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IRRIGATION ENGINEERING

[BTAI 2201]

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Root Zone Depth

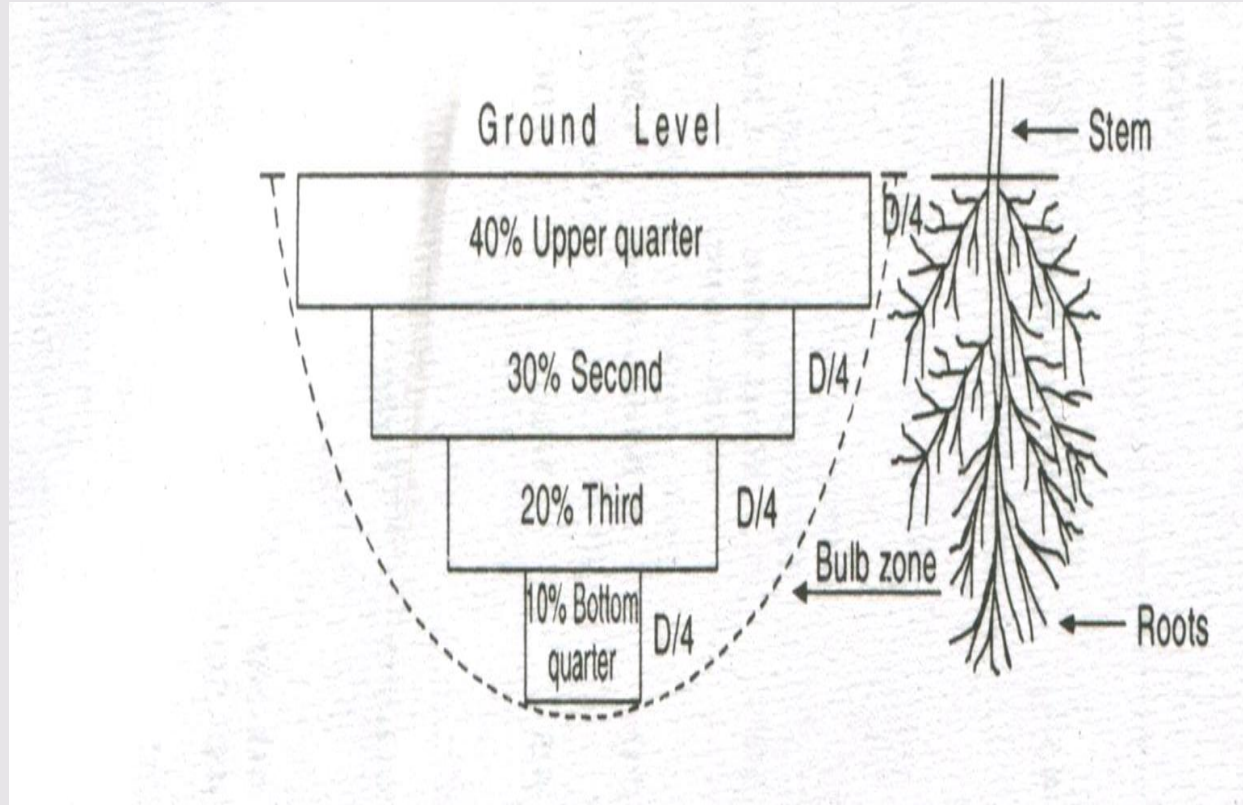
Depth below the ground surface in which the root systems of the plant develop to derive water and minerals from the underneath to prepare food and support growth is called as root zone depth. The root systems of the plants in the root zone may consist of (i) tap roots, (ii) shallow primary roots and (iii) lateral roots.

Crops, in general, develop most of their root systems in the upper most portion of the root zone. Pattern of moisture absorption of the plants varies from layer to layer in a given root zone. The first quarter of this depth uses 40% of the total soil moisture in the root zone whereas the second, third and the fourth quarter uses 30, 20 and 10% of the soil moisture, respectively (Fig. 6.8).



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Soil Water & Crop Yield Response to Soil Water

There are mainly two crop water production functions models available for assessment of soil water deficit affect on yield of dry land crops at different growth stages.

They are

- (i) multiplicative model and
- (ii) additive model.

Again each of the above two mentioned models may be **seasonal or dated**. Out of the various types, **additive dated model** is important. **An additive model of dated crop-water production function** derived from sensitivity factors for water stress in physiological growth stages as proposed by (Rao *et al.*, 1990) is given as:



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$$\frac{Y_a}{Y_p} = 1 - \sum_{tg=1}^{NP} K_{tg} \left(1 - \frac{ET_{crop}}{PET} \right)_{tg}$$

Y_a and Y_p = actual & potential yield of crops, respectively, kg ha^{-1}

K_{tg} = yield response factor for growth stage, tg (FAO 56)

ET_{crop} & PET = actual & potential evapotranspiration, respectively, mm;

tg = growth stage index and

NP = total number of periods for the crop (generally for all crops it is four).



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Following table gives data of actual and potential evapotranspiration and yield response factor of a crop at different growth stages. Find out the percentage reduction of yield due to water stress. If the potential crop yield is 10 q/ha, then find out the actual crop yield?

Growth stages	Potential evapotranspiration, mm	Actual evapotranspiration, mm	Yield response factor
Initial	22.0	20.0	0.5
Crop developmen t	30.0	25.0	0.8
Mid season	35.0	32.0	0.9
Maturity	20.0	15.0	0.5



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Growth stages	Potential evapotranspiration (<i>PET</i>), mm	Actual evapotranspiration (<i>ETcrop</i>), mm	Yield response factor, <i>Ktg</i>	<i>Ktg</i> ($1 - ET_{crop}/PE_T$)
Initial	22.0	20.0	0.5	0.045
Crop development	30.0	25.0	0.8	0.133
Mid season	35.0	32.0	0.9	0.077
Maturity	20.0	15.0	0.5	0.125
Total			0.380	

$$\frac{Y_a}{Y_p} = 1 - \sum_{tg=1}^{NP} K_{tg} \left(1 - \frac{ET_{crop}}{PET} \right)_{tg}$$

$$= 1 - 0.380 = 0.620$$

Hence, the percentage reduction of yield = $(1 - Y_a/Y_p) 100 = 38.0$

If potential yield is 10 q/ha, then the actual yield will be $0.620 \times 10 = 6.20$ q/ha.



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Infiltration

Infiltration is defined as the entry of water into soil through interstices or pores of the soil. It occurs both prior to and during occurrence of surface runoff but decreases with time until a minimum rate of infiltration is reached.

The rate at which infiltration takes place during a rainfall or when irrigation is applied to crop field, expressed in terms of depth of water per unit time (usually mm/hr, cm/hr) is called as infiltration rate. It is equal to the rainfall rate or infiltration capacity whichever is less.

It is maximum at first & gradually decreases with time. The infiltration capacity curve which is a graphical representation of infiltration rate vs. time is an exponential decay curve and indicates that the rate may be zero at infinite time.

A number of factors influences the infiltration capacity namely soil texture, soil structure, vegetation condition, slope, cultivation practices, AMC of soil etc. A number of models in hydrology are available to predict the infiltration rate: most of them are empirical



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Flow of Water into & Through Soils

The total energy (H) of a flowing fluid comprises potential energy, kinetic energy and pressure energy. This is given by Bernoulli's as:

$$H = \frac{V^2}{2g} + \frac{p}{\gamma} + Z$$

Since velocity of flow in soil is very small, kinetic energy head term of above Eq. can be ignored & hence the total energy head (H) is simplified as:

$$H = \frac{p}{\gamma} + Z$$

Head, H in above Eq can be used as in saturated soil by simple piezometer & in unsaturated soil by a tensiometer.



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Piezometer readings can be used to determine direction of flow of water in soil & can also be used to measure hydraulic gradient (i). Knowing hydraulic gradient & permeability of the soil (K), flow velocity in soil can be determined applying the Darcy's law

$$v = K \cdot i$$

Piezometric readings can be helpful to calculate percolation rate in soil in a given layer.

Darcy's Law can also be used to find direction of Groundwater Flow.

$$v = - K \cdot i = - K \cdot \frac{H_L}{L}$$

H_L = difference of piezometric head and

L = difference of elevation head of two piezometers put in soil.



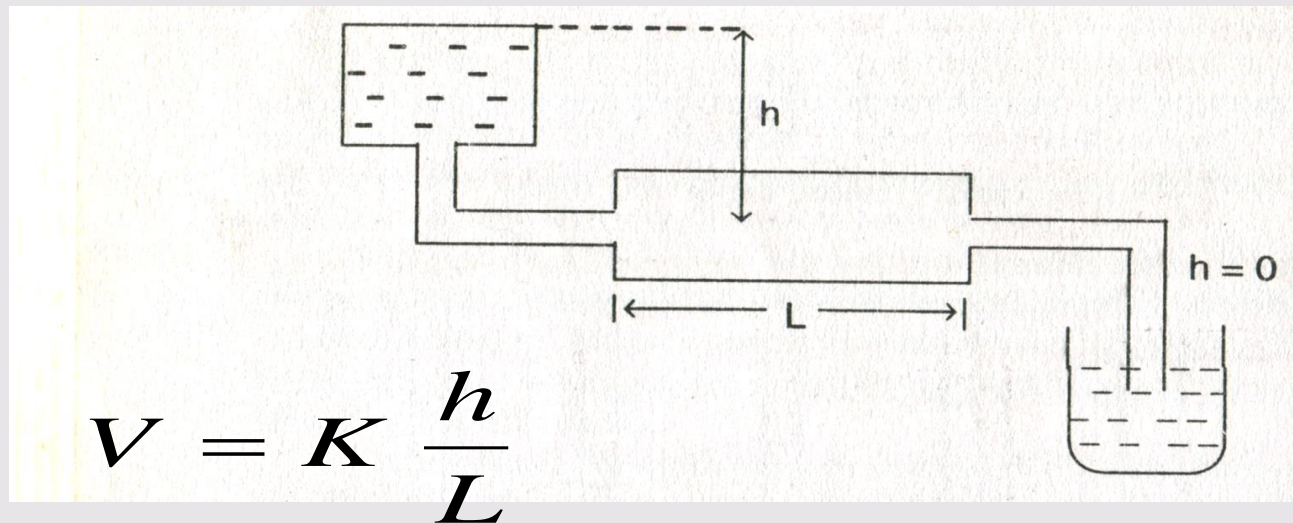
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Using the continuity equation, discharge, Q
as:

$$Q = A V = A K i = A K H_L / L$$

Flow of Water in Horizontal Soil Column in Unsaturated Condition

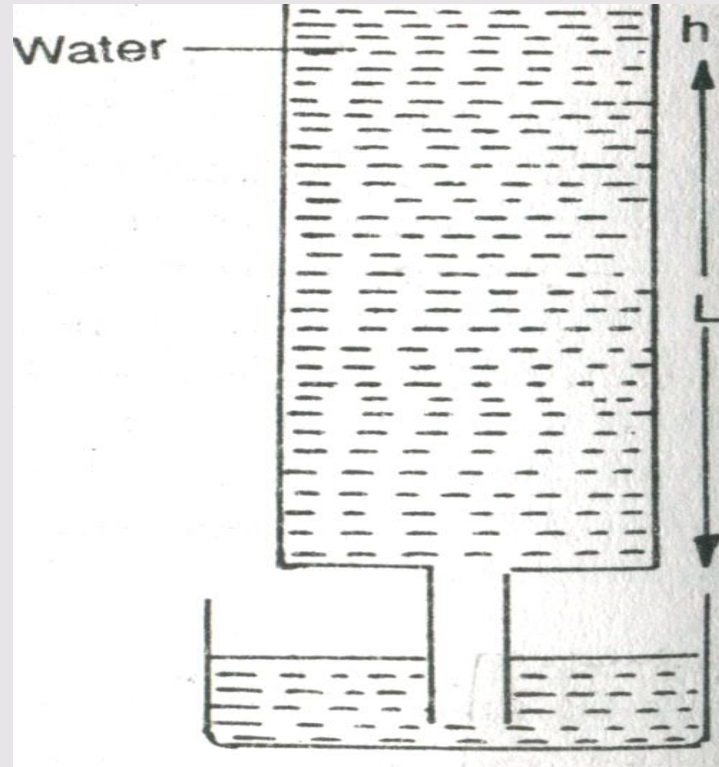




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Flow of Water in Vertical Soil Column in Unsaturated Condition



$$V = K i = K \frac{(h + L)}{L}$$



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