Term Preparation

Example - 2.15: After how many days will you supply water to soil in order to ensure sufficient irrigation of the given crop, if, i) Field Capacity of soil = 28%

ii) Permanent wilting point = 13%

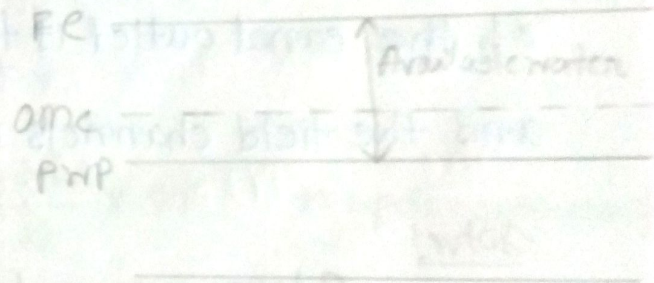
iii) Dry density of soil = 1.3g/cc

iv) Effective depth of root zone = 70cm

v) Daily consumptive use of water for the given crop = 12mm

Assume any data not given

Ans:



Available moisture

= FC - PWP = (28-13)%

= 15%

Let us assume readily available moisture or optimum moisture level is 80% of available moisture

Readily available moisture = 0.8×15 = 12%

∴ Optimum moisture = ~~28 - 0.8×15 = 12%~~

= 28 - 12 = 16%

$$\frac{\rho_d}{\rho_w} = \frac{\rho_d \times g}{\rho_w \times g} = \frac{\gamma_d}{\gamma_w} = \frac{1.3 g/cc}{1 g/cc} = 1.3$$

Depth of water to be irrigated : $d_w = \frac{\rho_d}{\rho_w} \times (FC - omc) \times D_s$

$= 1.3 \times \frac{(28-16)}{100} \times 70$

$= 10.92\ cm = 109.2\ mm$

so, water is to be supplied after $\frac{109.3}{12} = 9.1 \simeq 9$ days

(Ans)

2012-13

Example - 2.16: Wheat is to be grown in a field having a field capacity of 27% and PWP 13%. Find the storage capacity in 80cm depth of the soil, if dry unit weight of the soil is 14.72 kN/m³. If irrigation water is to be supplied when the average soil moisture falls to 18%, Find the water depth need to be supplied if field application efficiency is 80%, what is the amount of water needed at the canal outlet if the water lost in the water-courses and the field channels is 15% of outlet discharge?

Solve:

Storage capacity $d_w = \frac{\gamma_d}{\gamma_w} \times D \times (F.C - PWP)$

$= \frac{14.72}{9.81} \times 80 \times (27-13) \times \frac{1}{100}$

$= 16.8$ cm (Ans)

$NIR = \frac{\gamma_d}{\gamma_w} \times D \times (F.C - 18\%)$

$= \frac{14.72}{9.81} \times 80 \times (27-18) \times \frac{1}{100}$

$= 10.8$ cm

$F.IR = \frac{NIR}{\eta} = \frac{10.8}{0.8} = 13.5$ cm (Ans)

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Quantity of water needed at the canal outlet

$$= \frac{FIR}{\eta_e} = \frac{13.5}{0.85}$$

$$= 15.88\ cm\ \text{(Ans)}$$

Example-2.17: 800 m^3 of water is applied to a rice field of 0.6 hectares. When the moisture content in the soil falls to 40% of the available water betwn the Field capacity (36%) of soil and PWP (15%). Determine the field application efficiency. The root zone depth of rice is 60cm. Assume porosity = 0.4.

Soln: $F.C = \frac{\gamma_w}{\gamma_d} \times \frac{V_v}{V} = \frac{\gamma_w}{\gamma_d} \times n$ $\quad n = \text{porosity} = 0.4$

$$\Rightarrow 0.36 = \frac{\gamma_w}{\gamma_d} \times 0.4$$

$$\therefore \frac{\gamma_d}{\gamma_w} = 1.11$$

$$NIR = \frac{\gamma_d}{\gamma_w} \times D_s \times 60\% \text{ of } (F.C - PWP)$$

$$= 1.11 \times 60 \times 0.6 \times (0.36 - 0.15)$$

$$= 8.4\ cm$$

$$F.IR = \frac{800}{0.6 \times 10000} = 13.33\ cm$$

Efficiency of field application, $\eta = \frac{NIR}{FIR} \times 100\%$

$= \frac{8.4}{13.3} \times 100\%$

$= 63\%$ (Ans)

Example-23: Determine the field capacity of a soil for the following data:

i) Depth of root zone = 1.8 m ii) Existing moisture = 8%

iii) Dry density of soil = 1450 kg/m³ iv) Area to be irrigated = 10³ m²

v) Water loss due to deep percolation and evaporation = 10%

vi) Quantity of water to be supplied to soil = 650 m³

Solve:

$$NIR = \frac{650 - 10\% \text{ of } 650}{1000} = 0.585\ m$$

now,

$$NIR = \frac{1450}{1000} \times 1.8 \times (FC - 0.08)$$

$$F.C = 30.4\%$$ (Ans)

[illegible] Example 2.13:

Dates and period of growth (1)	Pan evaporation Ep or Pe in cm (2)	Consumptive use coefficient (K) (3)	Effective precipitation in cm (Re) (4)
Oct 16-31	8.49	0.44	3.42
Nov 1-30	15.57	0.54	2.19
Dec 1-31	16.59	0.94	0.54
Jan 1-31	19.10	0.99	0.15
Feb 1-2	1.54	0.73	0.02

~~[illegible]~~

~~Evapotranspiration~~

Consumptive use E_t ~~or~~ or $C_u = K \cdot E_p$ (5)	$NIR = C_u - R_e$ (5) − (4)
3.74	0.32
8.41	6.22
15.6	15.06
18.91	18.76
1.12	1.1
$\Sigma = 47.78$	$\Sigma = 41.46$

∴ Total consumptive use = 47.78 cm (Ans)

Net Irrigation requirement = 41.46 cm (Ans)

2012-13 (6-d) → sheet example

solve

Crop factor (K)	$f = \frac{p}{40} \times t(°F)$	$Cu = K \cdot f$	Re (cm)
0.8	17.523	14.02	~~10~~875
0.85	18.972	16.13	108
0.85	17.472	14.85	130
0.85	15.036	12.78	115
0.65	13.62	8.85	105
0.65	10.005	6.5	25
0.6	7.56	4.54	0
0.6	10.52	6.31	0
0.65	13.4	8.71	0
0.7	13.26	9.28	0
0.7	13.84	9.69	0
0.75	16.58	12.44	0
		Σ = 124.1 cm	Σ = 558

Total consumptive use = 124.1 cm

Usefull rainfall = 80% of Re

= 0.8 × ~~558~~55.8

= ~~4.464 cm~~

= 44.64 cm

So. Net irrigation requirement $NIR = C_u - R_e$

$= 124.1 - 44.64$

$= 79.46 cm$

$F.I.R = \frac{79.46}{0.5}$

$= 158.92 cm$

$G.I.R = \frac{158.92}{0.75}$

$= 211.89 cm$

Volume of water to be diverted $= \frac{5000 \times 10^4 \times 211.89}{100}$

$= 105.945 \times 10^6 m^3$

(Ans)

2012-13 6(d) → sheet problem-6 :

Water diverted from ~~stream~~ canal = 130 lps

Water delivered to the field = 100 lps

Irrigated area = 1.6 hectares

Time of irrigation = 8 hrs

The effective root zone depth = 1.7 m

Runoff loss in the field = 420 m^3

Moisture holding capacity of soil = 20 cm/m

Irrigation was started at a moisture extraction level of 50% of the available moisture

a) Water conveyance efficiency $\eta_c = \frac{100}{130} = 76.9\%$

b) Water application efficiency, $\eta_a = \frac{\text{water stored}}{\text{water supplied}}$

water supplied $= 100 \times 10^{-3} \times 8 \times 3600$

$= 2880 m^3$

water stored $= 2880 - 420 = 2460 m^3$

$\eta_a = \frac{2460}{2880} \times 100\%$

$= 85.42\%$

c) Water storage efficiency $\eta_s = \frac{\text{water stored}}{\text{water needed in the root zone}}$

Available moisture holding capacity $= 20 \times 1.7$

$= 34 cm$

water needed in the root zone $= 50\%$ of $34 cm$

$= 17 cm$

water stored $= \frac{2460}{1.6 \times 10^4} \times 100 = 15.375 cm$

$\therefore \eta_s = \frac{15.375}{17} \times 100\%$

$= 90.44\%$

e) Average depth of water, $D = \frac{1.7 + 1.1}{2}$ ~~= 0.9m~~

$= 1.4m$

Average of the variations of the absolute values

$$d = \frac{|1.7 - 1.4| + |1.4 - 1.1|}{2}$$

$= 0.3$

Water distribution efficiency, $\eta_d = \left(1 - \frac{d}{D}\right) \times 100\%$

$= \left(1 - \frac{0.3}{1.4}\right) \times 100\%$

$= 78.6\%$

2011-12 #1(c) available water holding capacity = 130mm/m

The root depth of crop = 70cm

Allowable depletion of water = 55%

Daily water use by the crop = 9mm/day

now, Water holding capacity = 130 × 0.7

= 9.1cm

Depth of water to be irrigated = 9.1 × 55%

= 5.005 cm

Frequency of irrigation = $\frac{5.005 \times 10}{9}$

= 5.56 days

≃ 5 days

so, net depth of irrigation = 9 × 5

= 45mm (Ans)

2011-12 2(b) For the month of march.

Reference evapotranspiration ET_0 = 7.2

Effective rainfall R_e = 1.0

K_c = 1.3

so. Evapotranspiration. $ET = ET_0 \times K_c$

$ET = 7.2 \times 1.3$

$= 9.36 \text{mm/day}$

Net irrigation requirement $NIR = (9.36 + 8 - 1)$

$= 16.36 \text{mm/day}$

Field irrigation requirement $FIR = \frac{NIR}{\eta_a}$

$= \frac{16.36}{0.85}$

$= 19.25 \text{mm/day}$

Gross irrigation requirement $GIR = \frac{FIR}{\eta_c}$

$= \frac{19.25}{0.65}$

$= 29.62 \text{mm/day}$

Area to be irrigated $= 25 ha = 25 \times 10^4 m^2$

so, discharge capacity of pump $= \frac{25 \times 10^4 \times 29.62 \times 10^{-3}}{15 \times 3600}$

$= 0.137 m^3/s$

$= 137 lps$ (Ans)

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2010-II 5(c) Here F.C = 28%, PWP = 13%

Irrigation area = 0.5 ha = ~~5~~ $0.5\times10^{4}\ m^2$

Root zone depth D_s = 80 cm

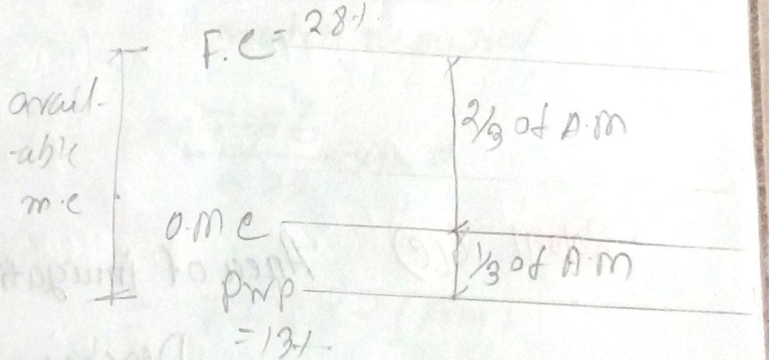
ρ_s = 1.5 gm/cc

moisture level in the soil is to be maintained at no less than one-third of available water.

Available moisture content

= F.C − PWP = (28−13)%

= 15%



Readily available moisture content = 2/3 of Available moisture

= 2/3 × 15% = 10%

so, O.M.C = 28% − 10% = 18%

now Net irrigation requirement,

$$NIR = \frac{\rho_s}{\rho_w} \times D_s \times (F.C - \text{O.M.C})$$

$$= \frac{1.5}{1} \times 80 \times (28-18)\frac{1}{100}$$

= 12 cm (Ans)

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Field irrigation requirement → $FIR = \frac{NIR}{\eta_a}$

$= \frac{12}{0.7}$

$= 17.143$ cm

Time required to irrigate $= \frac{\frac{17.143}{100} \times 0.5 \times 10^4 \times 10}{20}$

$= 42857$ sec

$= 11.9$ hrs (Ans)

2010-11 6(c) Area of irrigation $= 1.2 \times 10^4 m^2$

Discharge $= 30 l/s$

Time of irrigation $= 12$ hrs

Depth of root zone $D_s = 1.2$m

Water holding capacity $= 18$ cm/m

Total water holding capacity $= 18 \times 1.2$

$= 21.6$ cm

Depth of irrigation required $= 21.6 \times 0.45$

$= 9.72$ cm

Application efficiency, $\eta_a = \frac{\text{water stored}}{\text{water supplied}}$

Depth of water applied = $\frac{30\times10^{-3}\times12\times3600}{1.2\times10^{4}}\times100$

$= 10.8$ cm

So, $0.7 = \frac{\text{water stored}}{10.8}$

water stored $= 7.56$ cm

Water storage efficiency, $\eta_s = \frac{\text{water stored}}{\text{water required}}$

$= \frac{7.56}{9.72}\times100$

$= 77.8\%$ (Ans)

now, Average depth $D = \frac{0.7+0.98+1.1+0.95+1.07+0.85}{6}$

$= 0.9417$ m

Average of absolute deviations $d = \frac{(0.9417-0.7)+(0.9417-0.95)+(0.98-0.9417)+(1.1-0.9417)+(1.07-0.9417)+(0.9417-0.85)}{6}$

$= 0.11$ m

So, Distribution efficiency, $\eta_d = \left(1-\frac{d}{D}\right)\times100$

$= \left(1-\frac{0.11}{0.9417}\right)\times100 = 88.3\%$ Ans

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10-11 7(b) Maximum temperature, $T_{max} = 35°C$

Minimum temperature, $T_{min} = 25°C$

Average temperature. $T = 30°C$

Maximum Relative Humidity. $RH_{max} = 55\%$

Minimum Relative Humidity. $RH_{min} = 45\%$

Wind speed at 2m above ground = ~~150cm/s~~

$u_2 = 1.5 m/s$

Net radiation R_n = 18.16 MJ/m² per day

Soil heat flux, G = 0.16 MJ/m² per day

Slope of vapor pressure-temperature graph = 0.312 kPa/°C

$\therefore D = 0.312$ kPa/°C

The psychrometric constant, $\gamma = 0.69$ kPa/°C

Effective Rainfall R_e = 8cm

now,

Average Relative Humidity $RH_{mean} = \frac{55\% + 45\%}{2}$

$= 50\%$

$$e^{\circ}(T) = 0.611 \exp\left[\frac{17.27T}{T+237.3}\right]$$

$$e^{\circ}(T_{max}) = 0.611 \exp\left[\frac{17.27 \times 35}{35+237.3}\right] = 5.625 \text{ kPa}$$

$$e^{\circ}(T_{min}) = \text{~~4.24 kPa~~ } 0.611 \exp\left[\frac{17.27 \times 25}{25+237.3}\right]$$

$= 3.169$

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$e^\circ(T_{max}) +_2 e^\circ(T_{min})$

saturated vapor pressure, $e_s = \dfrac{e^\circ \times T_{max} + e^\circ \times T_{min}}{2}$

$= ~~4.24 \times 30~~ \quad \dfrac{5.625 + 3.169}{2}$

$= ~~127.33~~ kPa \quad 4.397 kPa$

Actual vapor pressure, $e_a = \dfrac{RH_{mean}}{100} \times e_s$

$= 0.5 \times ~~127.33~~ \, 4.397 \, kPa$

$= ~~63.7 kPa~~ \, 2.1985 \, kPa$

$= 2.2 \, kPa$

now, Reference crop evaporation,

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma\left(\frac{900}{T+273}\right)u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$

$$= \frac{0.408 \times 0.312(18.16 - 0.16) + 0.69 \times \left(\frac{900}{30+273}\right)1.5 \times (4.397 - 2.2)}{0.312 + 0.69(1 + 0.34 \times 1.5)}$$

$= ~~147.6 \, mm/day~~ \quad 6.69 \, mm/day$

Evapotranspiration of the crop $ET = ET_o \times K_c$

$= ~~147.6~~ \, 6.69 \times 0.92$

$= ~~135.8 \, mm/day~~$

$= 6.153 \, mm/day$

Total ET of 1 month $= 6.153 \times 30/10$

$= 18.46 \, cm$

Now effective rainfall $R_e = 8$ cm /day

$\therefore$ NIR $= \frac{135.8}{11.6}$ (18.46) $- 8 = $ ~~5.58~~ 10.46 cm/day

$$F.I.R = \frac{NIR}{\eta_a}$$

$$= \frac{10.46}{0.75}$$

$$= 13.95 \text{ cm/day (Ans)}$$

2009-10 7(c) Water delivered in the field = 105 l/s

Area of field to be irrigated $= 2 \times 10^4 \, m^2$

Time of irrigation = 8 hr

The depth of root zone = 1.2 m

Available water holding capacity = 15 cm/m

Total water holding capacity = 15 × 1.2 = 18 cm

management allowable depletion = 55%

Depth of water required = 0.55 × 18

= 9.9 cm

$$\text{Water supplied} = \frac{105 \times 10^{-3} \times 8 \times 3600}{2 \times 10^4}$$

= 15.12 cm

Runoff loss $= \dfrac{50\times10^{-3}\times 8\times3600}{2\times10^{4}}$

$= \sout{7.2\,cm}\ 3.6\,cm$

Depth of water stored $= 15.12 - \sout{7.2}\ \sout{3.6}\ 7.2$

$= \sout{7.92\,cm}\ \sout{11.52}\ 7.92\,cm$

so Application efficiency, $\eta_a = \dfrac{\sout{11.52}\ 7.92}{15.12}\times100$

$= \sout{76.19\%}\ 52.38\%$

Water storage efficiency, $\eta_s = \dfrac{\sout{11.52}\ 7.92}{9.9}\times100$

$= 80\%$ (Ans)

now, $D = 0.974$

$$d = \frac{(0.974-0.82)+(0.98-0.974)+(1.1-0.974)+(1.02-0.974)+(0.974-0.9)+(0.974-0.85)+(1.07-0.974)+(1.05-0.974)}{8}$$

$= 0.088$

Distribution efficiency $\eta_d = \left(1-\dfrac{0.088}{0.974}\right)\times100\%$

$= 90.99\%$ (Ans)

2009-10-6(d)

	C_i	R_e
	9.4024	1.7
	8.6744	1.1
	8.2368	2.5
	8.732	2.3
	Σ = 35.0656	7.6

NIR = 35.0656 − 7.6

= 27.47cm

$$FIR = \frac{NIR}{0.75}$$

= 36.62 cm (Ans)

C_u = 35.0656 cm (Ans)

2009-10-5(d)

Sampling depth	Sample volume (cm^3)	Wt of moist sample	Dry wt of sample	dry density γ_d (g/cc)	Moisture content(%)
0-30	150	215.5	194.8	1.3	10.63
30-60	152	227.5	205.2	1.35	10.87
60-90	146	230.5	208.5	1.43	10.55
90-120	145	235.3	210.3	1.45	11.89

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Average dry density, $\gamma_d = \frac{1.3 + 1.35 + 1.43 + 1.45}{4}$

$= 1.38$

Average moisture content $= \frac{10.63 + 10.87 + 10.55 + 11.89}{4}$

$= 10.985\%$

now, $NIR = 1.2 \times \frac{1.38}{1} \times (0.16 - 0.10985)$

$= 8.3 cm$

$FIR = \frac{NIR}{\eta_a} = \frac{8.3}{0.7}$

$= 11.86 cm$

Time required $= \frac{\frac{11.86}{100} \times 1.5 \times 10^4}{35 \times 10^{-3}}$

$= 14.124 hr$ (Ans)

2008-09 5(d) Total water holding capacity $= 140 \times 0.3$

$= 42 mm$

$= 4.2 cm$

Depth of water required $= 4.2 \times 0.35$

$\therefore$ Allowable depletion depth $= 14.7 mm$

(Ans)

Frequency of irrigation $= \frac{14.7}{5} = 2.94 \simeq 3$ days

(Ans)

net application depth of water = 5×3

= 15mm (Ans)

Practice Problems (sheet-5) (Book page-250, 16)

1. Cation exchange capacity = $\frac{2.5 \times 100}{5}$

= 50 me/100 gm soil

Exchangeable sodium ion = $\frac{1.25 \times 100}{5}$

= 25 me/100 gm of soil

ESP (exchangeable sodium percent) = $\frac{25}{50}$

= 50% (Ans)

Example pH problem-1:

a) Sodium absorption Ratio, SAR = $\frac{Na^+}{\sqrt{\frac{Ca^{2+}+Mg^{2+}}{2}}}$

$= \frac{22}{\sqrt{\frac{3+1.5}{2}}}$

= 14.67

If SAR value is 10 to 18 then it is classified as Medium Sodium and is represented by S_2.

Hence electrical conductivity is 200 µmhos/cm so it is betn 100–250 µmhos/cm. The water is called low conductivity (C_1).

Hence the given water is classified as C_1-S_2 water (Ans)

b) In fine-textured soil, the medium sodium (S_2) water may create the following problems.

i) Soil becomes less permeable

ii) It starts crushing when dry

iii) It becomes plastic and sticky when wet

iv) Its pH increases towards that of alkaline soil

c) Gypsum ($CaSO_4$) addition, either to soil or to water is suggested to overcome sodium hazards posed by the given water

Problem-2:

2300 ppm NaCl salt

2300 ppm = 2300 mg/L

$$= \frac{2300}{58.5/1} \text{ me/L}$$

$$= 39.32 \text{ me/L} \text{ (Ans)}$$

Problem-3: Sodium salt concentration = 8300 ppm

We know,

salt concentration (ppm) = 640 × EC (mmhos/cm)

$\Rightarrow 8300 = 640 \times EC$

$E.C = ~~12.08~~ 12.97$ mmhos/cm (Ans)

$= 12.97 \times 10^{3}$ µmhos/cm (Ans)

$= 12.97 \times 10^{-3}$ mhos/cm (Ans)

Problem-4: Electric conductivity = 2.6 µmhos/cm

Osmotic Pressure (atm) = 0.36 × Electric conductivity (mmhos/cm)

$= 0.36 \times 2.6 \times 10^{-3}$.

$= 0.936 \times 10^{-3}$ atm (Ans)

Problem-5: Book example-6.1:

Electrical conductivity of saturated extract of soil = 10 mmhos/cm

$\Rightarrow$ ~~e~~ $E.C(e) = 10$ mmhos/cm

Electrical conductivity of irrigation water

$E.C(i) = 1.2$ mmhos/cm

$C_u = 80$ mm

now, Electrical conductivity of leaching water,

$E.C_{(d)} = 2 \times E.C_{(c)}$

$= 2 \times 10 = 20$ mmhos/cm

We know, Leaching Requirement, $LR = \frac{D_d}{D_i} = \frac{EC_{(i)}}{EC_{(d)}}$

so, $LR = \frac{D_d}{D_i} = \frac{1.2}{20}$

$= 6\%$ (Ans)

now, $D_i = C_u + D_d$

or $D_d = D_i - C_u$

so, $\frac{D_i - C_u}{D_i} = 6\%$

$\Rightarrow 1 - \frac{80}{D_i} = 0.06$

$D_i = 85.11$ mm

So the required water depth for irrigation $= 85.1$ mm

(Ans)

Problem-5: Depth of soil $D = 30$ cm

Density of irrigation water, $d_w = 1$ gm/cm^3

Bulk density of soil $= 1.48$ gm/cm^3

Saturation point, $SP = 36\%$

Change in electrical conductivity, $\Delta E.C_e = 9$ m mhos

Electrical conductivity of ~~saturated~~ s irrigation water. $EC_{(iw)}$ = 1 mmhos/cm

~~D_i~~ now, $\frac{D_{iw}}{D_s} = \frac{d_s}{d_w} \times \frac{SP}{100} \times \frac{\Delta EC_e}{EC_{iw}}$

$\Rightarrow D_{iw} = 30 \times \frac{1.48}{1} \times \frac{36}{100} \times \frac{4}{1}$

$= 63.94$ mm (Ans)

Duty & Delta problems:

Problem-7: Total irrigation days $= \frac{120}{10} =$ ~~10~~ 12

$\Delta = 12 \times 10$ cm $= 120$ cm (Ans)

Problem-8: Totatal irrigation days $= \frac{140}{28} = 5$

$\Delta = 5 \times 7.5 = 37.5$ cm (Ans)

Problem-9: D = 864 hectares/cumec

B = 120 days

$\Delta = \frac{864B}{D} = \frac{864 \times 120}{864}$

$= 120$ cm (Ans)