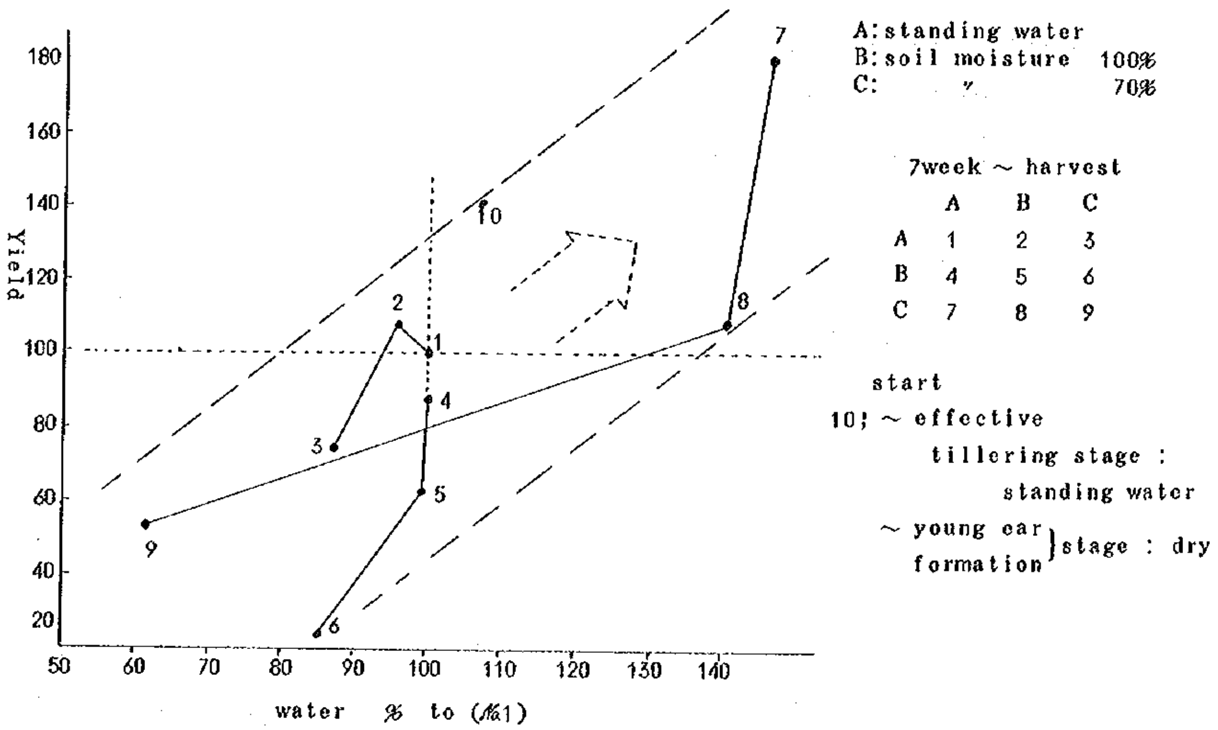



Fig.2 Yield & Water Consumption (2) (Dr. Murakami)

Note • In cases 7, 8 consumption are higher because of long term of growth

• Maha-Illuppallama. Variety H4

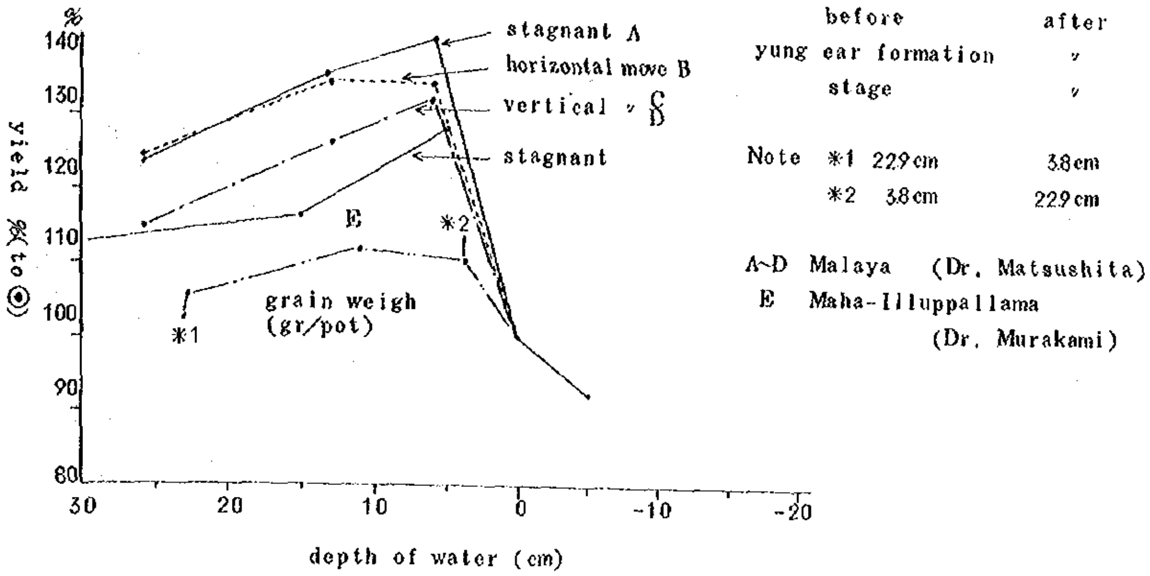



Fig.3 Relation between Yield and water depth & water level

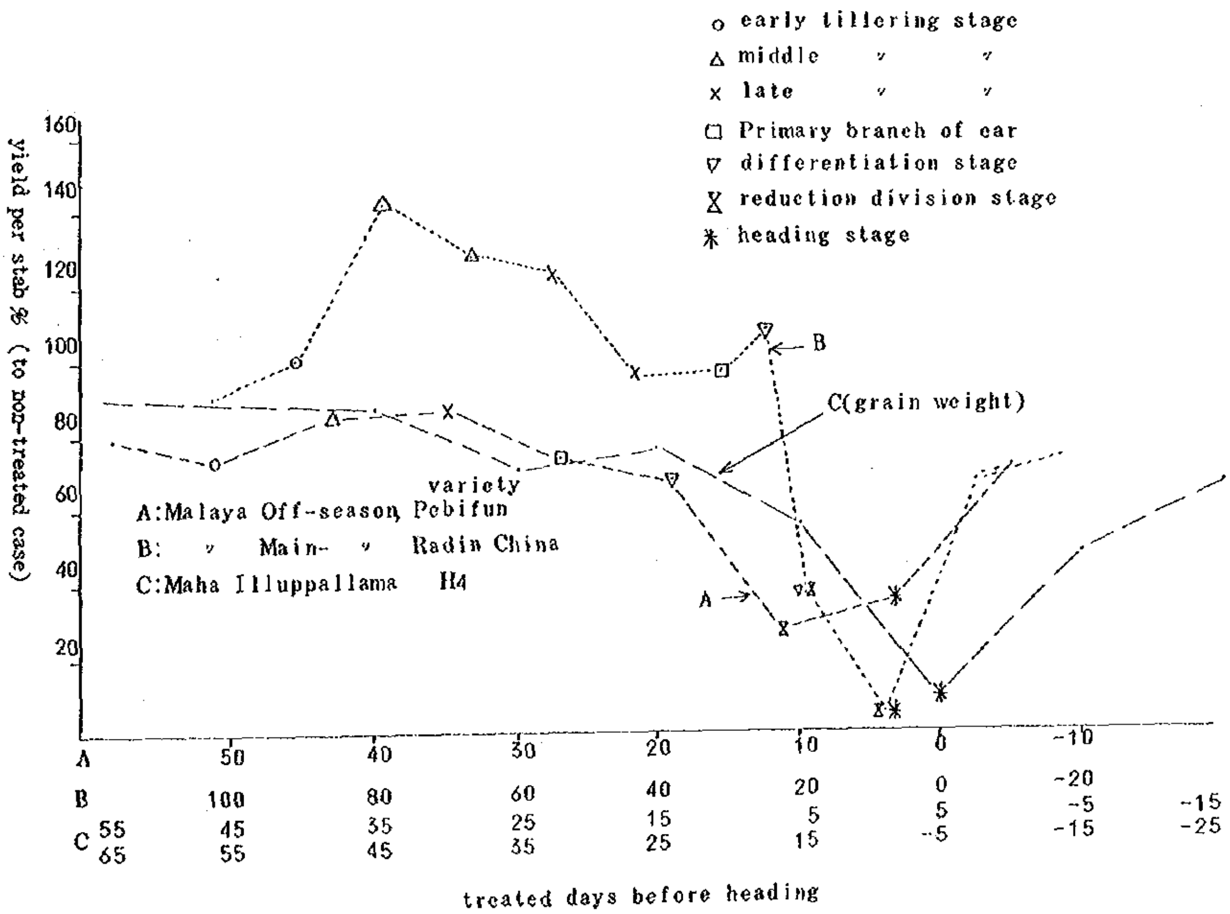



Fig.4 Effect of water cut at different stages

A,B Dr. Matsushita

C Dr. Murakami

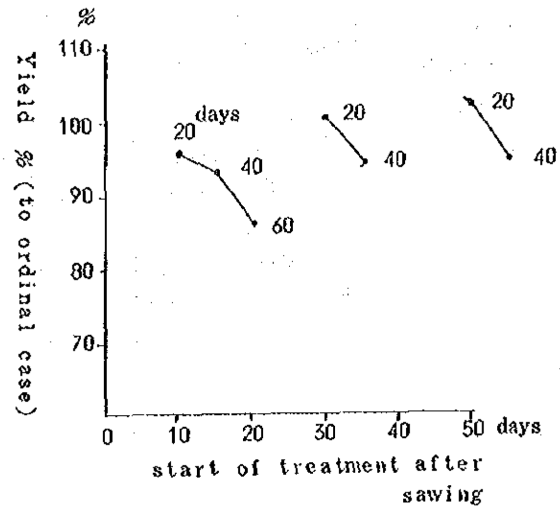



Fig.5 Effect of non-standing water at different stages

Maha-Illuppallama
(Dr. Murakami)

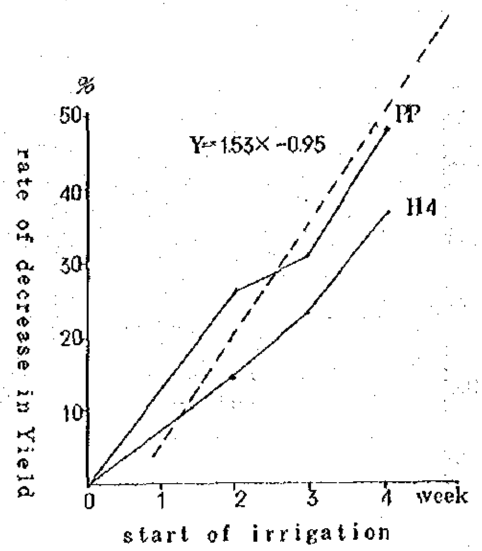



Fig.6 Relation between rate of decrease in Yield & start of irrigation

Maha-Illuppallama
(Dr. Murakami)

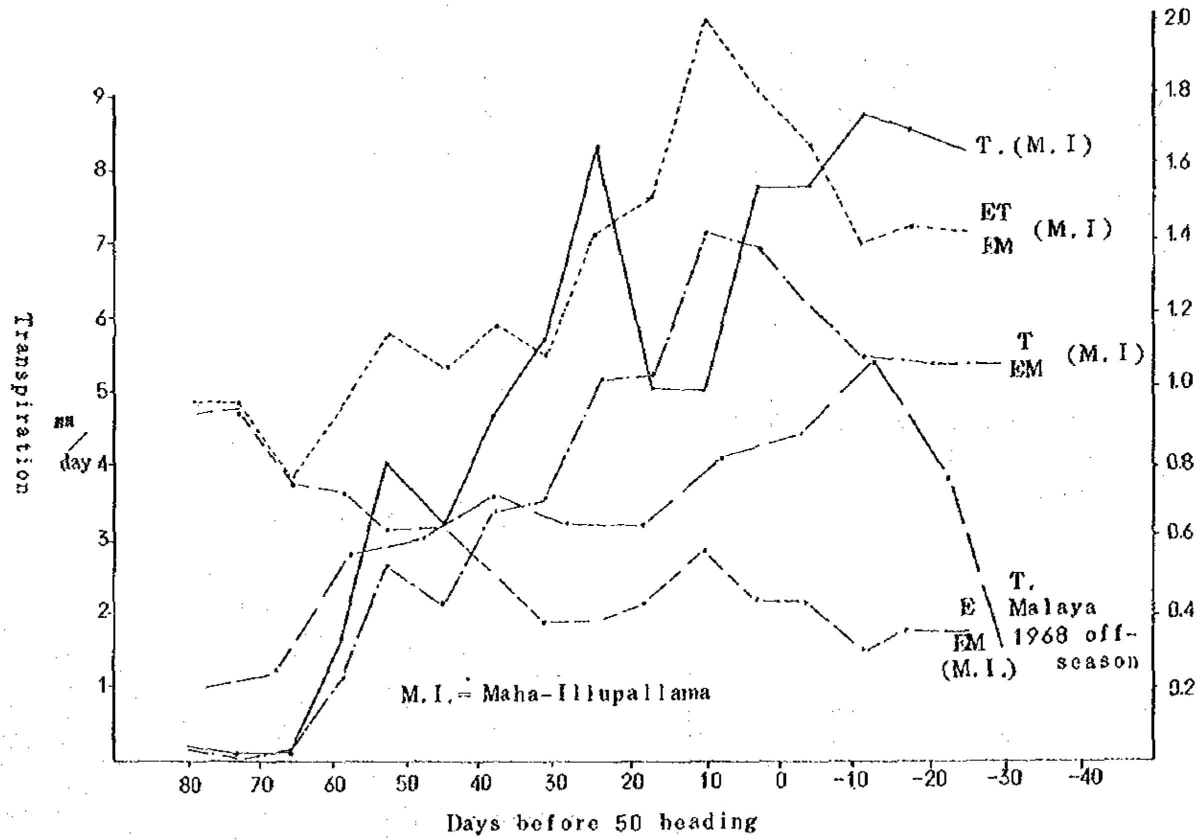



Fig.7 Change of Evaporation, Transpiration Evapo-Transpiration (rate to ground Evaporation) (Dr. Murakami)

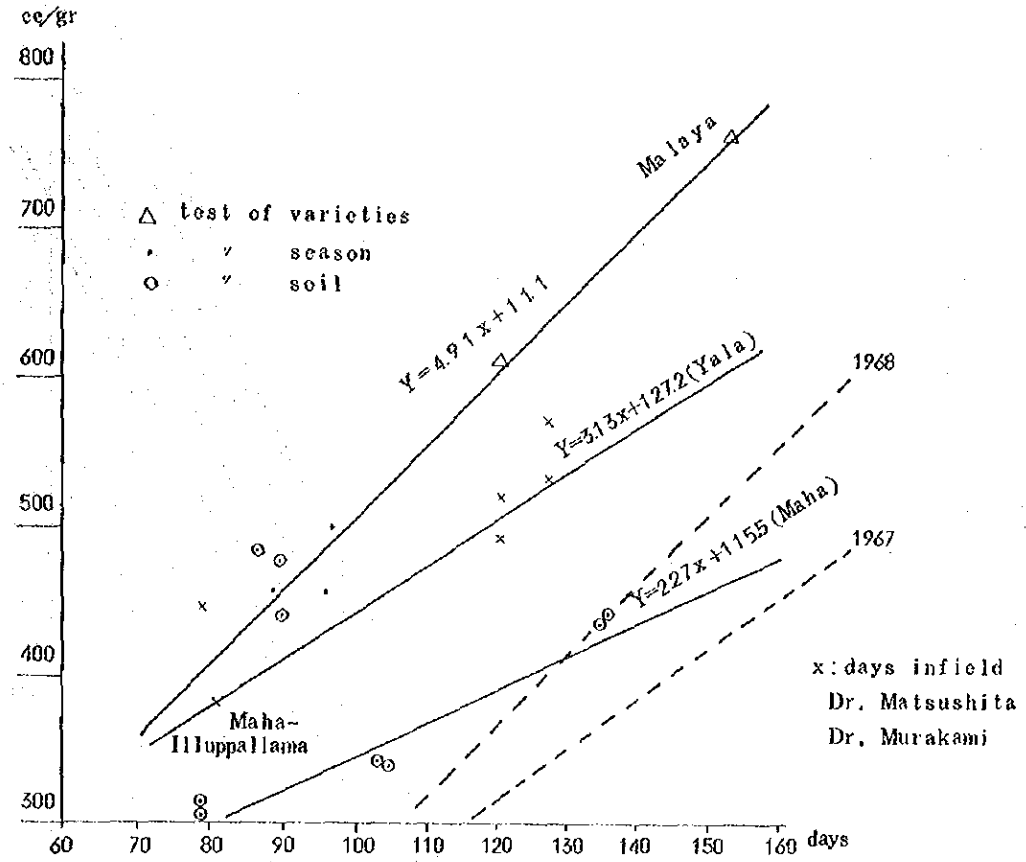



Fig.8 Required water in c.c. to produce 1 gr of dried material of paddy.

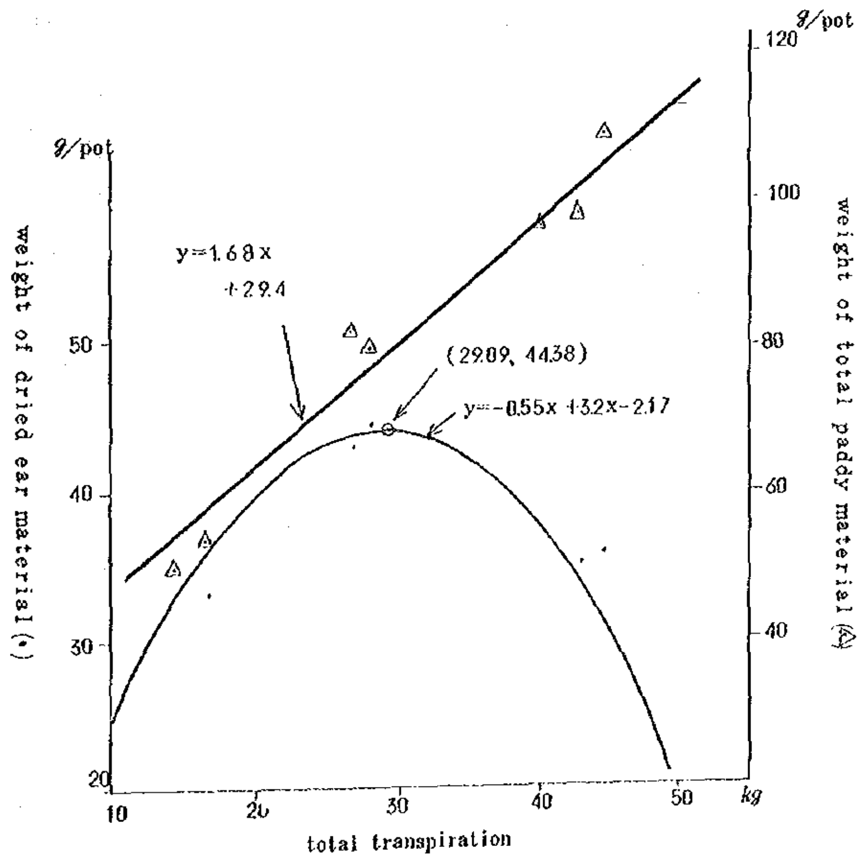
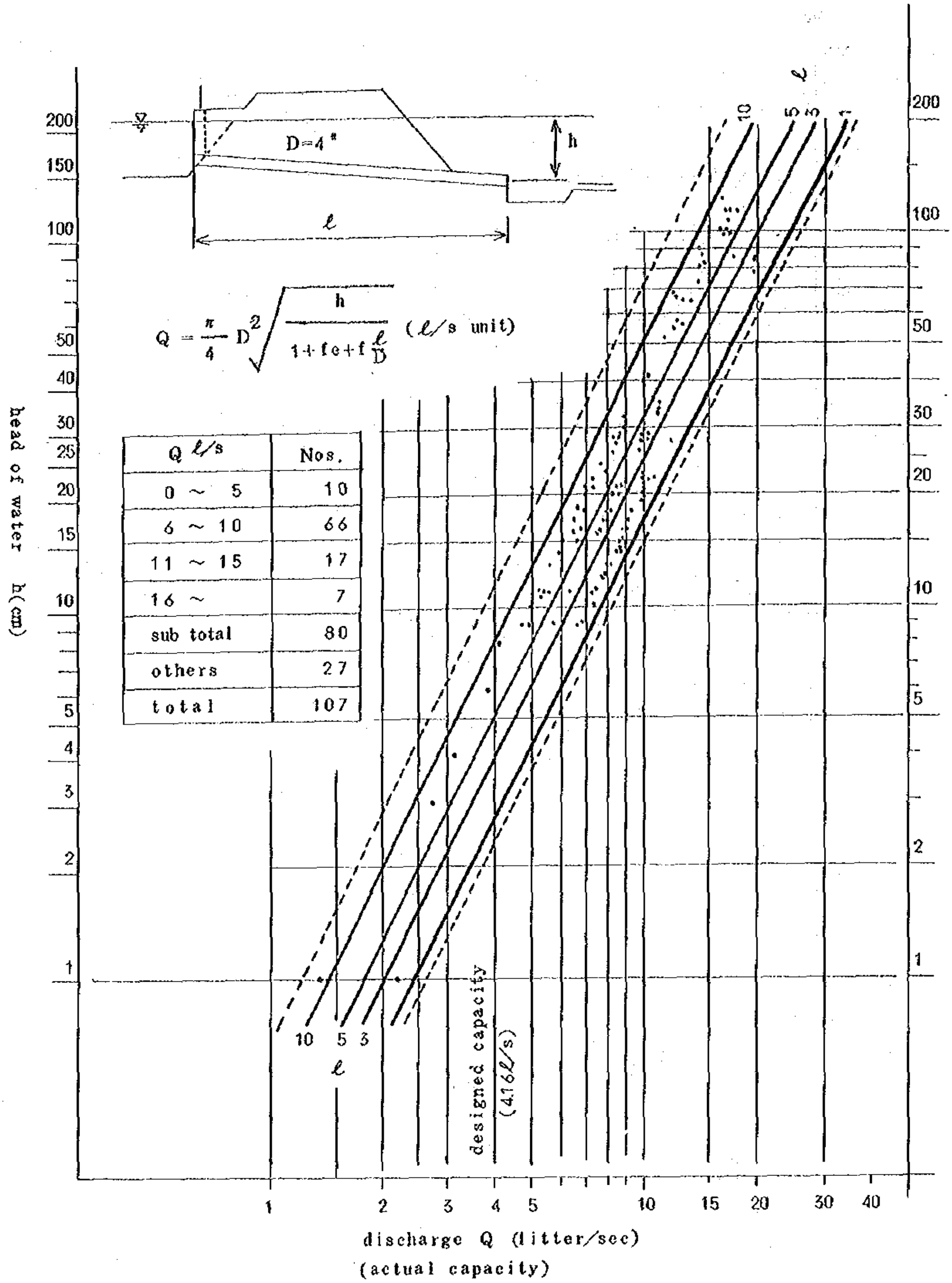



Fig.9 Evapo-Transpiration and weight of Yield.
at Maha-Illuppallama
Maha season
(Dr.Murakami)




$$Q = \frac{\pi}{4} D^2 \sqrt{\frac{h}{1+fe+f\frac{\ell}{D}}} \quad (\ell/s \text{ unit})$$

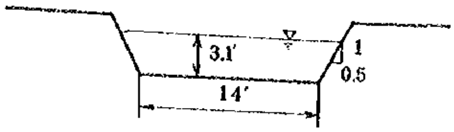
| Q ℓ/s | Nos. |
|---|---|
| 0 ～ 5 | 10 |
| 6 ～ 10 | 66 |
| 11 ～ 15 | 17 |
| 16 ～ | 7 |
| sub total | 80 |
| others | 27 |
| total | 107 |

Fig. 10 Variety in Capacity of Outlet in Tract 3

Appendix 8 - 5

## ON THE SHAPE OF CROSS SECTION OF CHANNEL

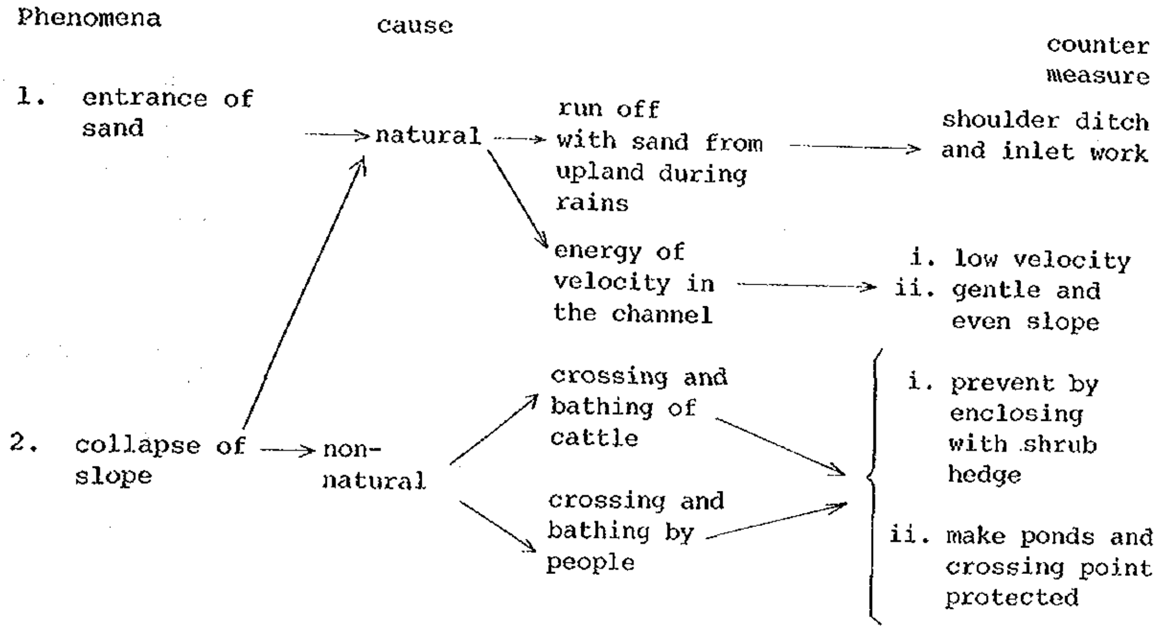
The slope gradient of cross section of Dewahuwa main channel is 1/0.5 as shown in the figure on the right.




Much labour is requested to take out silt which is caused by collapse of slope and entering sand from upland.

As for big channels such as Elahela Yoda ela and Kalawewa Yoda ela, the clearance is so big that the collapse and silting will not cause severe probrems, but in small or medium channels like Dewahuwa in which the width is about the "length of cattle" the effect is big.

The causes have been classified as follows after close observation.




In the above figure causes are shown separately but practically they are connected to each other.

A foothold of cattle crossing becomes the starting point of collapse caused as run off water from upland or water flow itself in the channel strikes at the point.

The run off of rainfall carrying sand from the upland causes silting but what is more significant is how it aggravates the collapse of the slope.

Some more comments are given below about the above figure.

1. A counter measure for crossing and bathing of cattle.

There are 6 permanent bridges and 18 log bridges (1.4 points/mile, 4.2 points/mile respectively), in the project area.

Still more there are 43 crossing points which are habitually used by people and cattle. (one point in 535 feet, or one point in 463 feet except pertaining well section).

Most of these points are in danger of being eroded or already have been eroded.

Bathing of cattle is prohibited but practically un preventable.

Therefore it is recommended to make bathing ponds and crossing points and to shut out other parts physically by shrub hedges and barbed wire.

Luckily, there is plenty of reserve land here to be used for these purposes.

2. Run off water

As for counter measures for run off water from upland, construction of shoulder ditches has been studied and approved but unfortunately, we could not construct these because we could not get cement for this.

The idea is to make a shoulder ditch (or catch) and to catch run off water from upland caused by rainfall, and prevent it entering directly into the channel.

As earthen ditch protected by shrub will be all right, according to the natural conditions of the site.

The run off water caught by a shoulder ditch is allowed to flow into an inlet box where the sand gets deposited and only the pure water is led into the channel, or it is carried away across the channel by an under cross or an over cross which can be used as a foot bridge, too.

3. Cross section

As for cross section, we don't see collapse at the section of gentle slope.

A section of gentle slope inevitably requires to increase land width, execution section, evaporation loss and seepage loss.

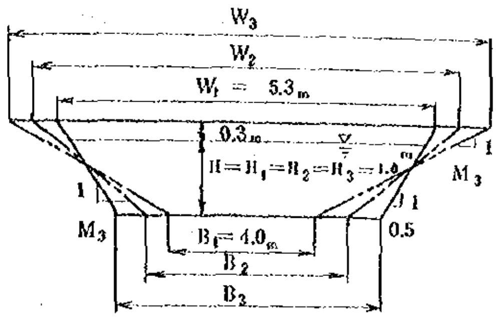
But here in the dry zone of Sri Lanka, land width does not bring about severe problems, and other reasons are more significant in conveyance loss.

Therefore here, only the execution section is examined.

We will study the difference in the quantity of earth work and top width of the channel in several cases of slope gradient and the bottom width of the section, of a channel of the same capacity as Dewahuwa with a certain longitudinal slope discharge and depth.

Capacity, water depth, free board, co-efficient of roughness, bottom width and slope gradient of the standard section are given as $2.5m^3$/sec, 1.0m, 0.3m, 0.03, 4.0m and 1 : 0.5 respectively, and also slope gradients of the compared channels are 1 : 1.0, 1 : 1.5, as shown in the following figure.

Cross sectional area of flow : A. wetted perimeter. B. hydraulic mean depth. R of each section are shown in the following table.




| | $A=HB+nH^2$ | $P=B+2H\sqrt{1+m^2}$ | $R=A/P$ | $R^{2/3}$ |
|---|---|---|---|---|
| $S_1$ | $A_1=4.5$ | $P_1=6.236$ | 0.7216 | 0.8045 |
| $S_2$ | $A_2=B_2+1.0$ | $P_2=B_2+2.828$ | $\frac{B_2+1.0}{B_2+2.828}$ | $R_2^{2/3}$ |
| $S_3$ | $A_3=B_3+1.5$ | $P_3=B_3+3.606$ | $\frac{B_3+1.5}{B_3+3.606}$ | $R_3^{2/3}$ |

From Manning formula,

$$V_1 = \frac{1}{n} I^{\frac{1}{2}} R^{\frac{2}{3}} = \frac{0.8045}{0.03} I^{\frac{1}{2}} \quad \text{---------- (1)}$$

$$Q = A_1 V_1 \quad \text{---------- (2)}$$

From (1) and (2) we can get $\frac{Q}{A} = \frac{0.8045}{0.03} I^{\frac{1}{2}}$

then, $I^{\frac{1}{2}} = 0.02071$, $I = 0.00042$

and from (1) $V_1 = 0.555$m/s

Similarly we can get following data

| | | S1 | S2 | S3 |
|---|---|---|---|---|
| bottom width | (B) | 4. m | 3.54 | 3.15 |
| velocity | (V) | 0.555 m/sec | 0.551 | 0.538 |
| top width | (W) | 5.3 m | 6.14 | 7.05 |
| execution section | (S) | 6.045 $m^2$ | 6.292 | 6.630 |

Therefore difference of (S) between $S_1$ and $S_3$ per mile is

$(6.630 - 6.045)m^2 \times 1609m \times 0.353 = 335$ cub.

Supporting the unit cost of earth work is Rs.15/cub, the difference of unit cost becomes

335 cub x 15 ≒ Rs./mile 5000

As for Dewahuwa main channel, the total difference between $S_1$ and $S_3$ is calculated as

$5000 \times \frac{2}{3} \times 9.5$ miles = Rs. 32,000 supposing the average section is $\frac{2}{3}$ of the section at the starting point of the channel. This is smaller than the total expenditure Rs. 49,700 for desilting work done by the Project.

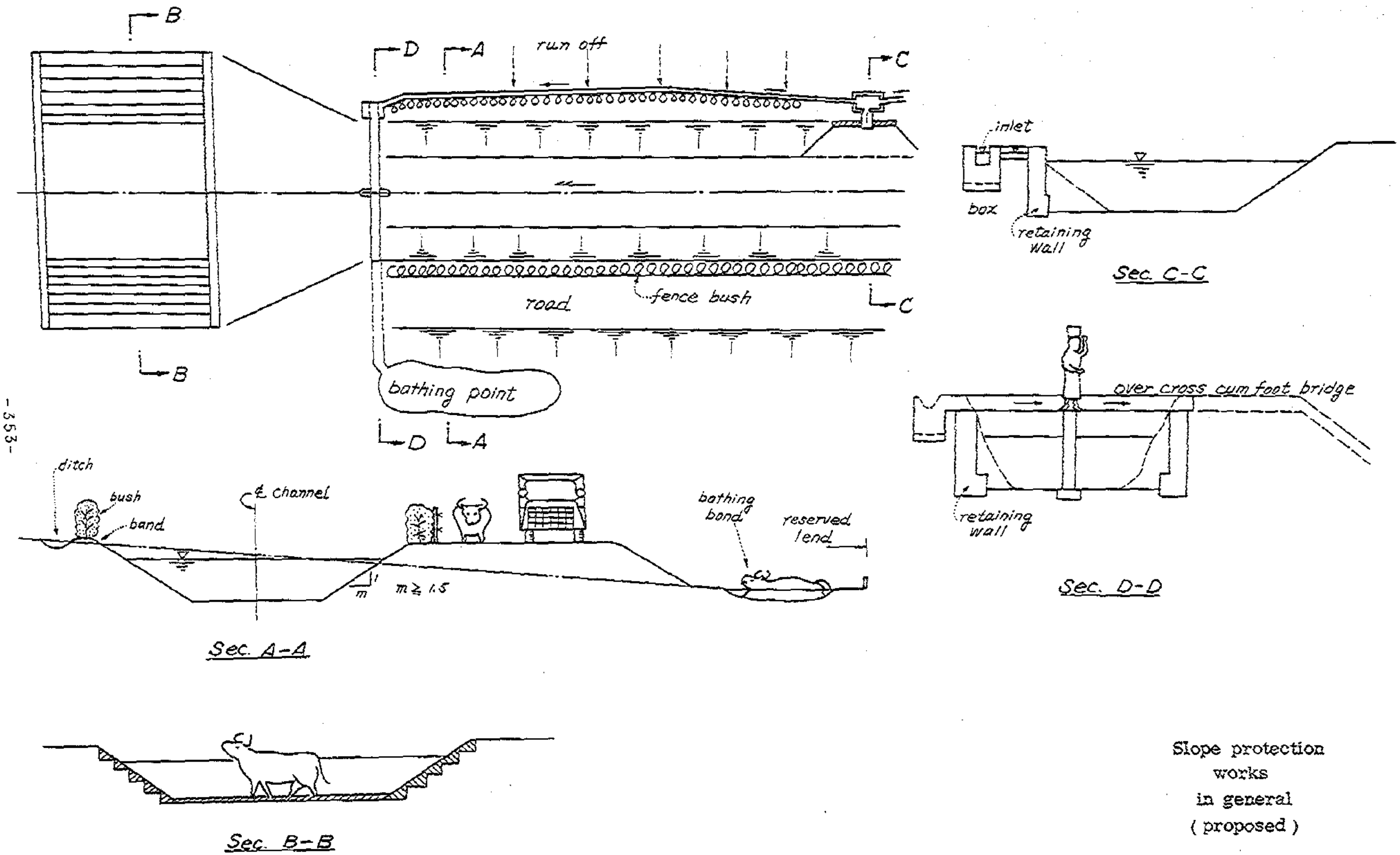
It will be necessary, therefore, to study to make a channel of gentle slope of cross section, in the dry zone where there is enough rather gently sloping land.

Proposals are summarized in 5 points below :

1. to make a gentle slope of cross section and to construct retaining wall only where this is not possible.
2. to make shoulder ditches mainly with bush and earth.
3. to lead away the run off water caught by the ditches.
4. to* make hedges of shrub at the roadside, so that cattle cannot enter the channel.
5. to make crossing points and bathing ponds with protection works where there is enough space.

These ideas are illustrated in the next page.

* by under crosses or by over crosses which can be used as foot bridges, or to lead only pure water into the channel after depositing sand in inlet boxes.




Slope protection
works
in general
( proposed )