Doc No.: FAD 17 (24327)WC
December 2023

BUREAU OF INDIAN STANDARDS

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भारतीय मानक मसौदा
विभिन्न सिंचाई विधियों को अपनाने के लिए अनुशंसा मानदंड

(*आइ एस 11711 का पहला पुनरीक्षण*)

Draft ***Indian Standard***

RECOMMENDATION CRITERIA FOR ADOPTABILITY OF DIFFERENT IRRIGATION METHODS

(*first revision of IS 11711*)

ICS **65.040.10**

Farm Irrigation and Drainage Systems Sectional Committee, FAD 17	Last date for Comments: **4 February 2024**

FOREWORD

(*Formal clause will be added later*)

Irrigation water may be applied to crops by flooding it on the surface, by applying it below the soil surface, by spraying it under pressure or by applying it in drops. The correct method of application of irrigation varies with the source of water, type of soil, topography of the land and the crop to be irrigated.

To facilitate the adoption of a particular method of irrigation, the standard was first published in 1988. The first revision of the standard has been undertaken to incorporate sub-surface drip irrigation method which is prevalent nowadays. apart from necessary editorial changes and to bring out the standard in latest style and format of Indian Standards.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with 2 :2022**.** 'Rules for rounding off numerical values (*second revision*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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RECOMMENDATION CRITERIA FOR ADOPTABILITY OF DIFFERENT IRRIGATION METHODS

(*first revision of IS 11711*)

1 SCOPE

1.1 This standard covers the criteria for adopting different methods of irrigation.

2 TERMINOLOGY

For the purpose of this standard the following definitions shall apply.

2.1 Irrigation methods shall be of following types.

2.1.1 *Surface Irrigation* — Water is applied directly to the land surface from a channel located at upper reach of the field. It shall be of the following types.

2.1.1.1 *Border strip method* — In this method water is introduced at the upper end of a strip of land and it flows between the low levees (bunds) to the lower end. The land is level between levees but has natural slope lengthwise.

2.1.1.2 *Check basin method* — This method consists in dividing the area into square or rectangular plots and irrigating each plot. The plots are generally level or have a very mild slope. The term check border is also used to describe this method of irrigation. The basin method of irrigation is a modification of the check basin method used for irrigation of orchards. Basins are constructed for each tree or group of trees. Water is conveyed to each basin, either by flowing through one basin into another or through a channel separately constructed.

2.1.1.3 *Furrow method* — This method consists in making the land into ridges and furrows and irrigating the area through furrows.

2.1.1.4 *Corrugation method* — This is a method of irrigating close growing crops using small closely spaced-furrow shaped channels called corrugations. They are constructed along the slope of the field and water moves down through several corrugations at a time. Unlike deep furrows, water in corrugations overtop them during flow.

2.1.2 *Sub-surface irrigation or Sub-irrigation* — In this method water is applied below the ground surface by maintaining an artificial water table at some depth and is made available to plants through capillary action. Topographic conditions can permit natural water application through sub-irrigation as well.

2.1.3 *Sprinkler irrigation* — In this method water is applied above the ground surface in the form of spray resembling rainfall. The spray is developed by the flow of water under pressure through small perforations or rotary nozzles.

2.1.4 *Drip or Trickle irrigation* — This is a method of application of water directly to the land surface or near the plant root in small quantities but continuously. Water application is accomplished through an extensive network of small diameter pipes fitted with emitters or drippers.

2.1.5 *Sub-surface drip irrigation* — Subsurface drip irrigation is a low-pressure, high efficiency irrigation system that uses buried drip tubes or drip tape to meet crop water needs.

3 INFILTRATION CHARACTERSTICS OF SOIL

3.1 For the purpose of deciding the method of irrigation and its subsequent design the infiltration characteristics of the soil should be understood. Infiltration is the downward flow of water into the soil. In irrigation practices, it is also known as water intake. The term infiltration applies to a level soil surface covered with water, whereas the water intake refers to a particular soil surface configuration such as furrow. The infiltration is much higher at the beginning and decreases with time. It is influenced by soil properties and moisture gradient. In surface irrigation, the depth and velocity of flowing water also influence the infiltration. The infiltration is either expressed as accumulated or cumulative infiltration, instantaneous infiltration rate, average infiltration rate, or basic infiltration rate.

3.1.1 *Accumulated or Cumulative Infiltration* — It is the volume of water per unit of surface area entering into the soil at the end of a given time. The volume per unit area may also be expressed as depth of infiltration.

3.2 Instantaneous Infiltration Rate — It is the rate at which water enters into the soil at a particular time. Thus, it is the volume per unit area per unit time. In terms of the accumulated or cumulative infiltration, it may be expressed as:

$$\boldsymbol{I_r = \frac{\delta(I_c)}{\delta t}} \quad \textbf{(1)}$$

in which I_r = instantaneous infiltration rate, I_c = accumulated or cumulative infiltration, and t = time.

3.3 Average Infiltration Rate — It is obtained by dividing the accumulated or cumulative infiltration with time as:

$$I_{av} = {}^{I_c}/_{t} \quad \textbf{(2)}$$

in which I_{av} = average infiltration rate. The average infiltration rate for a time interval from t_1 to t_2 shall be obtained as:

$$I_{av} = \frac{I_{c2} - I_{c1}}{t_2 - t_1} \quad \textbf{(3)}$$

in which I_{c2} and I_{c1} are values of the accumulated or cumulative infiltration respectively at the end of the time t_2 and t_1.

3.4 Basic Infiltration Rate — The infiltration rate decreases with time and approaches a constant value at large value of time. The constant value of the infiltration rate is known as basic or final infiltration rate. The basic infiltration rate is considered to be the point at change in the infiltration rate is 10 percent or less in an hour.

3.5 Intake Families — Infiltration shall be expressed by one of the following equations:

$$\boldsymbol{I_c = at^b + C} \quad \textbf{(4)}$$

$$\boldsymbol{I_c = at^b + ct} \quad \textbf{(5)}$$

$$\boldsymbol{I_c = a\,[\,1 - \mathrm{Exp}\,(-bt)\,]} \quad \textbf{(6)}$$

$$I_c = a\,[\,1 - \mathrm{Exp}\,(-bt) + ct\,] \qquad (7)$$

in which I_c = accumulated or cumulative infiltration, in cm; t = time in min, Exp = basic of the natural logarithms= 2.718, and a, b and c are characteristic constants. For the adoption of different irrigation methods, the soils can be placed in one of the eight infiltration groups called intake families. These intake families, as described by equation (4), are given in Table 1. The values of the characteristic constants a, b and c in equation (4) and the basic infiltration rates are the criteria in defining the intake families.

Table 1 Characteristic Constants Values for Different Intake Families

Sl.No.	Intake Family Symbol	Characteristic Constants			Basic Infiltration Rate (cm/h)	Infiltration Characteristics
		a	b	c		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	*A*	0.062	0.661	0.7	0.05	Very slow
ii)	*B*	0.093	0.721	0.7	0.75	Slow
iii)	*C*	0.119	0.756	0.7	1.25	Moderately slow
iv)	*D*	0.178	0.785	0.7	2.50	Moderate
v)	*E*	0.228	0.799	0.7	3.75	Moderately rapid
vi)	*F*	0.275	0.808	0.7	5.00	Rapid
vii)	G	0.365	0.816	0.7	7.50	Very rapid
viii)	H	0.444	0.823	0.7	10.00	Extremely rapid

3.6 Measurement of Infiltration

Infiltration may be measured by cylinder infiltrometers, volume-balance method, inflow-outflow method, or sprinkler, pending and furrow simulators. The measurements in volume-balance and inflow-outflow methods are done with the flowing water. Whereas, in cylinder infiltrometers, ponding and furrow simulators point measurements are made with stagnant water. In the sprinkler simulator method artificial rain is created with the help of sprinkler and the measurements of infiltration rate are made by adjusting the water application rate. The infiltrometers, and the ponding and furrow simulators do not represent the actual water flow conditions during irrigation. The methods also do not take care of the soil heterogeneity and variations in soil surface conditions such as cracks. The volume balance method is found to be most accurate for borders and the inflow-outflow for furrow irrigation. The design of sprinkler irrigation system needs the knowledge of the basic infiltration rate which can be measured with any of the methods. The infiltrometer method is most easy and practical and shall be used to fair degree of accuracy for the measurement of basic infiltration rate.

3.6.1 The volume balance method is based on the principle of continuity and states that for any time period during which water is advancing down a border strip, the total volume of water infiltration into the soil is equal to the volume of water applied into the border strip minus the volume of water temporarily stored at the soil surface. In inflow outflow method, about 30 m

length of a furrow is selected and the water infiltration rate at a particular time is equal to the difference of the inflow and outflow water streams for the selected length of the furrow. The water infiltration rate is expressed as volume of water per unit time which may be converted into the depth of water per unit time using the following relationship:

$$\text{Water infiltration rate } \left(\frac{\text{depth}}{\text{time}}\right) = \frac{\text{Water infiltration rate in furrow } (\frac{\text{volume}}{\text{time}})}{\text{Furrow wtdth x furrow length}}$$

4. CRITERIA FOR ADOPTION OF IRRIGATION METHODS

4.1 Border Irrigation

This method is suited to areas where soil depth and land topography permit the required land levelling with uniform low grade. This method is suitable for irrigating close growing crops and most suitable to soils having moderate to moderately high infiltration rates.

Different types of borders are as follows:

4.1.1 *Graded Borders* — The graded borders have some slope in the direction of irrigation. The slopes, generally range from 0.l to 0.5 percent, but higher slopes are used under unavoidable conditions. The slope selected shall not cause soil erosion problems. The stream size, dimensions of the border, time of irrigation are so adjusted as to get uniform application of water throughout the strip.

4.1.2 *Level Borders* — These borders have no slope in the direction of irrigation. Water is ponded until it infiltrates into the soil. Level borders generally have their ends closed and also known as check basins or check borders.

4.1.3 *Contour Borders* — While irrigating steep lands (lands greater than 2 to 3 percent slope), if borders are made longitudinally, it is difficult to get uniform application of water. Such borders also cause severe soil erosion problems. In such cases the land is converted into a series of borders in the transverse direction. These are known as contour borders. Because of land topography it may not be possible to get uniform width of the contour borders.

4.2 Check Basin Irrigation

This method is suited to smooth, gentle and uniform land surface and for all types of soils for irrigating close growing crops as long as the crop is not affected by temporary inundation. This method is especially adapted to irrigation of grain and fodder crops in heavy soils where water is absorbed very slowly and is required to stand for a relatively long time to ensure adequate irrigation. It is also suitable in very permeable soils which must be covered with water rapidly to prevent excessive deep percolation losses at the upstream and, for reclamation of salt affected soils and for irrigation of orchards.

4.3 Furrow Irrigation

This method is well adapted to irrigate row crops and vegetable crops and crops which are subjected to injury from ponded surface water or susceptible to fungal root rot. Furrow irrigation is suitable to most soils except sand that have a very high infiltration rate and provide

poor lateral distribution of water between furrows. The types of furrow systems and its adaptability is given in Table 2.

Table 2 Types of Furrow Systems and its Adaptability

Sl.No.	Type of System	Principal Features	Where Adaptable
(1)	(2)	(3)	(4)
i)	Flat land furrows	Essentially straight slopes less than 0.5 percent	Best suited for row crops
ii)	Contour furrows	Follows contours on steep land and hill sides	Suitable to irrigate steep and uneven slopes Hazardous in high rain-fall areas
iii)	Furrows of miscellaneous Shapes	Special cross-sections made because of unusual conditions	Adapted for special soil slope and crop production problems
iv)	Furrows of miscellaneous arrangements	Circuitous or broad based	Used in orchards and vegetable crops

4.4 Corrugation Irrigation

This method is suitable in loamy soils in which the lateral movement of water takes readily. This method is not suitable for clay soils, deep sandy soils and saline soils. Suitable to be used with borders having lateral slopes.

4.5 Sub-Surface Irrigation

This method is suited to soils having reasonably uniform texture and permeable enough to permit water to move both horizontally and vertically within the crop root zone. The soil profile must also contain a barrier against excessive losses through deep percolation either a nearly impermeable layer in the sub-stream or a naturally high-water table on which a perched or artificial water table can be maintained throughout the growing season. Topography must be smooth and nearly level or the slopes are very gentle and uniform. The quality of the irrigation water shall be good.

4.6 Sprinkler Irrigation

This method can be used for almost all crops (except rice and jute) and on most soils. This method is particularly suited to sandy soils that have a high infiltration rate. Soils too shallow to be levelled properly for surface irrigation methods can be irrigated safely by sprinklers. It is especially suitable for steep slopes or irregular topography because of its flexibility for the topography and its efficient control of water application. If soil erosion is a hazard, sprinkler irrigation can be used in conjunction with contour bunding, terracing, mulching and strip cropping. Land levelling is not essential for irrigation with sprinklers. Sprinkler irrigation can

be used to protect crops against frost and against high temperatures that reduce the quantity and quality of harvest. In this method the amount of water can be controlled to meet crop needs. Especially suited for regions of water scarcity where available water is insufficient to irrigate the command area by surface irrigation. Sprinklers are also suitable for irrigating plantation crops like tea, coffee, cardamom and orchards. It is not suited for the areas with vary windy and hot climate.

4.7 Drip Irrigation

This method can be used in areas with water scarcity and salt problems. For widely spaced crops like vegetables and fruit trees this system is more suitable. Drip irrigation permits the application of fertilizer through the system. Drip system operates on a much lower line pressure, thus provides a saving in energy requirement as compared to sprinkler irrigation. Most suitable for those crops which require frequent watering.

4.8 Sub-surface Drip Irrigation

This method is type of drip irrigation especially suitable for arid, semi-arid, hot, and windy areas with limited water supply, especially on sandy type soils. Since the water is applied below the soil surface, the effect of surface irrigation characteristics, such as crusting, saturated conditions of ponding water, and potential surface runoff (including soil erosion) are eliminated when using subsurface irrigation. With an appropriately sized and well maintained system, water application is highly uniform and efficient. Wetting occurs around the tube and water typically moves out in all directions. Subsurface irrigation saves water and improves yields by eliminating surface water evaporation and reducing the incidence of weeds and disease. Water is applied directly to the root zone of the crop and not to the soil surface where most weed seeds germinate after cultivation. As a result, germination of annual weed seeds is greatly reduced which lowers weed pressure on cash crops.

5 CROP ADAPTATION TO IRRIGATION METHODS

5.1 Crop adaptation according to different irrigation methods, are given in Table 3.

6 IRRIGATION METHOD ADOPTION TO SOIL AND LAND SLOPE GROUPS

6.1 Irrigation method adoption depending upon the soil and land slope group are given in Table 4.

Table 3 Crop Adaptation According to Irrigation Method

(*Clause* 5.1)

Sl No.	Crop	Normal Irrigation Application Percent of Available Moisture	Adapted Irrigation Methods						Remarks
			Check Basin	Border	Corrugation	Furrow	Sprinkler	Drip	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
i)	Wheat	50	X	X	X		X		
ii)	Barely	50	X	X	X		X		
iii)	Berseem	50	X	X	X		X		
iv)	Lucerne	50	X	X	X		X		
v)	Rape	40	X	V			X		
vi)	Sarson	40	X	X			X		
vii)	Raya	40	X	X			X		
viii)	Toria	40	X	X		X	X		
ix)	Potato	60				X	X	X	
X)	Gram	40	X	X	X		X		
xi)	Sugarcane	50		X		X	X		
xii)	Paddy		X	X					
xiii)	Maize	50	X	X		X	X		
xiv)	Bajra	40	X	X	X	X	X		
xv)	Groundnut	40	X	X		X	X		
xvi)	Sorghum	50	X	X		X	X		
xvii)	Cotton	50	X	X		X	X		Furrow irrigation is particularly useful
xviii)	Soyabean	50	X	X			X		

xix)	Moth	40	X	X		X	X		
xx)	Mash	40	X	X		X	X		
xxi)	Mung	40	X			X	X		
xxii)	Chillies	50	X		X	X	X		
xxiii)	Vegetables	60			X	X	X	X	Drip irrigation and sprinkler can be widely used for raising these crops

Table 4 Irrigation Method Adoption Depending Upon Soil and Land Slope Groups

(*Clause* 6.1)

Sl No.	Irrigation Method	Slope Group (Percent)					Intake Family								Rremarks
		0	0.1	0.25	0.5	1.0	A	B	C	D	E	F	G	H	
		0.1	0.25	0.5	1.0	2.0									
		(Design Slope Percent)													
		Level	0.2	0.4	0.75	1.5									
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
i)	Border strip		X	X	X			X	X	X	X	X	X		Almost suited to all soil except with very low and high infiltration rate
ii)	Check basin	X					X	X	X	X	X				Well suited for soils of moderate to slow infiltration
iii)	Corrugation		X	X	X	X	X	X	X	X					Particularly adapted for close growing crops
iv)	Furrow	X	X	X	X			X	X	X	X	X			Graded furrows are adapted in soils with high filtration and level furrows in soils with low infiltration
v)	Sprinkler	X	X	X	X	X	X	X	X	X	X	X	X	X	Soils varying from very low to very high infiltration rates
vi)	Drip	X	X	X	X	X	X	X	X	X	X	X	X	X	For maximum water economy where surface irrigation methods cannot be successfully adopted