WATER LIFTING DEVICES

According to power sources water lifts can be classified as manual, animal and power operated devices. The brief description of these devices is as under:

Human Powered Devices

Man has a limited physical power output, which may be in the range of 0.08 to 0.1 hp. This power can be used to lift water from shallow depths for irrigation. The common man powered devices are:

1. **Swing basket.** The device consists of a basket made from the cheap materials like woven bamboo strips, leather, or iron sheet to which four ropes are attached. Two persons hold the basket facing towards each others, dip the basket in water source and by swinging, the basket is lifted and filled in water course from where the water flows to the fields. The device is useful up to a depth of 0.75m and discharge may vary from 3500 to 5000 l/h.

2. **Counterpoise lift.** It is also known as *dhenkli* or *picottach*. It is generally used for lifting of water from unlined wells, stream or pond for irrigating small fields. It consists of a lever rod supported at a suitable point on a vertical post about which it can swing in vertical direction. About 2000 litres of water can be lifted from the depth of 2 to 3 metres in one hour.

3. **Don.** The principle of operation of *don* is similar to counterpoise lift. The *don* consists of a trough made from wooden log or iron sheet; closed at one end and open at the other. The open end of the trough is connected to a hinged pole with a counter weight through rope. For operation the trough is lowered by exerting pressure on it by pulling the rope and also by foot of the operator till the closed end is submerged in water. Upon releasing pressure the trough comes to its original position due to action of counter weight along with water. Water can be lifted from this device from a depth of 0.8 to 1.2m.

4. **Archimedean screw.** It consists of a helical screw mounted on spindle, which is rotated inside a wooden or metallic cylinder. One end of the cylinder remains submerged in water and is placed in inclined position at an angle of 30 degrees. It is used for lifting of water from a depth of 0.6 to 1.2 meters and may discharge 1600 litres per hour.

5. **Paddle wheel.** It is also known as *Chakram* and is mostly used in costal regions for irrigating paddy fields. It consists of small paddles mounted radially to a horizontal shaft, which moves in close fitting concave trough, thereby pushing water ahead of them. The number of blades depends on the size of wheel, which may be 8 for 1.2m and up to 24 for 3 to 3.6m diameters. The wheel having 12 blades may lift about 18000 litres per hour from a depth of 0.45 to 0.6m.

Animal Powered Devices

Animal power is abundantly available in India. They are used for lifting of water, besides other field operations and processing works. A pair of bullocks may develop approximately 0.80 horsepower. They can lift water from the depth of 30m or more. Of course the rate of discharge will go down with increase in lift. Some of the devices used for irrigation operated by animal power are as under.

1. **Rope-and-bucket lift:** Also known as *Mote, Charsa* or *Pur* it is used to lift water from lined wells up to a depth of 30m. The device consists of a bucket or bag made of GI sheet or leather, and pulley arrangement. A rope is attached to the bucket or bag, which passes over a pulley and finally fixed to the yoke of bullocks. The bullocks walk down on an earthen ramp sloped at an angle of 5-10 degrees to lift the water. About 9000 litres of water can be lifted per hour with two pairs of bullocks with this device from a depth of 15m.

2. Self-emptying bucket: The arrangement is similar to rope and bucket lift device. The system consist of a leather container shaped like a funnel which has a spout on the lower end and the upper portion resembles to a conical cylinder. The container is open from both ends. The capacity of container may range from 100 to 150 litres. The device is suitable when the lift does not exceed 9m at which discharge is about 8000 litres per hour.

3. Two bucket lift: In this device two buckets are raised and lowered alternately. The bullocks move in a circular path and with the help of central rotating lever, rope and pulley arrangement the buckets move up and down. Each bucket may have carrying capacity upto 70 litres. The buckets are provided with hinged flap at the bottom, which acts as a valve. Guide rods are provided in the well for the movement of buckets. The buckets are automatically filled and emptied during operation. The device is suitable for lift up to 5m at which discharge may be 14000 litres per hour.

4. Persian wheel: It is also known as *Raha.* It is used to lift water from a depth up to 20m. The efficiency of the device is considerably reduced after 7.5m. The device consists of endless chain of buckets made of GI sheet having capacity from 8-15 litres. The chain of bucket is mounted on a drum and is submerged in the water to sufficient depth. The drum is connected to a toothed wheel held in vertical plane by a long shaft, which is usually kept below the ground level. The vertical toothed wheel is geared with a large toothed horizontal wheel connected to a horizontal beam. This beam is yoked to a pair of animals. For operation the animals move in rotary mode that rotates the buckets carrying water through the gear system. The water is released when the bucket reach the top. Average discharge of Persian wheel is about 10,000 litres per hour from a depth of 9m with one pair of bullocks.

5. Chain pump: The chain pump is used to lift water from shallow wells and works most satisfactorily when the lift is about 6m. The pump consists of an endless chain on which discs are mounted at the interval of about 25cm. The endless chain usually passes over two drums. The upper drum is above the top of well to which axle and handle is attached for operation. The chain with disc passes through a pipe, which is about 10cm in diameter and extends downward from the top of well to about 0.6 to 0.9m below the surface of water. The discs on rotation of chain entrap the water and carry it to the top, which is discharged into the trough. The pump can be operated either manually or by animals having the system as that of Persian wheel.

Hydraulic ram

Hydraulic ram is a device to lift the water without any prime mover by utilising the kinetic energy of flowing water. In this system the impact of water is converted into shock waves, which is called water hammer. This energy is utilized for lifting of water. The essential components of the system are check dam, supply pipe, hydraulic ram, storage tank and discharge pipe. Except for changing of washers in the valves, there is no repair and maintenance required and the ram can operate 365 days in a year without any trouble.

For fixing a hydraulic ram a check dam is constructed on flowing water of a river, streams or *nullahs* to create low head. Due to velocity and pressure of the water, the valve of the ram closes suddenly which creates a water hammer in the system. This causes building up of high pressure, which opens the tank valve and water rushes to the tank. The tank is enclosed from

all sides and the air present in it creates further pressure on the water, which enters the tank and closes the valve of tank thus discharging water from it. This discharged water is lifted by the hydraulic ram to higher head than the supply head. During this action part of the water in the supply pipe also starts flowing in reverse direction and the water valve is opened due to its own weight and the water again starts running in supply pipe. This action continues unless the action of waste valve is stopped. The magnification factor of head and efficiency of hydraulic ram can be known by the following formula:

$q \times h = Q \times H \times e$

Where

q = amount of water lifted by the ram,

h = head to which water is lifted,

Q = amount of water supplied to supply pipe,

H = head due to which water enters the supply pipe, and
e = efficiency of the ram.

The efficiency of the system depends upon h/H, which is called magnification factor. Table below provides some values of magnification factor and efficiency.

Magnification factor h/H	3	4	5	7	8	10	15	20	30
Efficiency %	85	80	75	70	65	60	55	40	35

The pressure in the supply pipe depends upon amount of water, which enters in it. More the water enters, more is the velocity and water hammer effect. The researchers have optimised the inclination of supply pipe to 7 degrees at which the ram gives highest efficiency of 73% at magnification factor of 2.57 and discharge rate of 0.84 l/s. If the magnification factor is less and waste valve opens and closes more number of times per unit time, the ram will have higher efficiency. Generally if the waste valve opens and closes 44 to 60 times in one minute, the working of ram can be considered satisfactory.

Mechanically- Powered Water Lifting Devices

Mechanically powered water lifting devices are usually termed as pumps, which are operated with the help of auxiliary power sources such as engine or electric motor. These pumps are capable of lifting large quantity of water to higher heads and are usually employed for the irrigation of horticultural crops. Basically there are four principles involved in pumping water (1) atmospheric pressure (2) centrifugal force (3) positive displacement and (4) movement of column of fluid caused by difference in specific gravity. Pumps are usually classified on the basis of operation, which may employ one or more of the above principles.

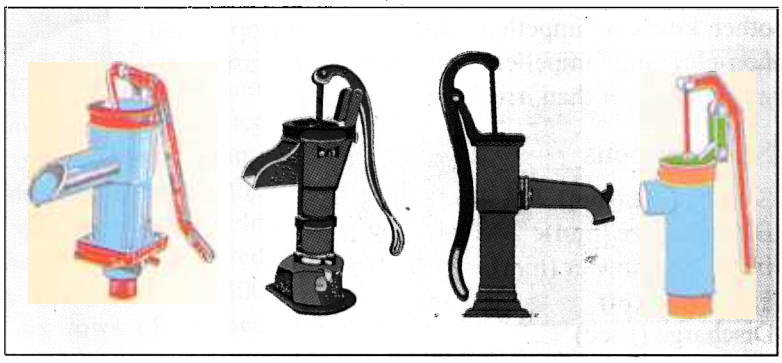
The pump can be classified as:

1. **Displacement pumps:** Reciprocating and rotary
2. **Centrifugal pumps:** Volute, diffuser, turbine, propeller
3. **Airlift pumps.**

RECIPROCATING PUMPS

Features

Reciprocating pumps are normally used for drinking water supply in addition to irrigation. The main parts of the reciprocating pumps are the pump cylinder in which an airtight piston or plunger moves up and down with the help of pump rod, handle for operation of pump, valves, pipe and strainer. As the plunger rises, water is drawn through a non-return valve at the bottom of cylinder into the cylinder, and on the downward stroke the water is released to the upper side of plunger. On the next upward movement of plunger water is raised to pump head and discharged through the spout. By changing either the frequency of reciprocation or stroke length of the piston the discharge rate can be varied. The reciprocating pumps are available in various designs and models, which can be operated manually, with animal power and auxiliary power sources.



Specifications

Length (mm)	:	510-750
Width (mm)	:	360-430
Height (mm)	:	715-1150
Diameter (mm)	:	63.5-200
Strokes per minute (numbers)	:	40-45
Discharge per stroke (l)	:	0.30
Discharge (l/min)	:	12-14
Water depth maximum (m)	:	62
Water depth optimum (m)	:	28-34
Weight (kg)	:	32-43

Uses

Reciprocating pumps are used to lift water from underground sources; therefore, if the water level is deep, the pump cylinder has to be lowered close to water surface to reduce the suction head. The number of cylinders can be increased according to power sources.

Sources (Appendix)

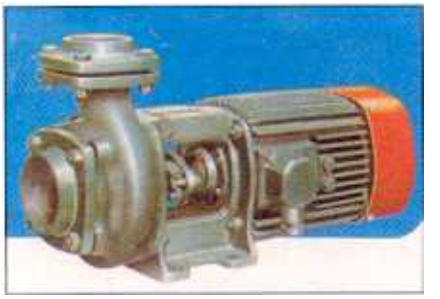
34, 211, 214, 248, 251, 283, 316, 450, 454, 571, 663, 722, 734, 735, 736, 774, 855, 902, 945, 952, 1006, 1031, 1063, 1090, 1283, 1321, 1336, 1421, 1463, 1539, 1649, 1655, 1660, 1688, 1699, 1776

MONOBLOCK PUMPS

Features

It is one of the most common types of centrifugal pumps employed for irrigation. It consists of impeller or rotor and progressively widening spiral or volute casing. The pump is directly connected to the prime mover, which may be electric motor or engine. The direct coupling feature reduces transmission losses. Upon rotation of the impeller, the water enters at the eye, which is thrown radially outward to the periphery. Such an action causes vacuum at the eye

and thus more water enters the suction pipe to maintain the continuous flow. The impeller accelerates the water to a high velocity and the casing converts this velocity head into pressure head due to volute design. Volute pumps usually employ closed type of impeller for irrigation, which has curved vanes for smooth flow of liquid. There are other kinds of impellers like open, semi open and non-clogging impeller., but these are used for purposes other than irrigation.



Specifications

Suction size (mm)	50-125
Delivery size (mm)	40-125
Impeller diameter (mm)	185-300
Total head (m)	4-45
Discharge (l/sec)	1.4-73
Revolution per minute	1380-1430
Motor rating (kW)	1.5-7.5

Uses

Monoblock pumps are used for agricultural purposes. These are also suitable for domestic and industrial applications of pumping water

Sources (Appendix)

34, 211, 214, 248, 251, 316, 450, 454, 571, 663, 722, 734, 735, 736, 774, 855, 902, 945, 952, 1006, 1031, 1063, 1090, 1283, 1321, 1336, 1421, 1463, 1539, 1649, 1655, 1660, 1688, 1699, 1776

END SUCTION CENTRIFUGAL PUMPS

Features

End suction type centrifugal pumps are most commonly used pumps for irrigation in agriculture. The pump can be coupled with electric motor or engine. The pump consists of casing, impeller, high tensile shaft, bearing pedestal, stuffing box, flanges and coupling. Upon rotation of the impeller, the water enters at the eye, which is thrown radially outward to the periphery. Such an action causes vacuum at the eye and thus more water enters the suction pipe to maintain the continuous flow. The impeller accelerates the water to a high velocity and the casing converts this velocity head into pressure head due to volute design. Volute pumps usually employ closed type of impeller for irrigation, which has curved vanes for smooth flow of liquid.

Specifications

Suction size (mm)	65-100
Delivery size (mm)	50-100
Impeller diameter (mm)	109-300
Total head (m)	6-30
Discharge (l/sec)	4.2-38.0
Revolution per minute	1400-2870
Motor rating (kW)	0.75-6.5

Uses

The end suction pump is used for lifting of water from open wells and boreholes for irrigation, domestic and industrial applications.

Sources (Appendix)

34, 211, 214, 248, 251, 316, 450, 454, 571, 663, 722, 734, 735, 736, 774, 855, 902, 945, 952, 1006, 1031, 1063, 1090, 1283, 1321, 1336, 1421, 1463, 1539, 1649, 1655, 1660, 1688, 1699, 1776

SELF PRIMING CENTRIFUGAL PUMP

Features

The self-priming pumps are available in stationary and portable models. These pumps are primarily used where low discharge is needed at higher heads. Due to self-priming features, pump can handle air and gases entrained in water. These pumps are primarily designed for handling of water. The pump does not require any foot valve. The pump has high suction lift characteristics and can suck water from much lower depth. The construction of the pump is similar to other centrifugal pumps and has enclosed impellers and can have many stages. The pump can be coupled with electric motor or engine.

Specifications

Stationary type

Discharge (l/min)	10-600
Total dynamic head (m)	3-244
Power (kW)	0.37 – 22.0

Portable type

Suction size (mm)	50-75
Delivery size (mm)	50-75
Maximum suction head (m)	7-8
Maximum total head (m)	20-30
Maximum discharge (l/min)	380-1115
Power (hp)	1.5-5, engine
Weight (kg)	26-56

Uses

The pump is used for water supply in hilly areas, small villages and multistoried buildings, sprinkler irrigation, domestic water supply and general industrial use for pumping water.

Sources

34, 211, 214, 248, 251, 316, 450, 454, 571, 663, 722, 734, 735, 736, 774, 855, 902, 945, 952, 1006, 1031, 1063, 1090, 1283, 1321, 1336, 1421, 1463, 1539, 1649, 1655, 1660, 1688, 1699, 1776

TURBINE PUMP

Features

These pumps are used in tube wells or in open wells where the water level is below the practical limit of centrifugal pump. The vertical turbine pump consists of a driving motor with discharge connection and the bottom suction centrifugal pump to which one or more impellers are attached. The impeller(s) are of either the volute or mixed flow type. The pump unit remains submerged in water where as the prime mover (motor or engine) is kept above the ground level. The pump unit is connected to the motor with the help of long vertical shaft supported on bearings, which may be water or oil lubricated. Although the turbine pump also operates on centrifugal principle, it differs from volute type as stationary guide vanes guide upward the water thrown by the impeller to the periphery. The gradual enlarging vanes guide the water to the casing, thus converting kinetic energy into potential energy. Therefore, the turbine pump generates heads several times that of a volute pump. Turbine pumps are most effective for tube wells, and applications requiring high heads and discharge. A well-maintained pump provides trouble free service for several years.

Specifications

Diameter of tube well (mm)	:	150-900
Discharge (l/min)	:	150-62000
Head per stage (m)	:	1.2-49.0
Speed (rpm)	:	960-2880

Uses

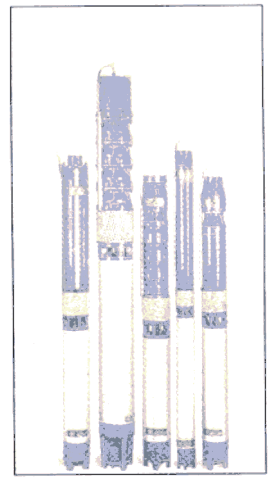
It is used for lifting of water from tube wells, open wells for irrigation, domestic and industrial applications.

Sources (Appendix)

34, 211, 214, 248, 251, 316, 450, 454, 571, 663, 722, 734, 735, 736, 774, 855, 902, 945, 952, 1006, 1031, 1063, 1090, 1283, 1321, 1336, 1421, 1463, 1539, 1649, 1655, 1660, 1688, 1699, 1776

SUBMERSIBLE PUMPS

Features



Submersible pumps are also turbine pumps where long vertical shaft connecting the motor and pump unit is replaced by a short shaft and the prime mover and pump become closely coupled and submerged in water. Submersible pumps are suitable for tube wells having a bore of 100 mm or more. Impeller of the pump may be closed, semi open or open. For irrigation usually closed types of impeller with bowl and stabilizing vanes are used. Several impellers may be used in series, which depends on head and discharge. The discharge from one impeller is guided to the inlet of the second and so on and finally to the outlet. The complete assembly of the pumping unit is suspended from the discharge column. Submersible pumps consume less power for the same output and also require less space.

Specifications

Pump size (mm)	100	150	200 and above

Number of stages	20-30	7-30	3-12
Stage-hp	0.08-0.25	0.25-3.0	3.30-40.0
Total head per stage(m)	1.6-4.6	5.0-10.5	12.0-31.0
Discharge (l/min)	20-350	30-1200	300-650

Uses

Ideal for lifting of water from tube wells for irrigation, domestic and industrial applications.

Sources (Appendix)

34, 211, 214, 248, 251, 316, 450, 454, 571, 663, 722, 734, 735, 736, 774, 855, 902, 945, 952, 1006, 1031, 1063, 1090, 1283, 1321, 1336, 1421, 1463, 1539, 1649, 1655, 1660, 1688, 1699, 1776

JET PUMP

Features

A Jet Pump is a diffuser pump that is used to lift water from both shallow and deep wells. During working, the output of the diffuser is split, and half to three-fourths of the water is sent back down the well through the pressure pipe. At the end of the pressure pipe water is accelerated through a cone-shaped nozzle. The water goes through a venturi in the suction pipe. The venturi has two parts: the venturi throat, which is the pinched section of the suction tube; and above that is the venturi itself which is the part where the tube widens and connects to the suction pipe. The venturi speeds up the water causing a pressure drop which sucks in more water through the intake at the very base of the unit. The water goes up the suction pipe and through the impeller, most of it for recirculation around to the venturi.

Specifications

Bore well size (mm)	75-115
Suction lift (m)	9-30
Discharge head (m)	12-18
Discharge (l/min)	14-45
Power (hp)	0.5-1.0

Uses

The jet pump is used for lifting of water from shallow and deep wells for irrigation and domestic applications.

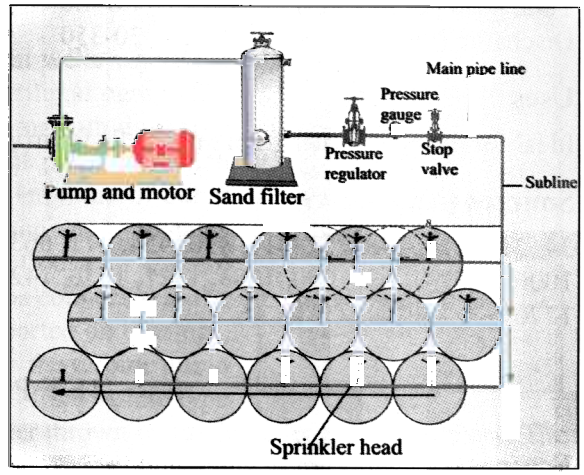
Sources (Appendix)

34, 211, 214, 248, 251, 316, 450, 454, 571, 663, 722, 734, 735, 736, 774, 855, 902, 945, 952, 1006, 1031, 1063, 1090, 1283, 1321, 1336, 1421, 1463, 1539, 1649, 1655, 1660, 1688, 1699,1776

SPRINKLER IRRIGATION SYSTEM

Irrigation by sprinkler is nearest to natural rainfall, where water is sprayed into air in the form of coarse droplets. Because of its ease of operation, sprinkler irrigation is used extensively all over the world. Water can be applied uniformly with this method. Water is subjected to pressure by pumping and discharged through small orifices called nozzles, which break the liquid into coarse droplets. Nozzles are mounted on a rotating head; therefore, each head

covers a circular pattern. Sprinkler system is suitable to all vegetable crops. It should not be used for fine textured soil where the infiltration rate is less than 4 mm/h. It is suitable for steep slope or irregular topography, therefore, does not require land levelling. Soluble fertilizers, herbicides and fungicides can also be applied with the sprinkler system. The system is also suitable for orchards, tea and coffee plantations. Sprinkler system cannot efficiently be adopted where the wind velocity is very high. Although it requires high initial investment but land levelling and labour cost is minimum. Power is usually high as the sprinkler head operate under 0.5-10 kg/cm^2 pressures. But the irrigation efficiency is high (up to 80 %), and, therefore, is most suitable for the area where water is scarce.



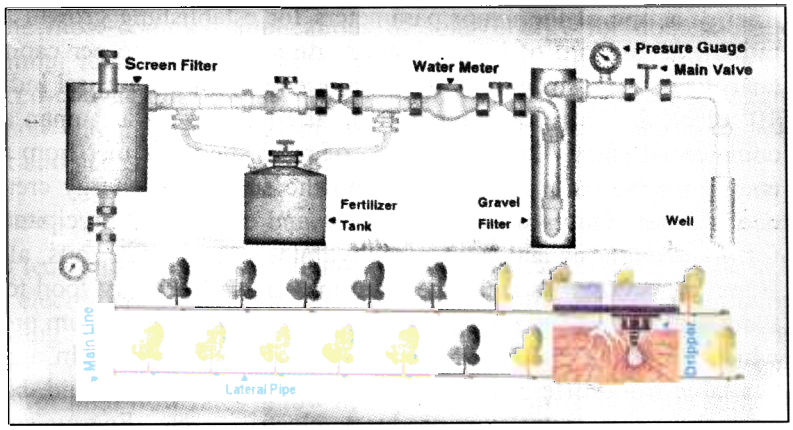
Sprinkler system is broadly classified as rotating head system and perforated pipe system. The rotating head system may be portable, semi portable, semi permanent, solid set and permanent system. Usually portable system is more popular which can be moved after applying one irrigation to the crop to another area and also requires less initial investment. The perforated system has holes perforated in the lateral irrigation pipes, which are operated under low pressure (0.5-2.5 kg/cm^2). This system can be operated by overhead tank. Perforated system is suitable for lawns, vegetables field, and gardens and to the crop where height is below 60cm. Sprinkler system requires clean water in order to avoid plugging of holes. The major components of sprinkler system are: (i) pump, which lifts the water from source and sends it under pressure in the system. (ii) main lines, which may be permanent or portable; portable lines are usually made of aluminum where as permanent lines may be of steel, asbestos cement or PVC. Main lines receive water from pump and discharge into laterals. (iii) lateral lines, which are usually made from aluminum and are portable; however in some orchards and nurseries permanent laterals are buried, (iv) riser pipes which are attached to the laterals. The height of the riser depends on the height of the crop, (v) sprinkler head, which convert the water stream into coarse droplets and also throw the droplets to a distance, since the sprinkler head rotates while in operation, a circular pattern is achieved. The diameter of water application area depends on the pressure of water and type of sprinkler head. The sprinkler head may have a single or two nozzles. There are special sprinkler heads for irrigation of lawns. The spacing of sprinkler head on the lateral lines depends upon the wind velocity. Up to 6.5 km/h wind velocity the sprinklers may be placed at a distance of 60 percent of the diameter of the water spread area. For wind speed between 6.5-13 km/h, the spacing may be 50 percent and above 13 km/h, 30 percent.

Sources (Appendix)

527, 558, 584, 644, 645, 646, 868, 992, 1145, 1182, 1298

DRIP IRRIGATION SYSTEM

Also known as trickle irrigation, it is one of the efficient ways of applying irrigation water to the horticultural crops. More than 90% water application efficiency can be achieved by this method. Water is applied in the form of drops or very fine stream, thereby limiting the discharge to 2 to 10 litres per hour to a single plant. The application is almost equivalent to consumptive use of plants; therefore, the losses due to deep percolation, runoff and evaporation are minimized. Drip irrigation has been found suitable to orchard and vegetable crops grown in rows. Grapes, guava, apple, mango, papaya and vegetable crops like tomatoes, beans etc have been found to respond well to drip irrigation. For widely spaced fruit trees, it has been found even more economical than sprinkler irrigation; 20 to 30 % more yield can be achieved with this system and 40 to 60% more area can be irrigated with the same quantity of water as compared to surface irrigation. Soluble fertilizer and pesticides can also be applied. The only drawback at present is high initial investment, but the land preparation requirement is negligible. It is well adapted to undulating topography, therefore, is suitable to hill tracts as well. The water can be applied on the surface or sub surface, very near to the root zone of the plant. The system consists of main line, sub lines, supply lines, laterals and emitters. The water is discharged either through emitters or micro-tubes. The pipe lines are made from black PVC to avoid growth of algae in the lines. Besides above, the system has a centrifugal pump, fertilizer tank and filtration tank. The water being used should be clean and free from any debris to avoid plugging of pipes, emitters or micro tubes. The system operates under low pressure and efforts are made to create head for the flow of water in pipeline only. The laterals to which emitters or micro tubes are attached may have a pressure as low as 0.15 to 0.2 kg/cm^2 and as high as 1 to 1.75 kg/cm^2.




DRIP IRRIGATION ON PAPAYA FIELD

Sources (Appendix)

527, 558, 584, 613, 614, 644, 645, 646, 868, 992, 1145, 1182, 1298