Sprinkler Irrigation

→ water is applied in spray form

→ Pressurized irrigation system

Adoptible Conditions

→ All type of soils

→ irrigate high parmeable soils

→ steep slopes ✓

→ erodible soils and undulated land ✓

→ frog and fost ✓

ADvantages

→ water saving is more as compared to other irrigation.

→ cereal and vegetable crop

→ chemicals and fertilizer can beapplied.

→ fog protech

→ works on all topography.

limitations

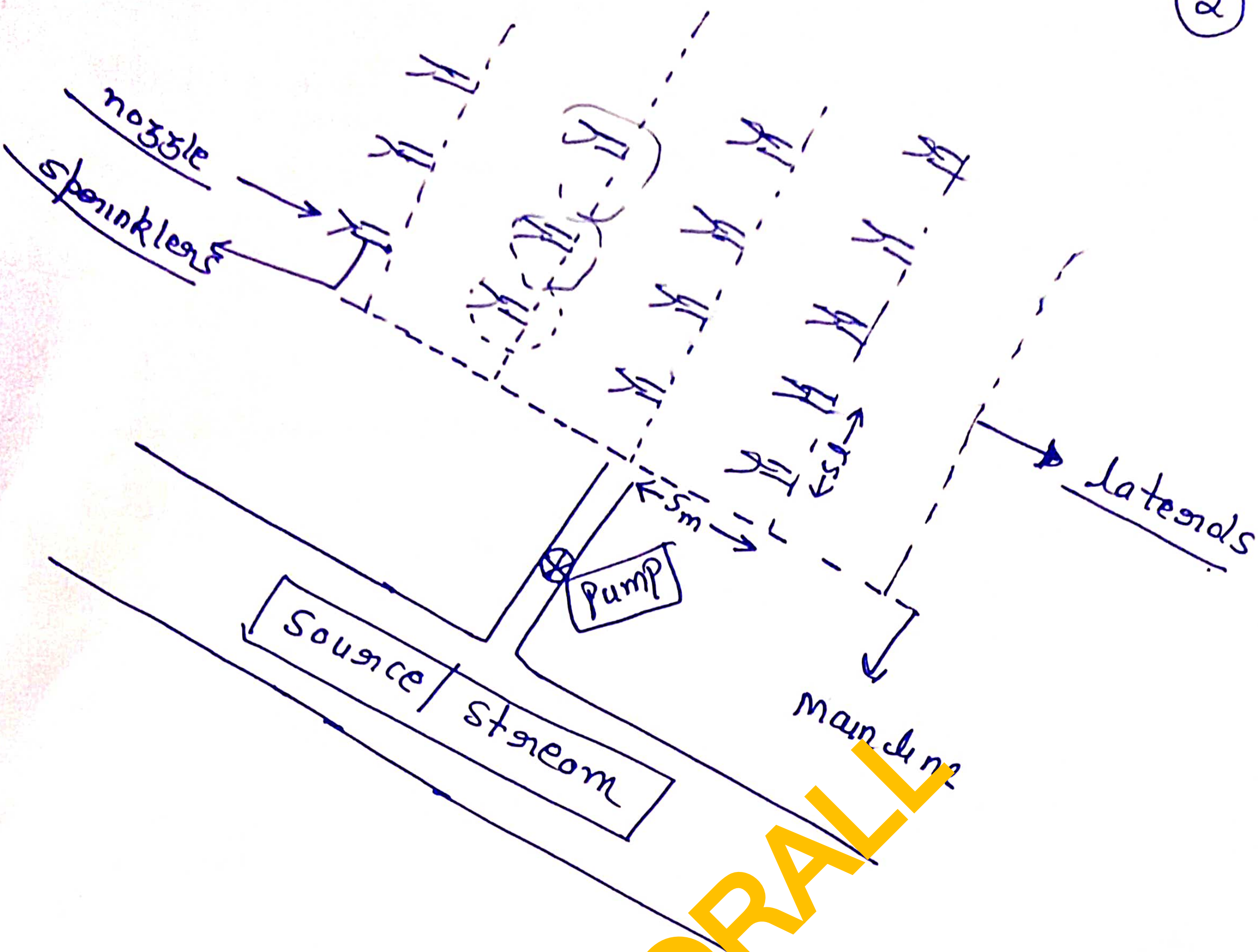
→ High initial investment and High operation cost.

→ Not suitable for fine texture soil with low infilteration rate

→ Not suitable for Jute and RICE

→ Not suitable for hot climate } evaporation more

→ " " " high wind



Components →

(1) Pumping unit → [Source] to [Mainline]

Centrifugal Pump for higher Distance
Turbine Pump for lower distance
Booster Pump for high pressure.

(2) Main line → HDPE [Pump ~~source~~ to sub Main]
laid up and down hill

(3) submain → may be or may not
[Main to laterals]
PVC/HDPE

(4) laterals → [submain] to [individual head]
Across slope, Along contour.
HDPE, for multiple d < 2m

(5) sprinkler head

(6) Riser

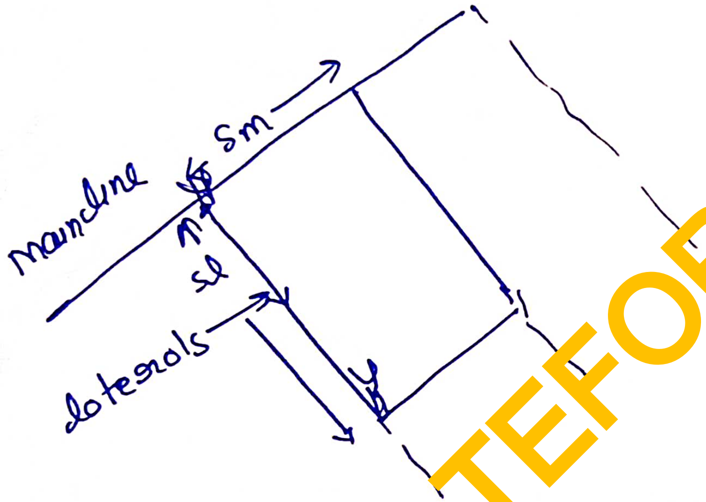
(7) FCV

(8) NRV [Non return Valve]

(9) VRV [Vacuum Return Valve]

(10) ARV

Capacity of sprinkler



$2n$ = total number of sprinkler

Q (capacity) $= \boxed{2n} \times Sl \times Sm \times i$

Sl = spacing along lateral b/w sprinkler

Sm = spacing along main → spacing b/w laterals

i = Application rate

Q (capacity) $= \dfrac{A \times dw}{F \times H \times E}$

F = days, H = hours, E = efficiency

$Q = 2n \times q$

$$\boxed{q = Cd \cdot \frac{\pi}{4} d^2 \sqrt{2gh}}$$

$$= Cd\sqrt{2gh}\left[\frac{\pi}{4} d_1^2 + \frac{\pi}{4} d_2^2\right]$$

Sprinkler irrigation uniformity

→ to check the uniformity in application of water.

→ given by Christiansen

$$u = 100\left[1 - \frac{x}{mn}\right]$$

$$u = 100\left[1 - \frac{\overline{\text{deviation}}}{\text{avg depth}}\right] = 100\left[1 - \frac{\bar{x}}{\bar{d}}\right] \times 100$$

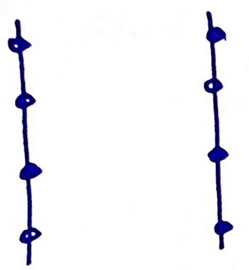
$\bar{d} = m$ = aggregate value of all observation

$\bar{x} = \frac{\Sigma x_i}{n} = \frac{x}{n}$ → x = summation of all deviation from individual sprinkler.

Types of sprinkler system

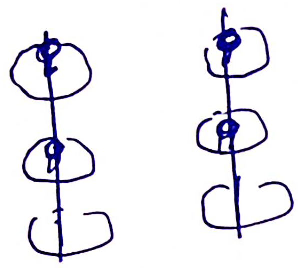
water Application.

- Perforated pipe



holes in lateral

- Rotating sprinkler



Revolving nozzles

360°

Type

- perforated pipe
- Rotating head (low Pressure) $= 0.5 - 2.5\ kg/cm^2$.
  1. portable system. → moving
  2. semi portable
  3. semi parmonent
  4. solid jet system
  5. parmonent system

Booster pump

Fertigator

Design of sprinkler irrigation system

Basic Design

- Sd, Sm, Q
- Power

Hydraulic Design

- (lateral size)
- (Main size)
- Main
- sub main

1. inventory of Resources
2. climatic condition
3. depth of irrigation
4. frequecy of irrigation
5. application rate
6. orientations of lateral →
   - the mains should be in direction of steepest slope.
   - lateral at right angle (as practically to Contour)

sprinkler Design

Basic Design

Sl, Sm, Q, Power

7 steps

Hydraulic Design

size of lateral
of Main pipe
of sub main
Hydraulic parameters

$$Q = 2n \times S_l \times S_m \times i$$

$$Q = \frac{A \times d}{F \times H \times e}$$

$$S_l = D_{mi}\left[1 - F/2\right]$$

$$S_m = D_{mn}\left[1 - F/2\right]$$

$$d_w = \left(\frac{FC - WP}{100}\right) \times \frac{\rho_s}{\rho_w} \times d_{root\,zone}.$$

$$Power = P \times Q.$$

$$P = \rho g H_{total}$$

$$H_n = H_a + H_r + \frac{3}{4} H_f \pm \frac{3}{4} H_e$$

sprinkler feed
arfe

$$F = \frac{1}{(m+1)} + \frac{1}{2N} + \frac{\sqrt{m-1}}{6N^3}$$

(Basic design)

Irrigation system steps

step I Volume of water Required

$$V_a = \frac{A \cdot ET_{max}}{E_a}$$

(m^3) → V_a; A in m^2; E_a → Application efficiency

$ET_{max} = ET_o \times k_c \times k_s$

ET_{max} → Max evapotranspiration; k_c → crop coefficient; k_s → stress coefficient

$k_s = 1$ not given

step II

$$Q = \frac{V_a}{t}$$ → (operating time)

$t = 4$ hr Assume.

step III (Calculate Application rate)

$Q = (2n) \times S_l \times S_m \times i$ → (application rate)

S_m = spacing along mainline or spacing b/w laterals.

$$i = \frac{Q}{A}$$

step IV

$S_l = D_{mi}[1 - F/2]$ → Manufacturing rated wetting diameter of sprinkler

$S_m = D_{mn}[1 - F/2]$ → " " of mainline

F = overlapping factor.

F = 0.7 for windy condition

F → 0.5–0.75

F → 1 (windy)

(Basic Design)

$$i = \frac{Q}{Area}$$

step IV

n (number of sprinkler) $= \dfrac{A}{S_l \times S_m}$

step V = $Q = 2n \times q$

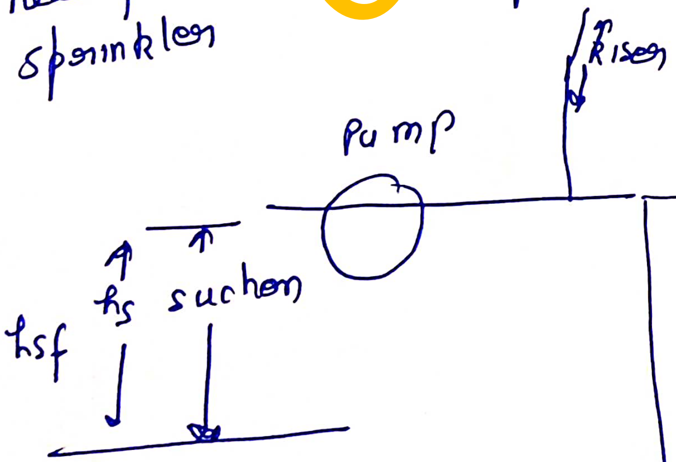
$\hookrightarrow S_l \times S_m \times 2i$

step VI $P_{ower} = Q \times P_{ressure}$

$Pressure = \rho g H_{Total}$

$$H_T = H_m + H_f + H_r + H_s + H_{sf}.$$

- H_m – min pressure head for sprinkler
- H_f – friction head
- H_r – riser height from pump
- H_s – suction head
- H_{sf} – friction head in suction line



$t = 4 hr$

$i = 2 mm/hr$

$f = 0.7$

$k_s = 1$

$H_f = 5\%$ of H_m

$H_s = 0$

$H_{sf} = 0$

$H_r = 1.5 m$

$E_a = 80\%$

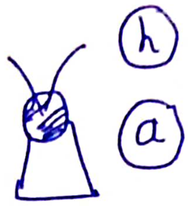
$t = 4 hr$

Hydraulic Design

Sprinkler irrigation system design :-

(i) Design of sprinkler nozzle

$$q = C_d a \sqrt{2gh}$$



C_d = coefficient of discharge [0.95 - 0.98]

$$a = \frac{\pi}{4} d^2$$

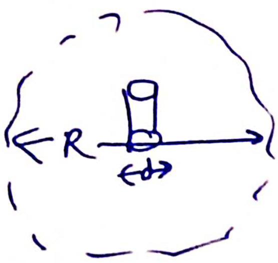
(ii) water spread area of sprinkler

$$R = 1.35 \sqrt{d h}$$

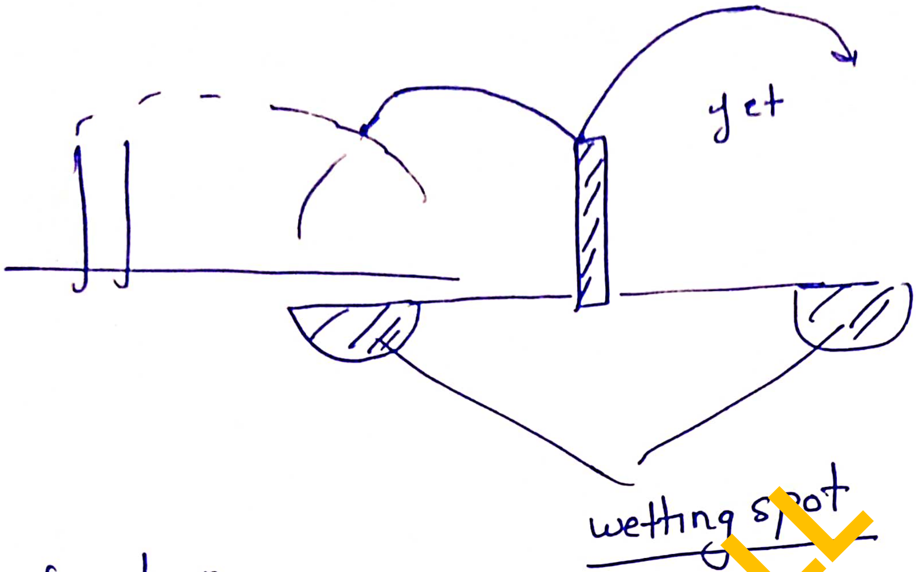
d = dia of nozzle

h = pressure head

Radius of wetted area



Hydraulic Design



Break-up of jet :-

$$P_d = \frac{h}{(10Q)^{0.4}}$$ (Tanda Scientist)

h = Pressure head at sprinkler

Q = sprinkler discharge

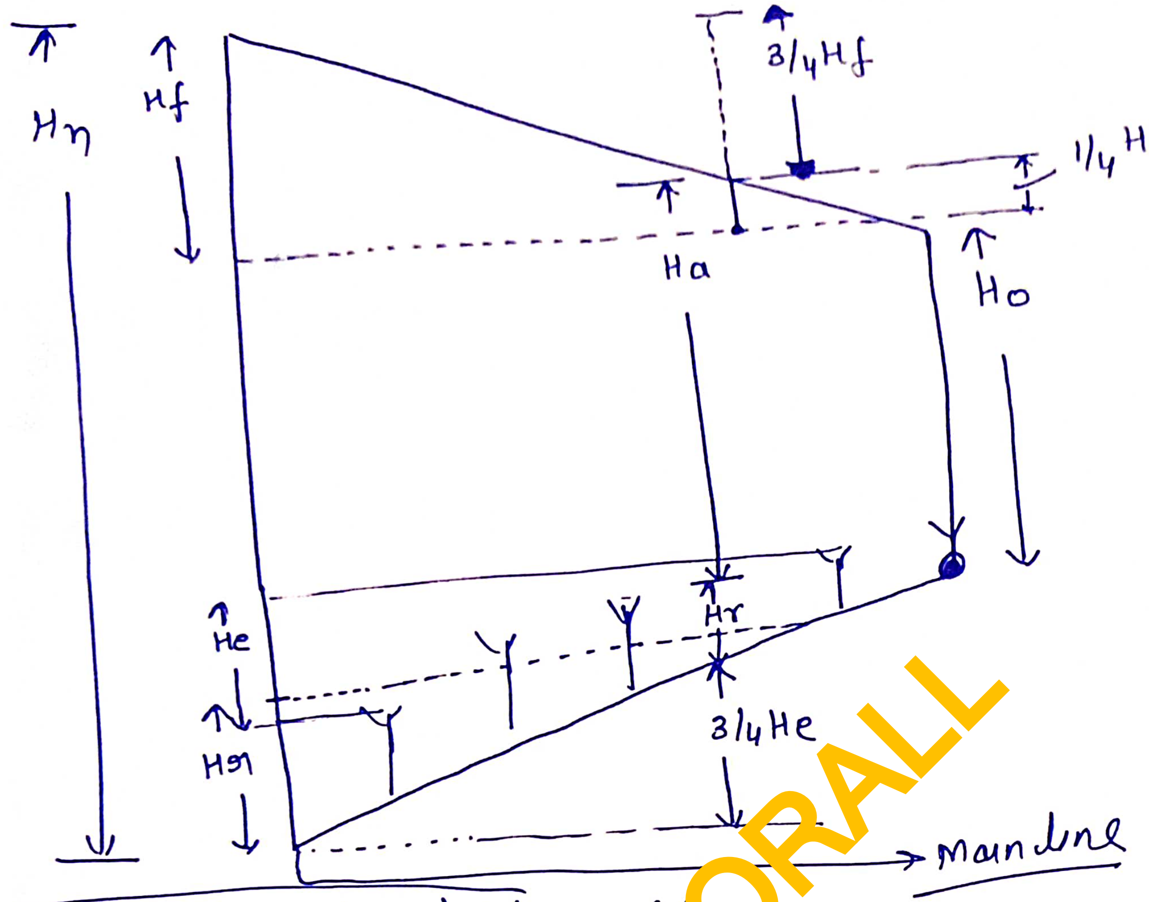
$P_d > 2$ Good

$P_d = 4$ Best

$P_d > 4$ wasted (Pressure)

$$\text{Water application rate (m/sec)} = \frac{Q \text{ (nozzle discharge)}}{A_w \text{ (wetted area)}}$$

Hydraulic Design



lateral Pressure variation ≤ 20%

H_o = pressure head at last sprinkler.

H_f = friction.

H_a = average head

H_e = Difference of head b/w first and last sprinkler

H_r = Riser height.

H_n = total head at Main

- No slope: $H_n = H_o + H_f$ [flat]
- slope: $H_n = H_a + H_r + \frac{3}{4} H_f \pm \frac{3}{4} H_e$
  - (+) lateral up
  - (−) lateral down

$$H_a = H_o + \frac{1}{4} H_f$$

s p r i [n] k l a r

s p r i n k l [a r f d e] l

$$H_n = H_a + H_r + \frac{3}{4} H_f + \frac{3}{4} H_e$$

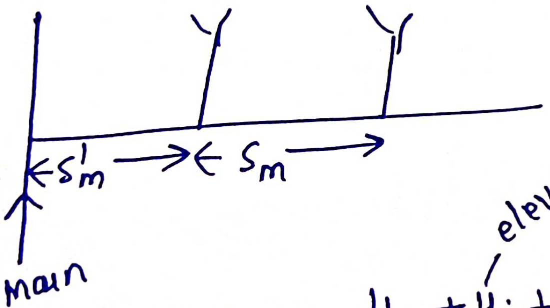
$$H_a = H_o + \frac{1}{4} H_f$$

→ Reduction factor

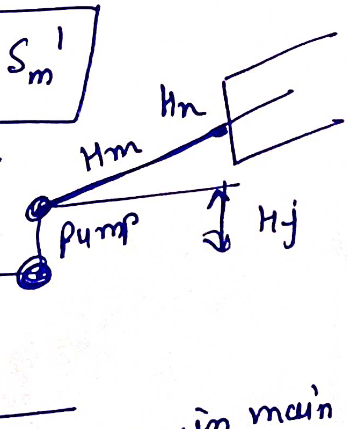
$$F = \frac{1}{m+1} + \frac{1}{2N} + \frac{\sqrt{m-1}}{6N^2}$$

m = value from table for Darcy

n = number of sprinkler



$S_m = S_m'$



$$H_T = H_n + H_j + H_s + H_m$$

elevation diff b/w pump and junction (H_j)

suction head (H_s)

friction loss in main (H_m)

$$H_f = \frac{k\, C\, L\, Q^{m}}{D^{2m-n}} \cdot F$$

L = length of pipe

D = Dia of pipe

F = friction factor

Q = flow rate

	Small limit (Main)	Lage system
Hf	3	12

$dw' = AWHC \times d_{root} \times$ depletion

$f = \frac{dw}{w}$

$Q = \frac{A \times dw}{F \times H \times E}$

→ Number of sprinkler

sl

sm

→ Assume m

Calculate F → Hf → D

Hf ↑ Hm ↑

Calculate D

(1)

$$q = C_d \cdot a \sqrt{2gh} \quad \text{(one nozzle)}$$

- q → nozzle, m
- C_d → coefficient of discharge
- a → area
- h → head

(2) $q = q_1 + q_2 = C_d\left(\frac{\pi}{4} d_1^2\right)\sqrt{2gh} + \frac{\pi}{4} d_2^2 \, C_d \sqrt{2gh}$

(3) Q =

→ $q = \dfrac{S_l \times S_m \times i}{\cdot}$ (S_l → m, S_m → m, i → m/sec (application rate))

$Q = 2n \times S_l \times S_m \times i$

→ $Q = 2n \times q$

→ $Q = \dfrac{A \times d_w}{F \times H \times E}$

- A → Area - m^2
- d_w → depth of water applied
- F → Frequency in number of day
- H → Hrs per day
- E → Efficiency

$$d_w = \left(\frac{FC - WP}{100}\right) \times \frac{\rho_s}{\rho_w} \times d_{\text{root zone}}$$

Fertilizer Injection

→ fertigation [Application of fertilizers through pressurized irrigation system]

→ crop yield ↑

→ water /soil quality ↑ (PH ↓)

→ crop disease ↓

fertilizers → N, P and K (Macro)	Micro Nutrient: Zn, Iron, Cu

N (Nitrogen)	Nitrate
P	triple super phosphate
K	[illegible] Amonium phosphate.

$$\omega_F = \frac{D_s \times D_e \times N_s \times \omega_f}{10000}$$

ω_F — fertilizer kg / setting

D_s — Distance b/w sprinklers

D_e — laterals

N_s — Number of sprinkler

ω_f — fertilize Dose / (kg/ha)

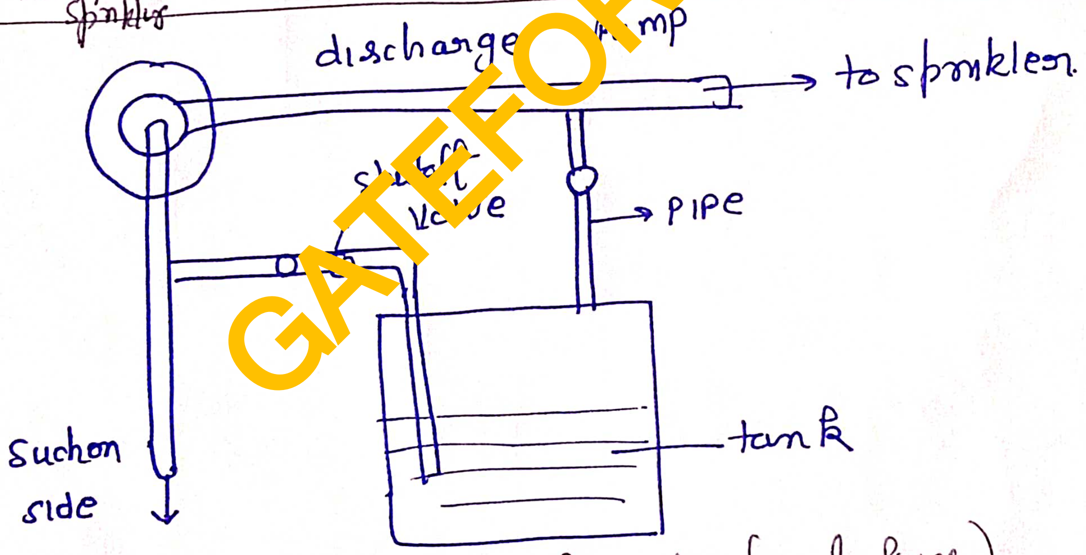
Fertilizer Injection

Concept →		Methods
Proportional	Constant Concentration of fertilizer.	~~Venturi~~ fertilization injection pump
Non Proportional	Non constant of fertilizer.	~~Tank~~ differential

Methods →

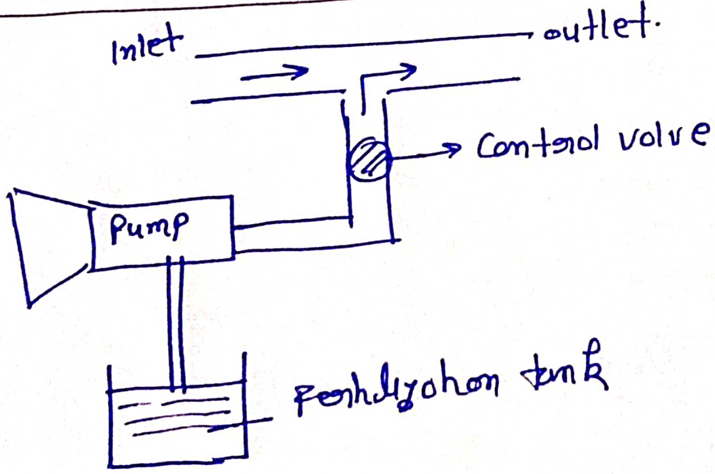
1. (Drip/sprinkler) → Fertilizer Injection through a volute centrifugal Pump (Fig 1)
2. (Drip) → Fertilizer Injection Pump system (Fig 2)
3. → Drip. Pressure differential injection system (→ Venturi, → Pump)
4. → Venturi injection system (Fig 3) (Drip/Sprinkler)

Fig 1



① (suction side of centrifugal pump)

Fig 2



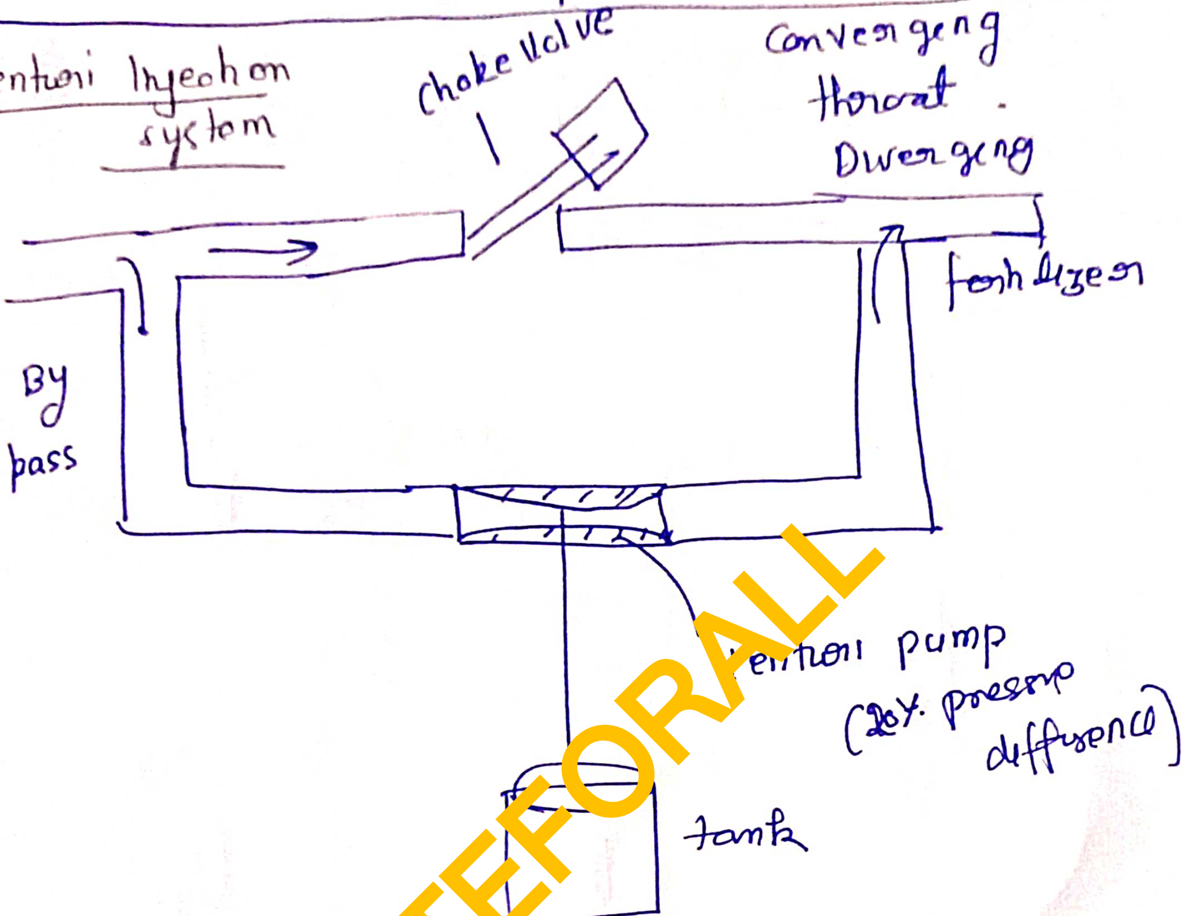
Fertilizer Injection Pump

Fig 3 Pressure differential

Pressure head difference.

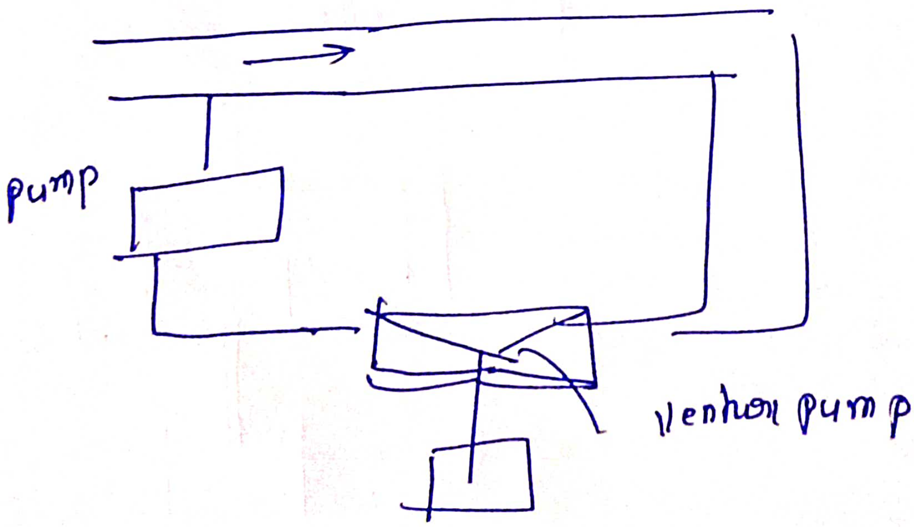
Non uniform concentration.

Fig 4 Venturi Injection system



$$n = 100 [e (-x d/100)]$$

flow rate of tank



why Booster Pumps

→ when existing Pump is not capable of forcing the sufficient quantity of water through sprinklers

→ should provide adequate pressure.
(small areas)

locations of fertigation system

→ system should be installed b/w sand and screen filter

→ fertilizer solution (2-90° turns)

→ Application at up stream end of screen filter. fertilizer filter to prevent clogging.