Basin Irrigation

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(Design and Evaluation)

1. Introduction

Basins are the simplest and most widely used of all surface irrigation methods. A field may be divided into one or more basins. Each one is a level area of land surrounded by earth bunds in which water can be ponded until it infiltrates into the soil as shown in Figure 1.

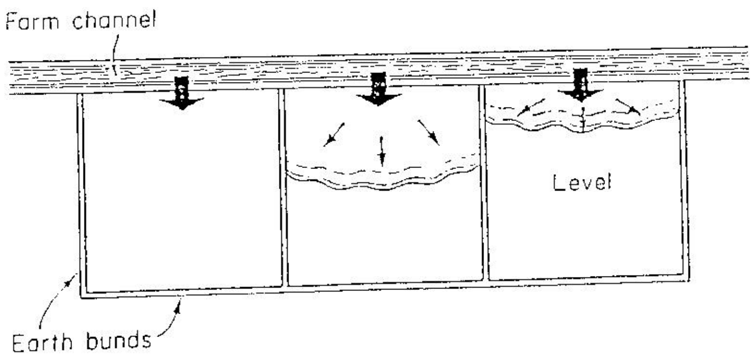


Fig. 1 Basin Irrigation

Basin irrigation can be adapted to suit many crops, soils and farming practices. However it is important to use the right size and shape of basin and good water management for the methods to work well.

2. Basin Size

There are many different sizes of basins. Some are only 1-2 m^2 while others are 3-4 ha or more. The size depends on : soil type, stream size, irrigation depth, field size, land slope and farming practices.

2.1 Soil Type, Stream Size and Irrigation Depth

These three factors are most important in determining the area that can be enclosed in each basin as shown in Figure 2.

When irrigating sandy soils water infiltrates rapidly. This means that basins must be small for water to spread quickly even when large stream sizes are used.

When irrigating clay soils water infiltrates much more slowly and so there is more time for water to spread over the soil surface. This means that basins can be much larger than on sandy soils even when the stream size is small.

Basins can usually be much larger on the same soil when a larger stream size is available. This is because water will spread more rapidly across the soil surface.

Applying a larger irrigation depth also means that basins can be increased in size. A larger depth of water needs a longer contact time and so there is more time available for water to spread across the soil surface.

There are no simple calculation to help an irrigator to select the best basin sizes for different stream sizes, irrigation depths and soil types. In places where basin irrigation is practiced, the experience of local irrigators often provides a good guide to the best size. When a new system is being planned or the local irrigation practices are obviously poor, the experience of others irrigation in similar conditions is needed. Table 1 is a collection of such experience. It provides a good guide to basin sizes for different stream sizes and soils which can give a uniform and efficient irrigation.

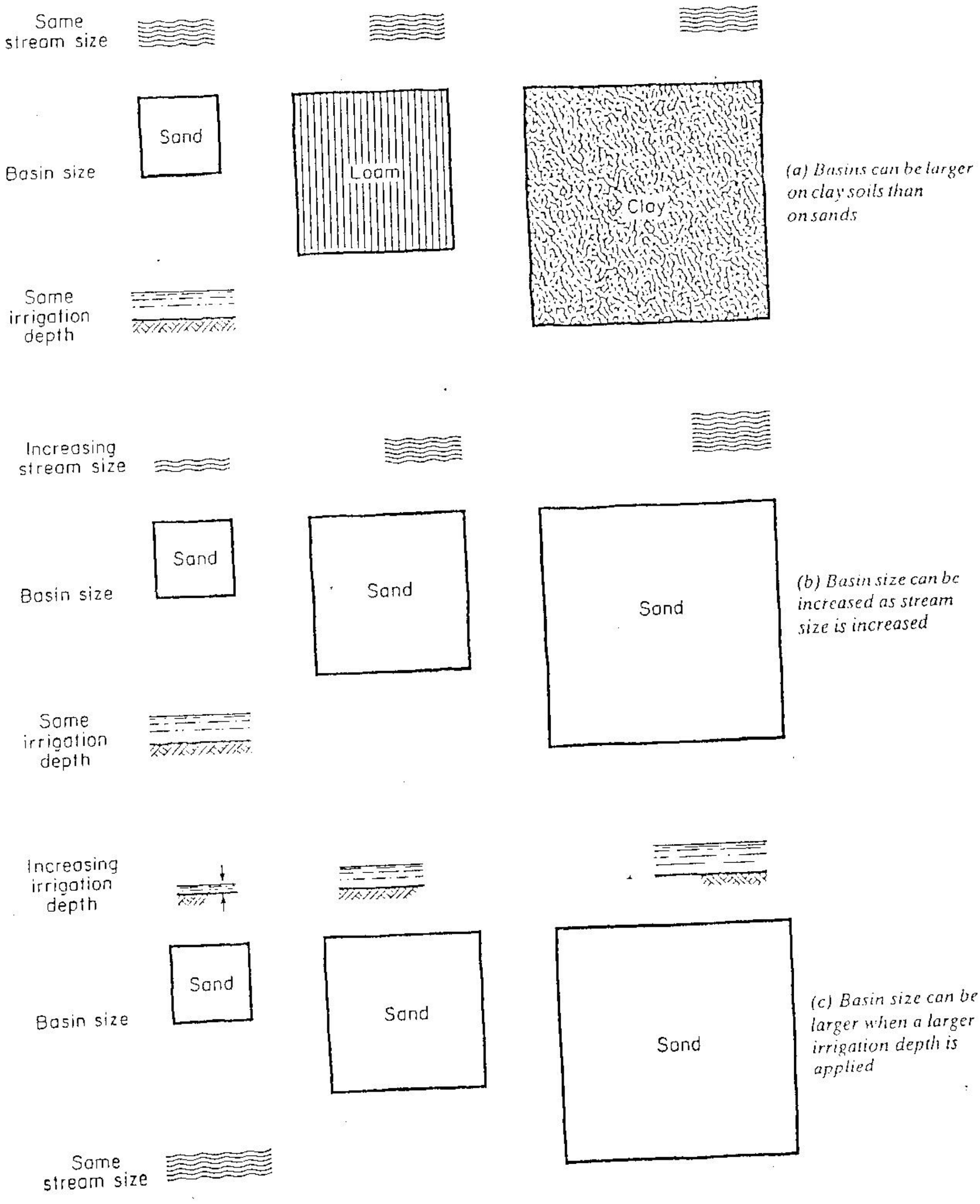


Figure 2 Factors Effecting Basin Size

For example, (from Table 1) when the stream size is 30 l/s the basin size is only 0.02 ha on sandy soil. The basin can be increased to 0.2 ha using the same flow on a clay soil. Notice also how large the stream sizes must be even for the smallest basins.

Table 1 Suggested basin sizes (ha)

Stream sizes (l/s)	Soil type			
	Sand	Sandy loam	Clay loam	Clay
15	0.01	0.03	0.06	0.1
30	0.02	0.06	0.12	0.2
60	0.04	0.12	0.24	0.4
90	0.06	0.18	0.36	0.6
120	0.08	0.24	0.48	0.8
150	0.10	0.30	0.60	1.0
180	0.12	0.36	0.72	1.2
210	0.14	0.42	0.84	1.4
240	0.16	0.48	0.96	1.6

2.2 Field Size

This may limit the choice of basin size. In very small fields the basin may be the same as the field size. In large fields a common practice is to divide the land into basins of equal size and shape. This makes it easier to deliver the same amount of irrigation water to each basin.

2.3 Land Slope

As the soil surface within each basin must be level, basin size can depend on the land slope.

When the land is level, basins can be as large as the stream size and soil type will allow.

On sloping and undulating ground the land surface must be re-shaped into level areas. A "Staircase" has been constructed to provide the level land for the basins. The steps are called terraces and normally the drop in level between them should be less than 150 mm to avoid erosion problems. In such cases the basin size is determined by the size of the terrace. This in turn is limited by the land slope and the depth of fertile top soil (Fugure 3). When the top soil is very deep the maximum drop of 150 mm. limits terrace width. When the top soil is shallow there is the danger of exposing unfertile sub-soils if there is too much excavation. The terrace width is limited in this case by the depth that can be excavated. (maximum drop 60 mm.) Suggested terrace widths for different land slopes can be calculated using Equation 1.

$$W = \frac{K}{S} \qquad \qquad (1)$$

where W = Terrace width in m.

S = Slope in %

K = A constant which depends on top soil if thick top soil, K = 15 if shallow top soil, K = 6.

2.4 Farm Practice

In many developing countries farms and fields are small, often only 1-2 ha or less. A wide range of crops are often grown at the same time and cultivation, planting and harvesting are done by hand or by animal power. Small basins are often used for this type of farming.

On large mechanised farms, channels and earth bunds surrounding basins are obstacles for the machines. Basins need to be as large as possible so that machines can turn around easily and have long

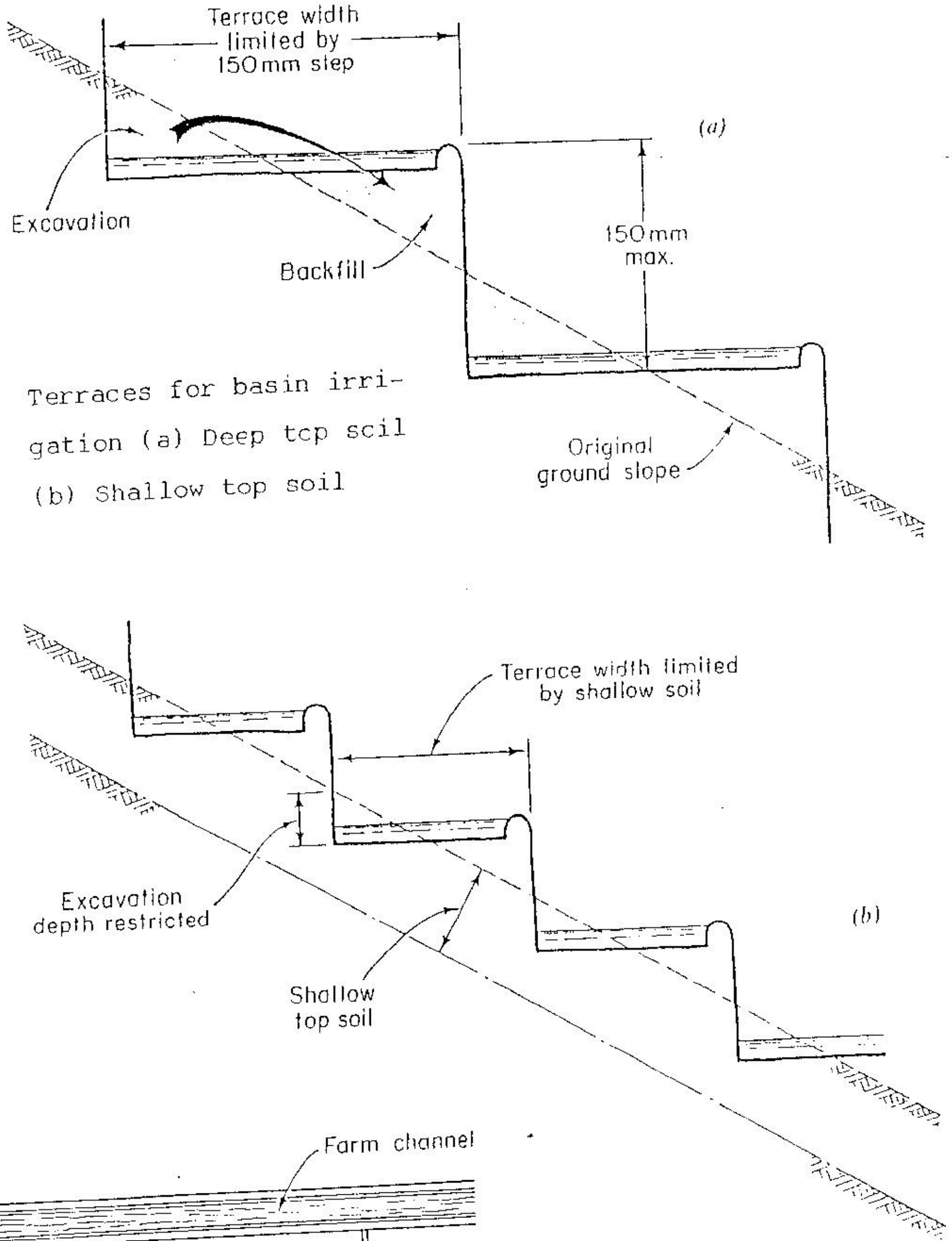


Figure 3 Terraces for basin irrigation (a) Deep tcp scil (b) Shallow top soil

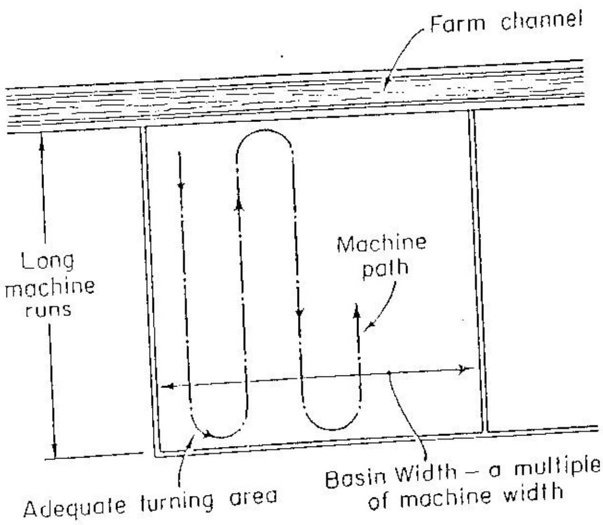


Figure 4 Large basins used for mechanised farming

runs without too many turns (Figure 4). The basin dimensions also need to be some multiple of the machine width. For example, if a cutter blade 2 m. wide is used to harvest alfalfa the basin width should be some multiple of 2 m.

Sometimes the type of cropping limits basin size. For example a small basin can be used in irrigating single trees in an orchard or a small plot in a vegetable garden.

3. Basin Shape

The shape of basins is mainly determined by land slope.

When the land is level or sloping uniformly basins can be rectangular. This makes it easier to plan the layout of canals, drains and roads around the farm and to use machines in the field.

When the land is undulating, basins can be shaped to the land contours. These are called contour basins and they can be very irregular in shape. On some systems undulating land is re-graded into large flat areas so that rectangular basins can be used.

Rectangular basins are generally long and narrow with the shorter side located alongside the farm channel (Figure 5). This reduces the number of farm channels required which in turn reduces labour and maintenance costs and improves vehicles access to the fields. On some farms it is possible to irrigate basins on both sides of the farm channel which further reduces the number of channels.

4. Crops

Many different crops are grown in basins. These include field crops such as rice, alfalfa and cereals; row crops such as cotton, maize

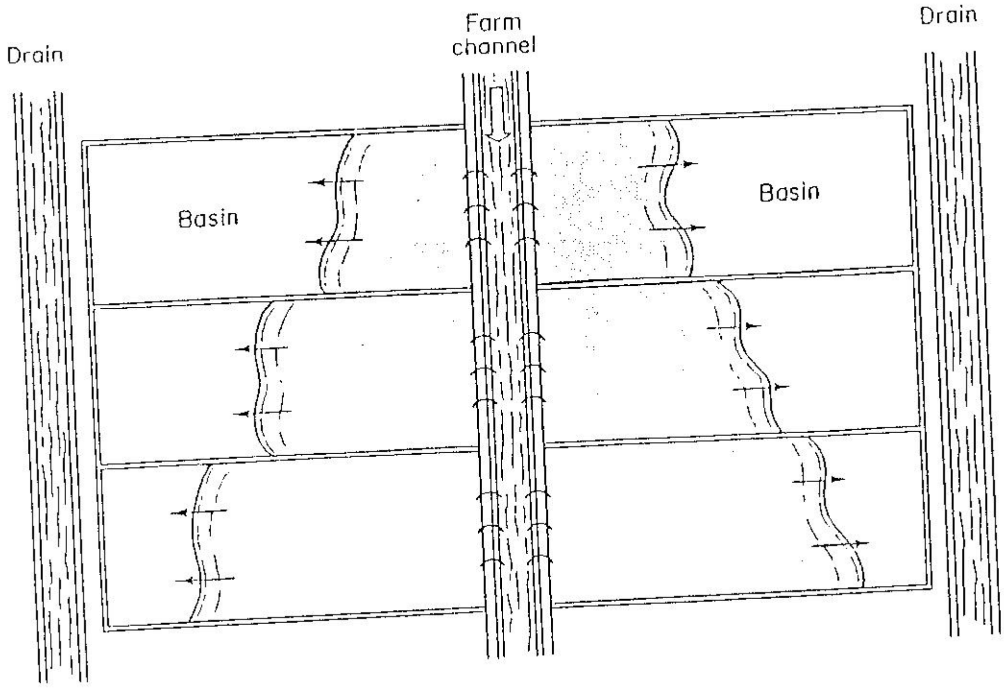


Figure 5 Typical Layout of Basins

and groundnuts, and orchard crops. Rice is perhaps the most common, basin crop. The level land on which water can be ponded provides the ideal growing conditions for this crop.

In orchards, basins can be easily adapted to the needs of growing trees. When young trees are first planted the root system is small and water demand is low. A small basin around each tree is sufficient. As the trees grow and their root systems expand the basins can be increased in size to supply more water.

Some crops suffer when they have to stand for long periods in water or very wet soil. These should not be grown in level basins but on furrows. An alternative is to grow them on raised beds or furrows within basins. Vegetables are often grown in this way. This method is also used when the soils are very heavy and water may stand in the basins for 24 hours or more before infiltrating.

5. Earth Bunds

These are small earth embankments built around each basin to hold water. The size and shape of bunds depends on irrigation depth, freeboard, wave action and farm machinery.

Bunds are usually built 150-300 mm high to contain water on the soil surface (irrigation depth 50-200 mm) with a small freeboard to stop water flowing over the top. In large basins waves can be a problem in windy conditions. In such cases a larger freeboard will be required (Figure 6).

Bunds vary between 0.6-1.2 m wide at the base. This provides sufficient soil to stop leakage.

Bunds in rice fields are usually much larger than for other crops. They are 400-500 mm high and 1.5-1.8 m wide at the base. This is bacause rice is often grown as a single crop on the same land and so more permanent bunds are constructed. On some farms the bunds are used as paths to the rice fields.

On mechanised farms bunds are carefully formed so that farm machinery can be driven over them easily, Figure 6.

To construct bunds, the steps are setting out, collecting soil, shaping and land smoothing.

Before construction can begin the position of each bunds is set out on the ground. This is done with small flag markers or by spreading white powder such as chalk along the line.

Collecting the soil to form the bund can be done by hand or by a tractor drawn disc plough. The soil is usually taken from an area close to the bund and this forms a borrow-furrow. Crops do not grow well in the borrow furrow and it tends to remain very wet, Figure 6.

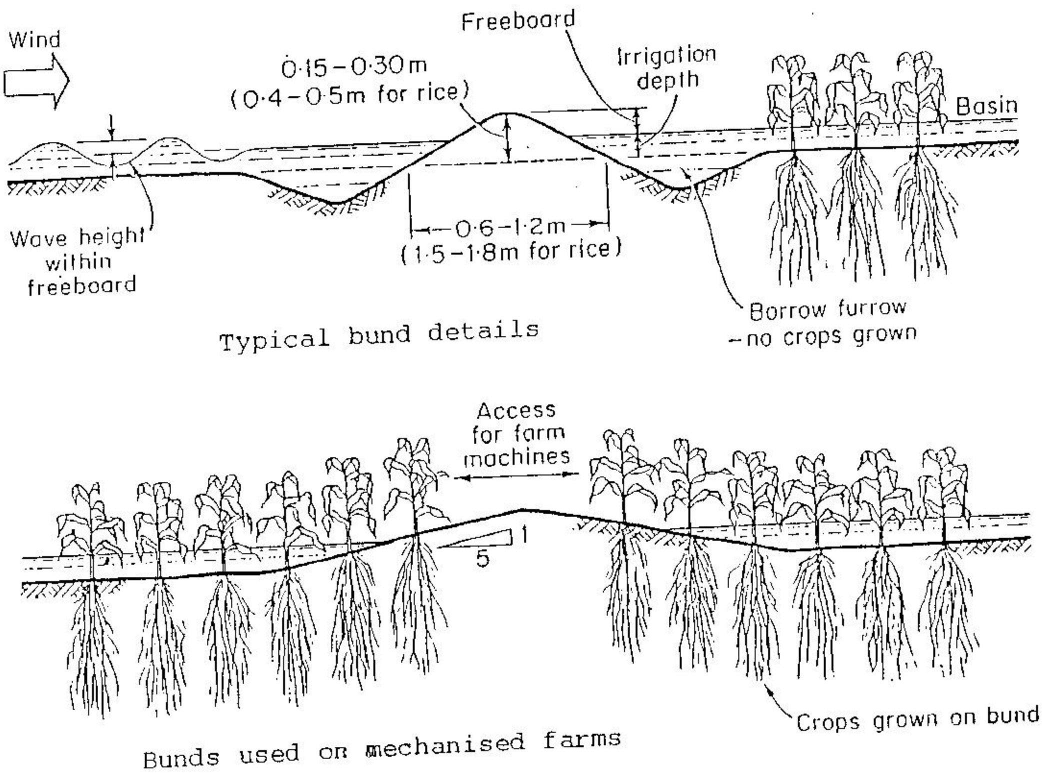


Figure 6 Typical Bunds

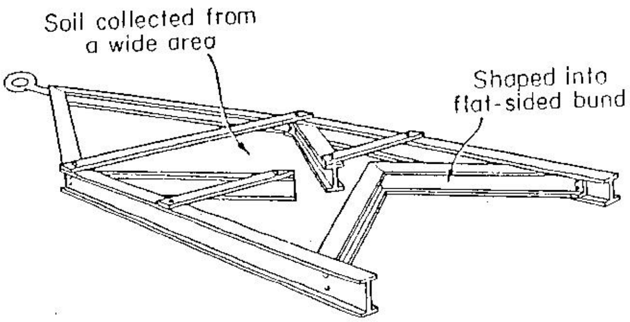


Figure 7 A frame for forming bunds

Once the soil has been collected it can be shaped with a tractor mounted A-frame (Figure 7) and compacted with a roller. It is usually built higher than is normally required to allow for settlement when the loose soil is wetted.

The final step is to smooth out any differences in level in the basins caused by taking soil to form the bunds. This can be done by hand in small basins or by a land plane in larger basin.

For most annual crops bunds are formed temporarity each season. For more permanent crops larger permanent bunds are formed but these need regular maintenance each season.

6. Irrigating Basins

When irrigating basins, water from the farm channel is turned into each basin using spiles or siphons. On some farms all the flow is directed into each basin in turn. On others the flow may be divided to irrigate several basins at the same time.

Whatever methods is used the stream size must be large enough for the flow to advance rapidly across the basins. This will ensure a reasonably uniform irrigation. The basins are then filled to some desired irrigation depth and the water ponded until it infiltrates into the soil.

Some water will always be lost in deep percolation when irrigating basins but this will be quite small if the right stream size is used. There should be no run-off losses because water can be ponded on the level soil surface.

There are two ways of supplying water to basins. Those are direct supply and cascade supply.

(1) <u>Direct Supply</u>

This is the best method for most crops and soils. A farm channel is constructed alongside every basin in the field as shown in Figure 1. Each basin is supplied directly from the basin channel.

(2) <u>Cascade Supply</u>

This method is sometimes used on sloping land where basins are constructed on terraces (Figure 8). Water is supplied to the first basin directly from the farm channel. It then flows from one basin to the next down the slope. There are two ways of using a cascade.

The first way is to fill basin 1, then basin 2 and so on until all the basins are irrigated. This is just the same as irrigating one large basin but in this case it is divided up into smaller ones, at different levels. To irrigate efficiently water must reach the last basin in one quarter of the contact time. The method is only suited to clay soils with low infiltration rates. On sandy soils deep percolation losses in the top basins can be very high. This method is often used for rice irrigation. Small structures are built into the bunds to control the flow from one basin to the next. A common practice when irrigating rice is to release a small continuous stream into the cascade throughout the season. This is adjusted regularly as the water demand of the crop changes. The irrigator checks that sufficient water is entering the cascade by ensuring that there is always a small excess flowing into the drain.

The second method is more suited to soils with higher infiltration rates. The stream is released into a small channel alongside the upper basins 1, 2 and 3 so that basin 4 is irrigated first (Figure 8). The bunds between basins 4 and 3 is then closed and basin 3 is irrigated.

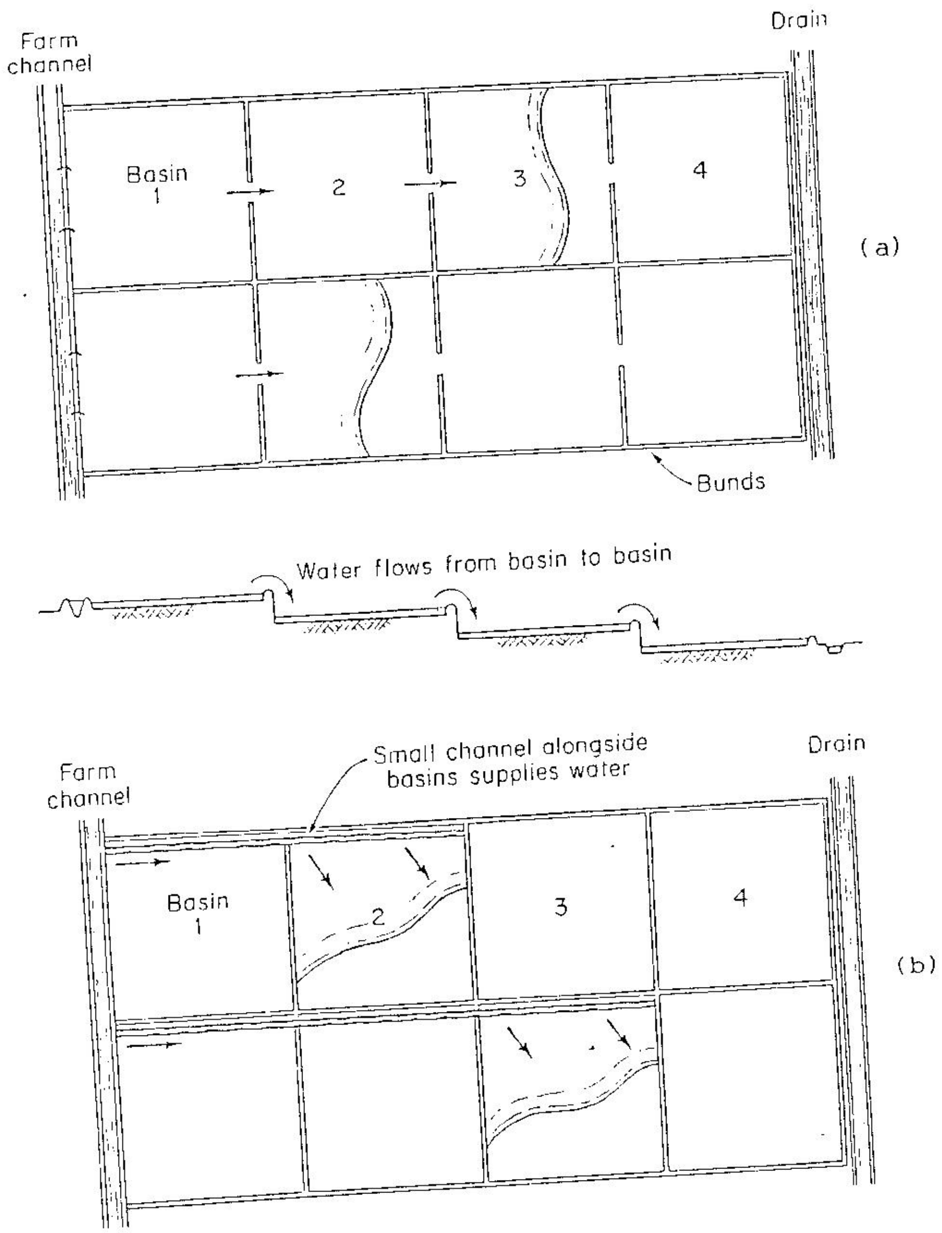


Figure 8 Cascade Method of Irrigating Basins

(a) For Clay Soils (b) For Sandy Soils

Basin 1 is the last one to be filled. This is very similar to the direct method but use is made of the small borrow furrow to carry the flow instead of constructing mcre farm channels.

7. Soil Erosion

When irrigating with large stream sizes on sloping land there is always the risk of soil erosion. If too much water is released into the basins at the top of a cascade system it may flow out of control over the earth bunds causing erosion further down. A serious flood could wash away the top soil and damage fields beyond repair. Great skill is needed to irrigate in these conditions.

8. Drainage

Drains are needed to remove excess water from basins. This may be due to excess irrigation water supplied from the farm channel or the result of a heavy rainstorm. When a rainstorm is exceptionally heavy, water is sometimes held in the basins and slowly released into the drains to avoid overloading the channels and flooding downstream. However, it is important that water does not stand in the basins for longer than a few days as some crops may be damaged and yields reduced. This of course does not apply to rice which grows best in flooded conditions.

Shallow drain channels are sometimes dug in large basins to help in draining them. This is often done in rice basins so that they can be drained quickly, at the end of the season for harvesting. A "herring bone" pattern of small channels guide the flow towards the drain (Figure 9).

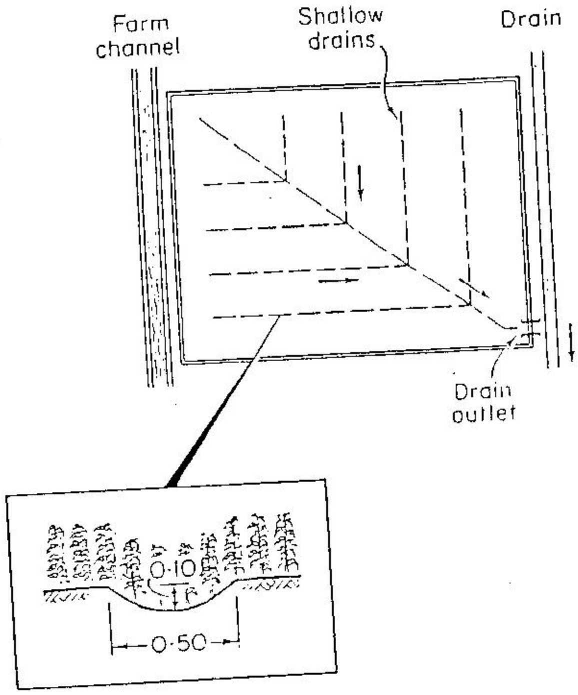


Figure 9 Shallow Drains in Rice Basins

9. Common Faults

Although basin irrigation can be very efficient there are common irrigation practices which result in poor uniformity and low irrigation efficiency. Some of these are described below.

9.1 Poor land preparation

When a basin is constructed on sloping ground and the land is not leveled, too much water ponds at the lower end (Figure 10) and is wasted in deep percolation (see section 10). Crops planted at the lower end may also suffer from water logging and reduced yields.

If a basin is constructed on reasonably level ground but the land has not been leveled properly too much water lies in the low areas and not enough is applied to the higher ground. Plants in the low areas may suffer from too much water while those on the high ground suffer from too little. Both result in poor crops.

These faults can be corrected by careful land preparation.

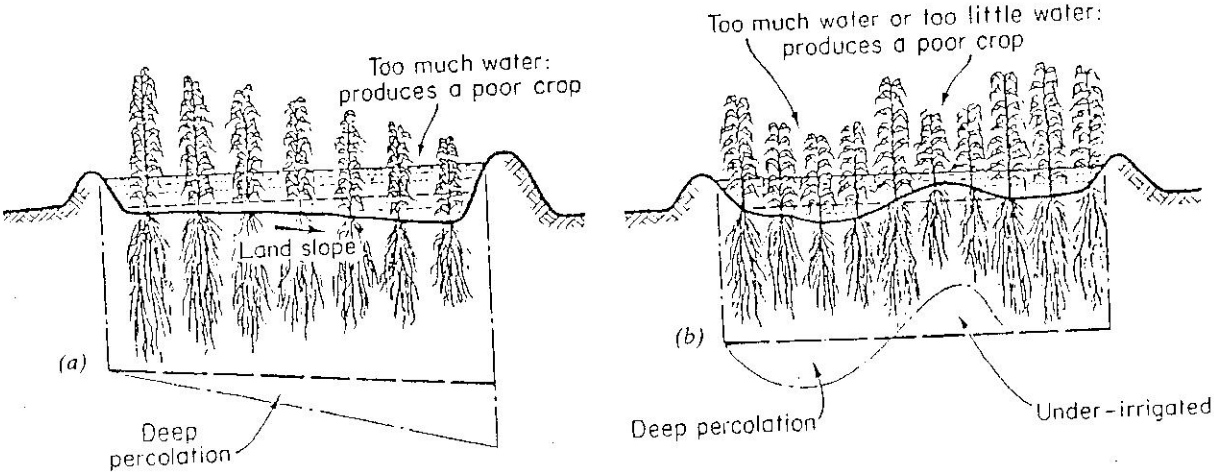


Figure 10 Common fault-poor land preparation.

(a) On sloping land (b) Flat land

9.2 Basins Covering Mcre Than One Soil Types

Variations in soil type within a basin can result in water infiltrating much faster in one place than in another. On the higher infiltration rate soil water may be lost from deep percolation. On the lower infiltration rate soil insufficient water may be applied (Figure 11). The only solution is to realign basin boundaries so that each basin contains only one soil type.

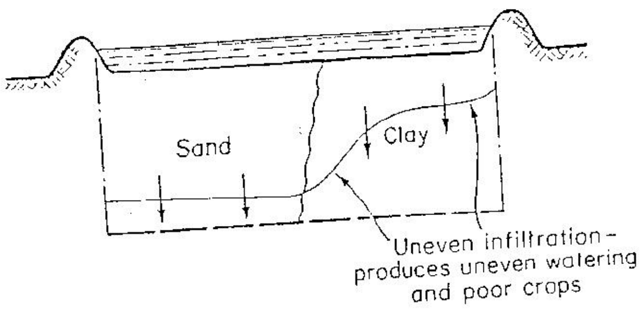


Figure 11 Common fault-basin covering more than one soil type.

9.3 Fixed Time Schedule

Irrigation time is sometimes fixed (eg. 8 or 12 hours) so that changing the flow from one basin to the next fits in with other work on the farm. This often means using a small stream size. The quarter time rule is ignored, the advance is too slow and a lot of water can be lost through deep percolation (Figure 12). Many irrigators are not aware of deep percolation losses, because it is below ground and cannot be seen.

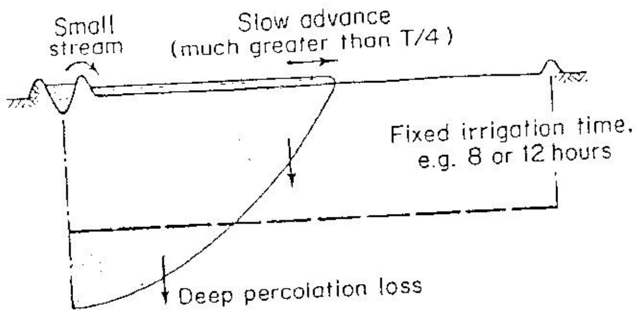


Figure 12 Common fault-irrigation to a fixed time schedule

10. Example 1

A basin 10 m wide is constructed on sloping ground and the land is not levelled (Figure 13). The irrigation depth required to fill the soil reservoir is 100 mm. What irrigation depth must actually be applied? How much water will be lost. What is the irrigation efficiency?

To apply 100 mm of water at the upper end, 150 mm must be applied at the lower end.

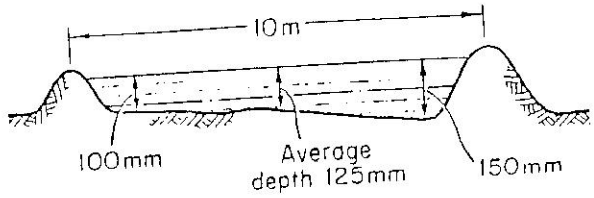


Figure 13 Basin on sloping ground (Example 1)

$$\text{Average irrigation depth} = \frac{100 + 150}{2}$$

$$= 125 \text{ mm.}$$

This is the depth of water that must be supplied to ensure the basin is irrigated adequately.

Water loss = Water depth supplied - water depth required

= 125 - 100

= 25 mm.

$$\text{Irrigation efficiency} = \frac{\text{Water depth required}}{\text{Water depth supplied}} \times 100$$

$$= \frac{100}{125} \times 100$$

$$= 80 \%$$

Thus a small difference in level of 50 mm across a 10 m wide basin reduces the irrigation efficiency to 80 %.

11. Efficiency

On well managed basins irrigation efficiency can be as high 90 %. When they are not used properly the efficiency will be much lower. The following are guidelines on the effects of poor practice on irrigation efficiency. The figures should be subtracted from 90 %.

Common faults	Subtract
Poor land preparation	10-20%
Different soil types in basin	5-10%
Fixed irrigation schedule	10-20%

It is easy to see from this how basin irrigation can be a very inefficient method when it is not managed properly.

12. Basin Irrigation Evaluation

The evaluation of basin irrigation is related to the measurement of water spreading, size of stream, infiltration, advance and recession. The evaluation requires the following equipments and procedures.

12.1 Required Equipments

1. A soil core sampler.
2. A soil probe.
3. A cut throat flume.
4. A watch.
5. A surveying tape for measuring basin size and setting a grid stake.
6. Stakes to setting up grid system for advance and recession measurements.
7. An infiltrometer with a hook gauge.
8. A paper to draw a basin layout map for advance and recession measurement.

12.2 Field Evaluation Procedure

The evaluation of the basin trial is to determine how effectiveness is the size and water application rate of the basin and to recommend the way to improve. The procedure is as follows :

1. Select 1 or 2 representative basins for field evaluation. Measure the basin size and set stakes to form a grid of 2 x 2 to 10 x 10 m^2. Draw 2 basin layout maps (true scale) with correct stakes position.

2. Measure soil moisture contents with a soil core smapler, at least 3 samples are required. Observe soil properties and crop conditions in the basin. Compare the soil moisture depletion with the allowable depletion to determine whether the irrigation should be started.

3. Measure infiltration rate using infiltrometer, at least 3 locations be measured.

4. Apply water at the same rate, time and method as farmers uses. Record starting and ending time. Measure application rate periodically.

5. Measure the advance to each stake until the whole basin is flooded. Sketch advance front at different time intervals. There should be 5-8 fronts depending on the basin size.

6. Measure and sketch the recession similarly to the advance. The high and low spots in basin should be noted.

7. Determine soil moisture penetration with soil probe after water is receded from the soil surface. The purpose is to determine infiltrated depth and uniformity of water application.

12.3 Analysis Procedure

The objective of evaluation is to determine the effectiveness of the basin irrigation; size of stream, size of basin and the application time, so as to use the field evaluation result to improve basin irrigation.

Preliminary Analysis

1. Calculate the total depth applied based on the basin size, stream size and application time.

2. Determine the cumulative infiltration curve.

3. Determine the opportunity time and depth infiltrated at each station.

4. Determine the soil moisture depletion.

Analysis of the Basin Effectiveness

1. Uniformity of Application.

2. Application Efficiency (E_a).

3. Adequacy of Irrigation

13. Example of Basin Irrigation Evaluation

In conducting basin irrigation evaluation, the size of basin is 40×50 m^2. The soil is silty loam. Other details are :

1. Application rate is 44 lps for 1 hr 40 minutes.

2. Soil moisture depletion 84 mm.

3. Basin layout maps with advance and recession fronts are shown in Figure 14.

4. Stake positions, advance and recession times for each station are shown in Figure 15.

5. Cumulative infiltration curve is shown in Figure 16.

13.1 Analysis

Total depth applied (D)

$$D = \frac{44 \times 70 \times 60}{40 \times 50} = 92.4 \text{ mm.}$$

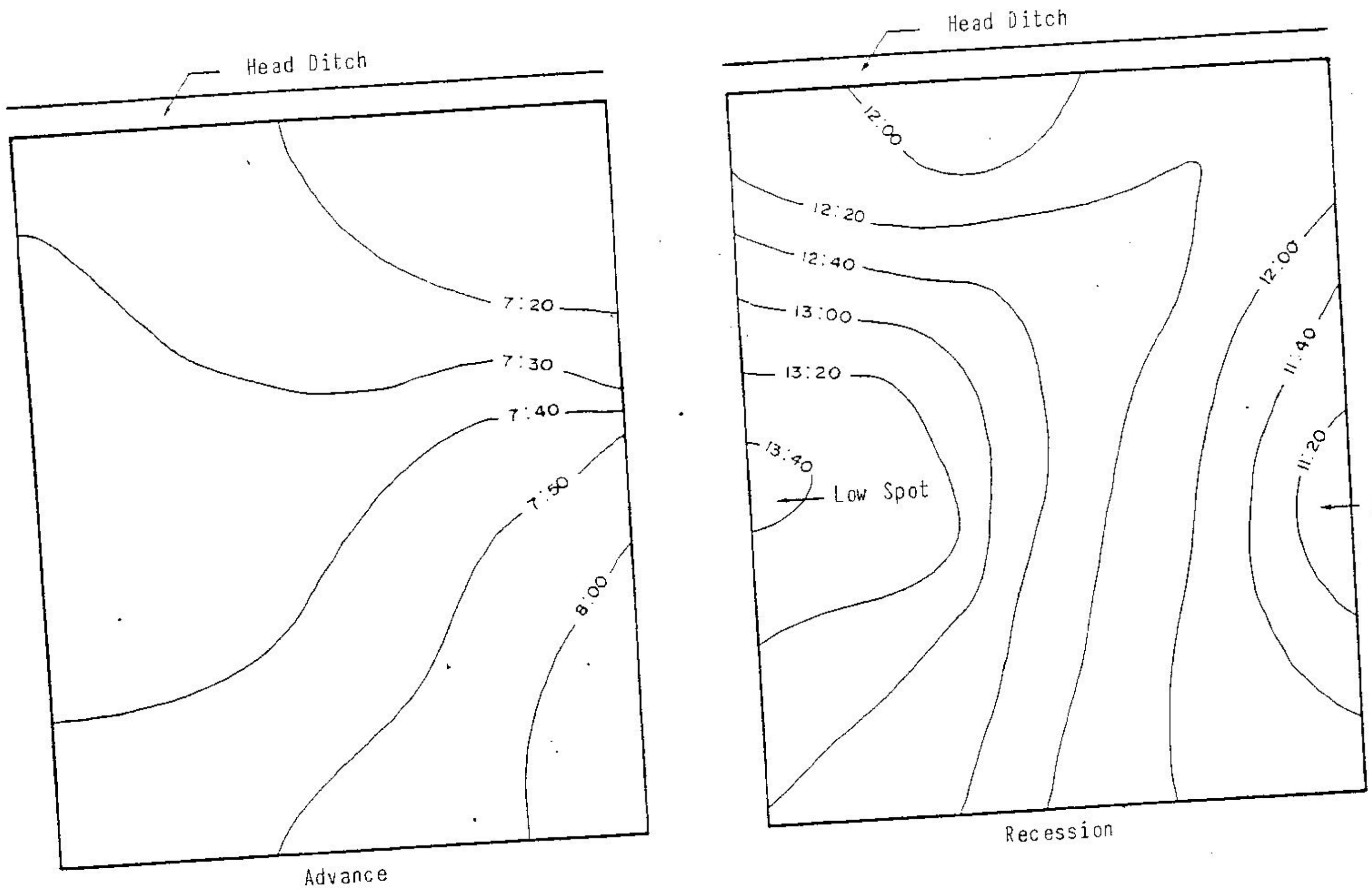
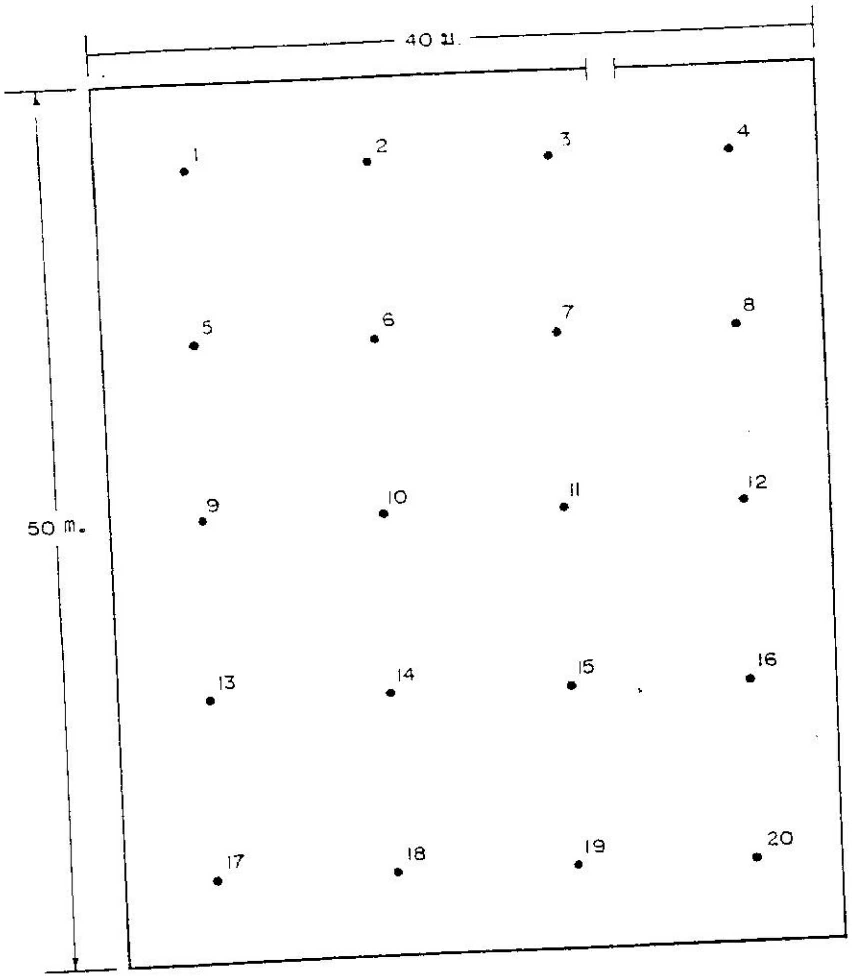


Figure 14 Advance and Recession Fronts



Flow Start : 7.10

Flow Stop : 8.20

Station (i)	Advance Time (min.)	Recession Time (min.)	Opportunity Time (min.)	Infiltrated Depth (D_i) (mm.)	$\lvert D_i - \bar{D} \rvert$
0					
1	7.28	12.15	287	90	1
2	7.22	12.00	278	89	2
3	7.13	12.12	299	93	2
4	7.14	12.10	296	93	2
5	7.32	13.05	333	100	9
6	7.27	12.50	323	98	7
7	7.24	12.28	304	94	3
8	7.20	11.53	273	88	3
9	7.35	13.42	367	101	10
10	7.34	13.10	336	100	9
11	7.39	12.20	281	89	2
12	7.46	11.35	229	79	12
13	7.37	13.18	341	100	9
14	7.40	12.50	310	94	3
15	7.47	12.10	263	86	5
16	7.58	11.30	212	76	15
17	7.44	12.56	312	97	6
18	7.49	12.35	286	90	1
19	7.55	12.05	250	84	7
20	8.05	11.50	225	78	13
			Total	- 1819 mm.	121
			Average ($\bar{D}$)	- 91 mm.	

Soil Type : Silt Loam

* 5 lowest depth infiltrated.

Figure 15 Advance and Recession Time in Basin

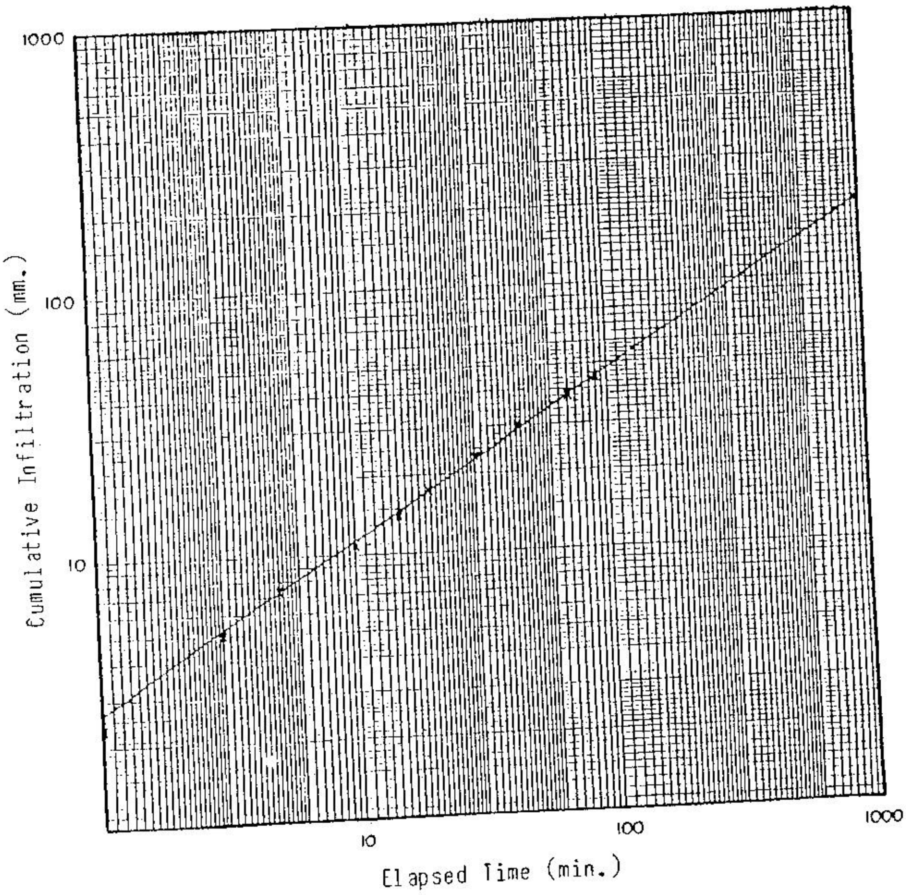


Figure 16 Cumulative Infiltration in Basin

Determine the opportunity time and infiltrated depth of 20 stations as shown in Figure 15.

$\bar{D}$ (average infiltrated depth) = 91 mm.

$\bar{D}$ is very close to D, therefore no adjustment on cumulative infiltration curve is necessary.

(1) Determine Uniformity of Application

Christiansen Uniformity Coefficient (CU)

$$CU = 100[1 - \frac{\sum_{i=1}^{n} |D_i - \bar{D}|}{n\bar{D}}] \quad \ldots\ldots (2)$$

From Figure 15,

$$CU = 100[1 - \frac{121}{20 \times 91}]$$

$$= 93.3\ \%$$

Alternatively, the uniformity can be determined using Distribution Uniformity (DU).

$$DU = 100\ \frac{\bar{D}_{LQ}}{\bar{D}} \quad \ldots\ldots (3)$$

$\bar{D}_{LQ}$ = Average Low Quarter Depth

From Figure 15,

$$\bar{D}_{LQ} = \frac{76 + 78 + 79 + 84 + 86}{5}$$

$$= 80.6\ \text{mm.}$$

$$DU = 100 \times \frac{80.6}{91} = 88.6\ \%$$

Both CU and DU indicate good uniformity of application.

(2) Application Efficiency (E_a)

$$E_a = \frac{V_{RZ}}{V_T} \times 100\ \%$$

where

V_{RZ} = Volume or depth stored in root zone.

V_T = Volume or depth applied.

Given SMD = 84 mm.

From Figure 15, there are 3 stations that got insufficient water. Those are D_{12} (79 mm), D_{16} (16 mm) and D_{20} (78 mm). Others got equal to or more than 84 mm.

$$V_{RZ} = \frac{17 \times 84 + 79 + 76 + 78}{20}$$

$$= 83.05 \text{ mm.}$$

$$E_a = \frac{83.05}{92.4} \times 100 = 89.9 \%$$

The application efficiency is very high. Only 10.1 % losses due to deep percolation take place.

(3) Adequacy of Irrigation

The cumulative frequency distribution of infiltrated depth can be used to determine the percent of adequacy of irrigation. Consider that each station covering the same size of area. The percentage area of each station is equal to

$$\frac{100}{20} = 5 \%$$

The frequency distribution of the infiltrated depths can be determined by arranging the infiltrated depths in descending order and calculating the cumulative area as follow :

Order (i)	D_i (mm.)	% area	% cumu. area
1	101	5	5
2	100	5	10
3	100	5	15
4	100	5	20
5	98	5	25
6	97	5	30
7	94	5	35
8	94	5	40
9	93	5	45
10	93	5	50
11	90	5	55
12	90	5	60
13	89	5	65
14	89	5	70
15	88	5	75
16	86	5	80
17	84	5	85
18	79	5	90
19	78	5	95
20	76	5	100

Plot D_i versus % cumulative area in Figure 17. The plot indicates 83 % of area receiving adequate irrigation.

The storage efficiency (E_s) is another alternative for calculation of adequacy of irrigation.

$$E_s = 100 \frac{V_{RZ}}{SMD} \%$$

$$= 100 \times \frac{83.05}{84} = 98.9 \%$$

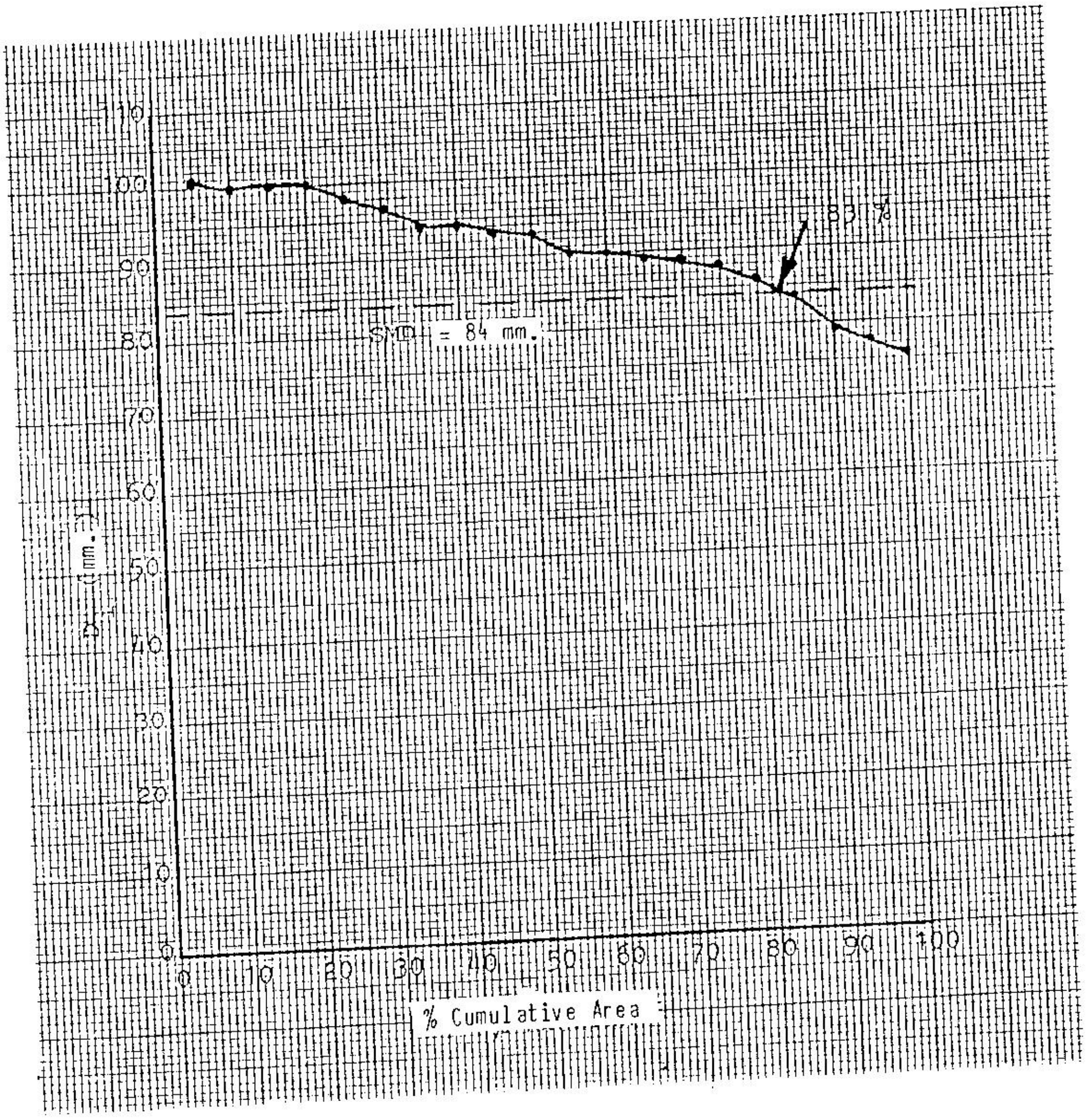


Figure 17 Frequency Distribution of Infiltrated Depth (D_i)

13.2 Approach to Improve Basin Irrigation

The analysis in 13.1 indicates that the trial basin irrigation has very high uniformity (CU = 93.3 % and DU = 88.6 %), very high application efficiency (E_a = 89.9 %) but the water application is inadequate (Adequacy of Irrigation 83 % or E_s = 89.9 %).

If one would like to complete irrigation. The application time should be longer than the trial until the minimum depth infiltrated at station 16 (D_{16} = 76 mm) is equal to SMD .

$$T = \frac{AD}{Q}$$

$$= \frac{40 \times 50 \times (84 - 76)}{44 \times 60}$$

$$= 6.06 \text{ min.}$$

Recalculate E_a

$$V_T = \frac{44 \times 76.06 \times 60}{40 \times 50}$$

$$= 100.4 \text{ mm.}$$

$$E_a = \frac{84}{100.4} \times 100 = 83.7 \%$$

E_a decreases from 98.9 % to 83.7 % because of deep percolation losses.

Advance Ratio

The advance ratio is the ratio of advance time (Tadv) to apportunity time (T_o) or tadv/To.

From Figure 16, To = 260 minutes

From Figure 15, Tadv = 55 minutes

$$\frac{Tadv}{To} = \frac{55}{260} = \frac{1}{4.7}$$

The advance ratio indicates proper application rate. This statement is also confirm by the calculated CU and Ea.

Field Practice

Field Evaluation of Basin Irrigation

1. Purpose

Basin irrigation has one important characteristics that is the land must be levelled or almost level with a slope of not exceeding 0.1 % . Basin irrigation can be applied to all types of crops, soils and farming practices. However, this irrigation technique will perform well only when it is properly designed and managed.

Size of basin depends on 3 main factors including types of soil, application rate and irrigation water depth applied. However the combined effect of these factors cannot be quantitatively defined. Therefore, field evaluation is needed to check how good the designed basin is under field conditions

2. Required Equipments

1. A leveling surveying instrument
2. A Surveying tape
3. A watch
4. 25 stakes of 60 cm long per basin with a hammer.
5. 2 cut-throat flumes of 30 x 90 cm. in size.
6. A shovel.
7. A bucket.
8. A water leveling indicator.
9. A soil core sampler with 5 sets of 1 + 3 + 1 cm. thick rings.
10. 3 sets of double ring infiltrometers.
11. A 70 cm diameter plastic sheet.
12. 3 hook gauges.
13. A water container of 20 liter.

14. 20 of 2" diameter of siphon tube.
15. A soil probe.
16. A form for recording infiltration.
17. A form for recording flow through cut throat flume.
18. A form for recording advance and recession.
19. 2 basin layout map for advance and recession observation.

3. Field Evaluation Procedure

1. Determine soil moisture content, bulk density, water contents at field capacity and permament wilting point using a soil core sampler. Take at least 3 samples.
2. Measure size of the basin and set stakes in grid pattern with 2 m. grid intervals. Sketch basin layout map with grid positions.
3. Read soil surface elevation on every grid using a leveling surveying instrument.
4. Install a cut-throat flume to measure inflow.
5. Measure infiltration characteristics using double ring infiltrometers.
6. Record time when flow was started and application rate. the application rate should be checked frequently.
7. Record time when water advance to each station and sketch advance pattern.
8. Record time when flow is stopped and time when water is receded at each station.
9. Check whether water infiltrates throughout the root zone on the next day.

4. Analysis Procedure

4.1 Preliminary Analysis

1. Determine infiltration curves or formula.
2. Determine advance and recession characteristics
3. Determine soil moisture depletion (SMD).
4. Adjust the infiltration curve.

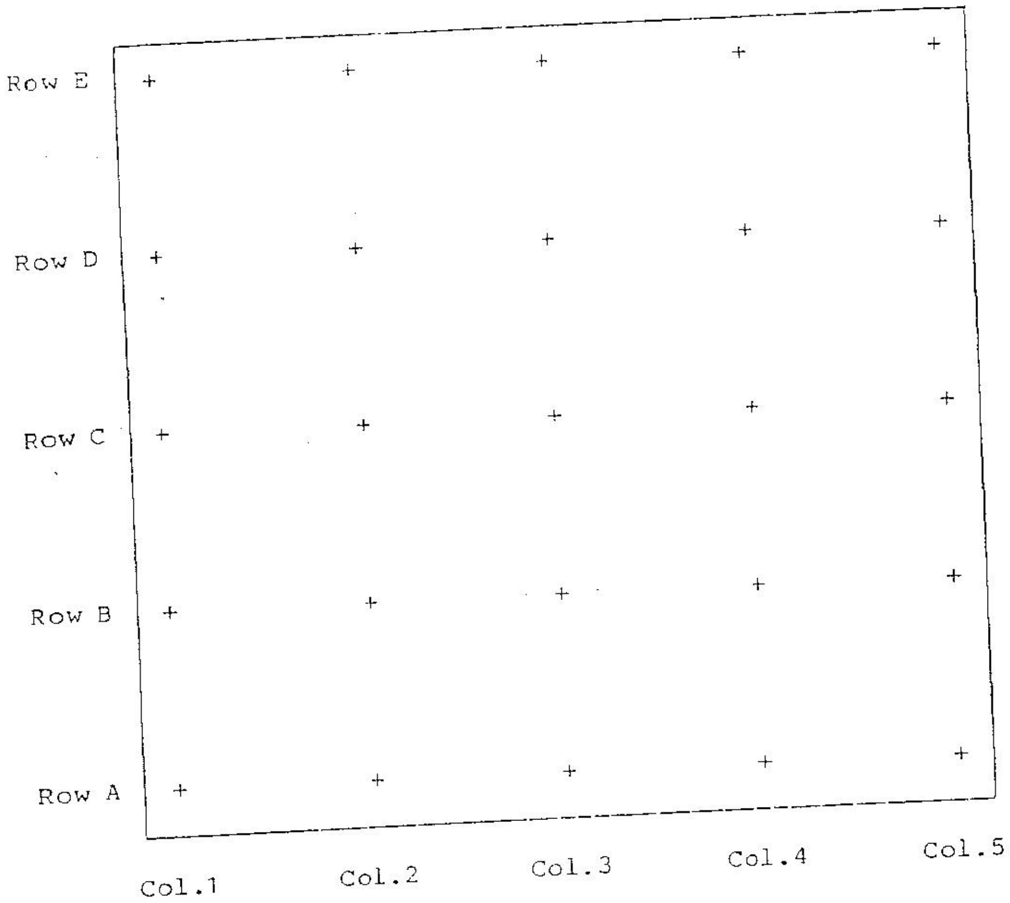
4.2 Analysis of Effectiveness of Water application

1. Uniformity
2. Application Efficiency
3. Adequacy.

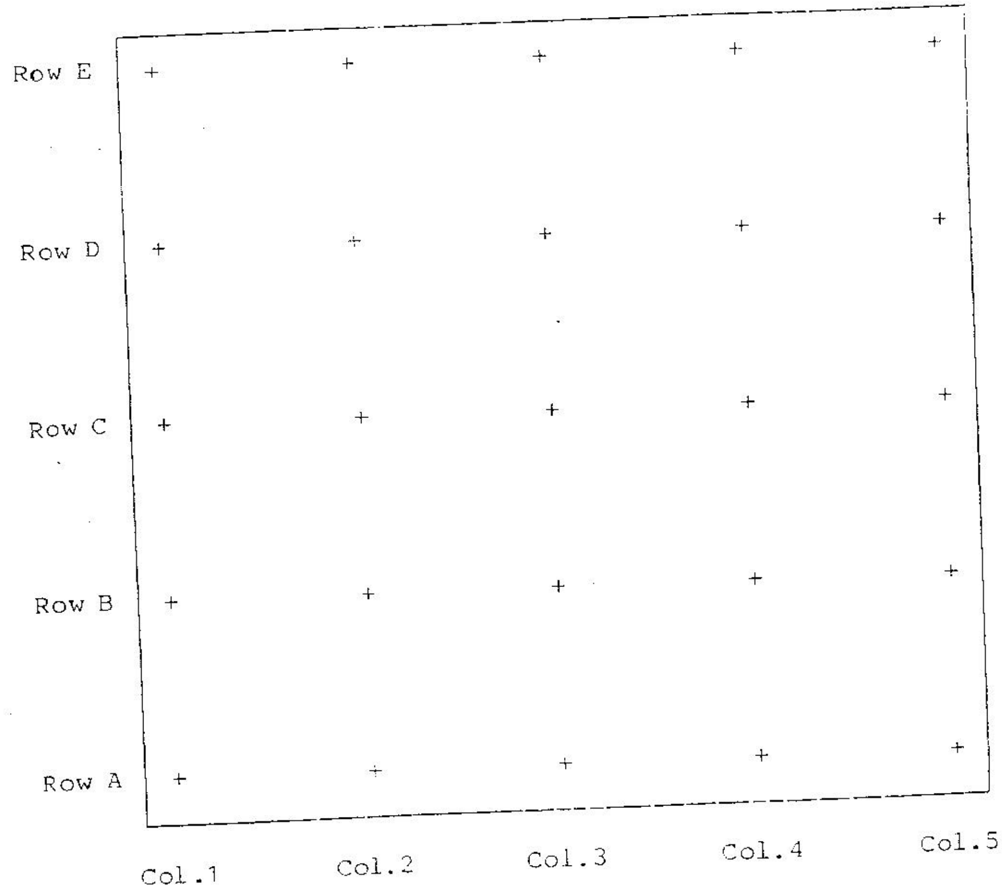
4.3 Analysis for Inproving Effectioness

1. Changine Q
2. Changine D.

5. Recommendations



Basin Layout Map for Advance and Recession Observations



Basin Layout Map for Advance and Recession Observations

Cylinder Infiltrometer Data

Location .... Observer .... Date ....

Soil Texture .... Soil Moisture ....

Crop Types .... Remarks : ....

Cylinder No.					
Time - min.			Infiltration (mm.)		
Watch	Diff.	Cumu.	Depth	Diff.	Cumu.

Cut Throat Flume Data

Type of Flume .... Size ....

Location.. Recorder ....

D-M-Y	Time	Ha (cm.)	Hb (cm.)	Hb/Ha	Types of Flow	Discharge m^3/s

Ha = upstream head

Hb = downstream head

Flow Start Time .... Flow End Time ....

Station	Advance Time	Recession Time	Opportunity Time (min.)	Infiltrated Depth (mm.)