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IRRIGATION ENGINEERING

[BTAI 2201]

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IRRIGATION SCHEDULING

When to irrigate?

How much to irrigate? and

How to irrigate?

When to Irrigate?

- Plant indicators
- Physiological growth stage
- Soil moisture regime concept
- Water balance technique and



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Plant Indicators

Appearance and Growth: Appearance & growth indicators of the plant can be visualized by eye. Leaf & shoot wilting & leaf colour are several appearance parameters to decide whether it is time for irrigation or not. Similarly, measurement of stem diameter & height can be made regularly to find out the growth rate.

Leaf Temperature: Rise in leaf temperature is associated with reduced transpiration rates resulting from partial or full stomata closure. The number of degrees by which canopy temperature exceeds the air temperature for each day is accumulated till a certain critical level is reached. This critical level depends on the crop and soil parameters. When the critical level reaches, it is the time for irrigation.

Leaf Water Potential: As plant removes water from soil, SMC decreases resulting total water potential of soil to get reduced. A decreased value of soil water potential causes low water flow in plant body. Lower leaf potential is an indicator of more water stress demanding irrigation.



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Physiological Growth Stages

In this method, approach is to mark important crop physiological stages & when there is deficit irrigation supply, irrigate the crop at these stages only.

Deficit irrigation refers to partial application of water to meet the crop water requirement. Deficit irrigation reduces crop yield but saves adequate amount of irrigation water & is practiced when there is shortage in supply.



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Physiological stages of crops with respect of irrigations

Sl. No.	Crops	Physiological stages	Critical stages
1.	Wheat	Crown root initiation (CRI), late tillering, late jointing, flowering, milk and dough	CRI, flowering
2.	Barley	Early vegetative stage, flowering and dough	30 days after sowing, pre-flowering
3.	Potato	Sprouting, stolonisation, stolon development, early tuberisation, 20% of tuber weight, 40% of tuber weight, 60% of tuber weight and 80% tuber weight	Sprouting, early tuberisation
4.	Gram	Pre-flowering and pod formation	Pre-flowering
5.	Soybean	Early seedling, pre-flowering, pod development	Pre-flowering, pod development
6.	Rice	Early tillering, panicle initiation, flowering, milk, dough	Early tillering, flowering
7.	Sorghum	Flowering, dough	Flowering
8.	Maize	Early vegetative growth, tasseling and silking, dough	Tasseling and silking
9.	Cotton	Branching, pre-flowering, boll formation	Pre-flowering, boll formation
10.	Sugarcane	Sprouting, tiller initiation, tillering	Sprouting
11.	Groundnut	Emergence, flowering, pod formation, pod development	Flowering, pod formation
12.	Mustard	Vegetative growth, flowering	Flowering



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Soil Moisture Regime Concept

SMC in root zone can vary between FC which is the upper limit of available soil water to PWP which is the lower limit of available soil water. As discussed earlier, total ASM ($ASM = FC - PWP$) is not allowed to deplete.

The optimum level up to which SMC may be allowed to be depleted in root zone without fall in crop yield has to be worked out for each crop from experimental data. Irrigation should be provided when this optimum level of SMC reaches and its quantity should be just sufficient to replenish the SMC in the root zone up to FC .



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Depth & Frequency of Irrigation

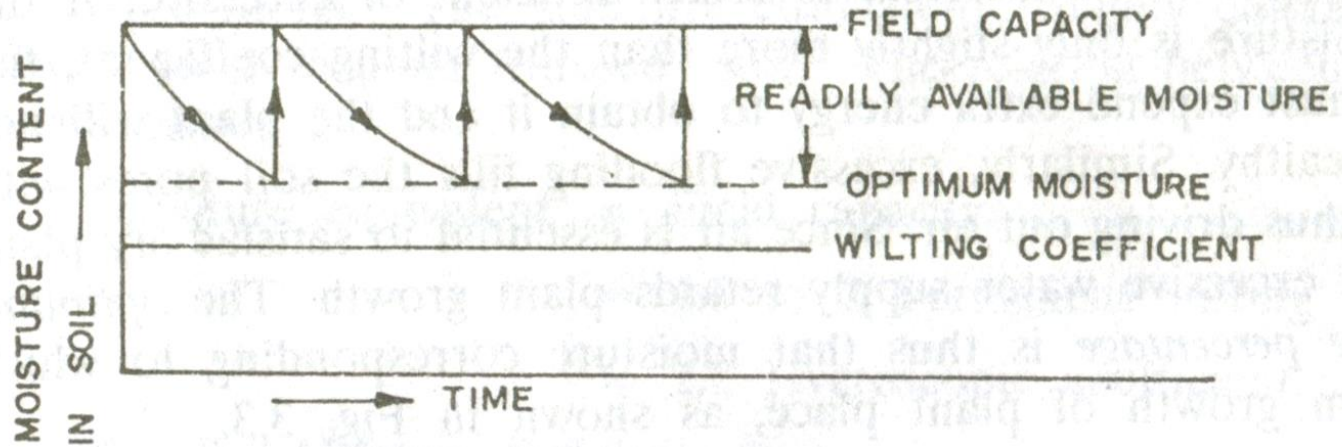


FIG. 3.4 FREQUENCY OF IRRIGATION



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Magnitude of available soil water depletions at which irrigation is to be scheduled may be a value ranging from 25 to 75 %.

Soil water depletion at which water should be applied for maximum yields of some crops

Sl. No.	Crops	Available soil water depletion (%) at 0-30 cm soil depth
1.	Wheat	50
2.	Potato	25
3.	Sugarbeet	50
4.	Sugarcane	65
5.	Soybean	60
6.	Tabacco	25
7.	Maize	50
8.	Sorghum	75
9.	Cotton	50
10.	Peas (grains)	65
11.	Berseem (fodder)	No depletion



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Irrigation Interval

$$\text{Irrigation interval} = \frac{\text{Allowable soil water depletion}}{\text{daily water use}}$$

Calculate the irrigation interval for a crop of tomato with the help of the following data.

$F C = 22.0\%$ dry weight basis, $PWP = 10\%$ dry weight basis,
Bulk density, $BD = 1.40$ g/cc

Effective root zone depth, $RD = 60$ cm

Daily water use, $ET_{crop} = 0.25$ cm/day Allowable soil water depletion = 25 percent of available soil water.



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$$\text{Available soil water} = \frac{(FC - PWP)}{100} \times BD \times RD$$

$$\text{So, available water} = \frac{(22.0 - 10.0) \times 1.40}{100} \times 60 = 10.08 \text{ cm}$$

$$\text{Allowable soil-water depletion} = \frac{25 \times 10.08}{100} = 2.52 \text{ cm}$$

$$\text{Interval of irrigation} = \frac{2.52}{0.25} = 10.08 = 10 \text{ days}$$



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Q. After how many days will you irrigate tomato if FC=26%, PWP=11%, BD = 1.3 gm/cc, Root zone depth = 70 cm, Daily ETC = 12 mm & Allowable Soil Water depletion = 100%.

Sol. FC = 26%, PWP = 11%, BD = 1.3 g/cc, RD = 70 cm

$$\text{Available soil water} = \frac{(26 - 11)}{100} \times 1.3 \times 70 = 13.65 \text{ cm}$$

$$\text{Allowable soil-water depletion} = \frac{100 \times 13.65}{100} = 13.65 \text{ cm}$$

$$\text{Therefore, number of days between watering} = \frac{13.65}{1.2}$$

= 11.34 days (11 days say).



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Q. After how many days will you supply water to soil in order to ensure sufficient irrigation of given crop, if FC & PWP are 28 & 15 %, BD = 1.5 gm/cc, Root depth = 50 cm, Daily consumptive use of water for crop = 10 mm & optimum soil moisture level = 80 percent of ASM.

Sol. $ASM = FC - PWP = 28 - 15 = 13 \%$

Optimum soil moisture level = $0.80 \times 13 = 10.4\%$

Irrigation is given when SMC is $28.0 - 10.4 = 17.6\%$ i.e. SMC varies from 17.6 to 28 %

Depth of water should be supplied such that optimum SMC rises from 17.6 to 28.0 percent which is estimated as:

$$d = \frac{1.5 \times 50 \times (28.0 - 17.6)}{100} = 7.8 \text{ cm}$$

Daily consumptive use = 10 mm = 1 cm

Hence the irrigation interval = $\frac{7.8}{1.0} = 7.8 = 7 \text{ days}$



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How Much to Irrigate? (Net Quantity of Water to be Applied)

After deciding when to irrigate a crop, next question comes how much water .to be irrigated to a crop at each irrigation.

Net quantity of water to be applied depends on magnitude of moisture deficit in the soil, leaching requirement and expectancy of rainfall.

When no rainfall is likely to be received & soil is not saline, net quantity of water to be applied is equal to the moisture deficit in the soil, i.e. the quantity required to fill the root zone to FC.

Water will gradually be utilized consumptively by the plants after irrigation & SMC will start gradually falling. When the depleting soil moisture reaches the optimum value, fresh dose of irrigation may be provided so that water content is again raised to FC.



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The moisture deficit (d) in the effective root zone that is to be filled up by irrigation is found out by determining the field capacity moisture content, actual available soil moisture content and bulk density of each layer and is given as:

$$d = \sum_{i=1}^n \frac{(FC_i - PW_i)}{100} \times BD_i \times RD_i$$

$\sum_{i=1}^n$ = summation of n-number of layers in the root zone;

FC_i and PW_i are SMC in i th layer on oven dry weight basis; BD_i = apparent specific gravity/bulk density of i th layer, and RD_i = depth of i th layer.



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Q. Find out the net quantity of irrigation water to be applied to ground nut with the following values of soil moisture content and other data.

Depth of soil layer in (cm)	Moisture % on oven-dry basis		Apparent specific gravity, gm/cc
	Field capacity	Actual	
0 – 15	26.0	17.4	1.39
15 – 30	24.0	17.8	1.47
30 – 60	22.3	19.2	1.51
60 – 90	22.2	20.5	1.53



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Moisture deficits in the different layers will be as follows:

$$\text{1st layer} = \frac{26.0 - 17.4}{100} \times 1.39 \times 15 = 1.79 \text{ cm}$$

$$\text{2nd layer} = \frac{24.0 - 17.8}{100} \times 1.47 \times 15 = 1.36 \text{ cm}$$

$$\text{3rd layer} = 1.40 \text{ cm}$$

$$\text{4th layer} = 0.78 \text{ cm}$$

So, net quantity of water to be applied is 5.33 cm.



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