CHAPTER 8: Hose-move sprinkler irrigation

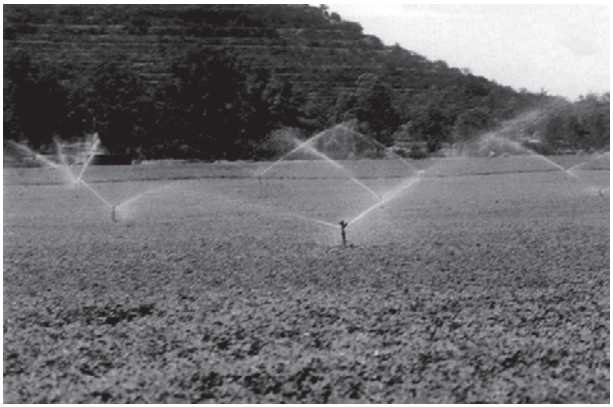
INTRODUCTION

In recent decades various sprinkler irrigation methods and installations, both solid and portable, have been developed to meet farmers' needs. The most widely adopted and least expensive system for irrigating small to medium-sized farms is the piped hand-move system with a low to medium operating pressure (2.0–3.5 bars). The sprinklers are mounted at equal spacings (6–12 m) on the lateral pipelines laid across the field at predetermined intervals (called lateral positions) of 6–18 m so that the irrigation water is sprinkled uniformly over the area covered (Figure 8.1).

To avoid lateral movement and to reduce labour requirements, the hose-move sprinkler system has been developed. It is an improvement on the conventional piped hand-move system and combines some features of semi-permanent installations with those of permanent ones. In this system the sprinkler lateral lines are placed permanently at a wide spacing up to 60 m apart. The sprinklers, mounted on tripod stands, are not fitted directly to the lateral pipes, but connected to them via flexible PE hoses which are 20–25 mm in diameter and up to 30 m in length. The hoses with the sprinklers can be moved laterally on either side to cover a number of lateral positions.

As the sprinklers are of low to medium pressure, this system can be classed as a low or medium pressure, semi-permanent, hand-move installation. It is recommended for the irrigation of full coverage crops such as alfalfa, maize, cotton, potatoes, carrots and groundnuts. It should be noted that hose-move systems are different from the drag-hose system. The latter is used only for under-tree sprinkling and the sprinklers are fitted on small skids which can be easily dragged backwards from a distance.

FIGURE 8.1 - Hose-move sprinkler irrigation.



SYSTEM LAYOUT AND COMPONENT PARTS

The layout of the system is the standard one consisting of a head control, a pipe distribution network (mains, submains and manifolds, where needed), hydrants, laterals and a number of hoses (one per sprinkler).

The head control is simple and includes only the regulating valves (shutoff, non-return, air, etc.). The main and submain pipelines are usually buried 90–150 mm rigid PVC pipes, or 75–110 mm HDPE pipes laid on the surface. The hydrants (2–3 inches) are located along the manifolds (mains or submains) at the same wide spacing as the sprinkler laterals. The manifolds and the sprinkler laterals can be either HDPE or quick coupling light steel/aluminium pipes (63–75 mm). The flexible hoses are soft 20–25 mm LDPE pipes. The tripod stands for the sprinklers can be made of 8 mm iron rods.

SPRINKLERS

The water discharged through the sprinkler devices is shot into the air and falls to the ground in a circular pattern around the sprinkler. Most of the agricultural sprinklers have a hammer-drive slow-rotating or revolving mechanism (hammer wedge and spring, or hammer and rocker weight) and use a low to medium operating pressure (2.0–3.5 bars). They are equipped with two nozzles for discharging the water: the range and the spreader. The range nozzle, larger in diameter, shoots a water jet and covers the area

distant from the sprinkler, activating the rotating mechanism at the same time. The spreader nozzle sprays the water in the vicinity of the sprinkler. The nozzles are interchangeable to allow variability in performance according to requirements. The sprinklers are made of brass or heavy-duty plastic. Most of them have several parts made of brass and others of plastic. The axle and the spring are made of stainless steel. The main performance characteristics of the sprinklers used in hosemove systems are:

- two nozzles: 3.0–6.0 mm (range) *x* 2.5–4.2 mm (spreader);
- low to medium operating pressure: 1.8–3.5 bars;
- water discharge: 1.1–3.0 m^3/h;
- diameter coverage (wetted): 18–35 m;
- jet angle: 20°–30° (except where low angle jet is needed, e.g. strong wind, treated water);
- type of connection: threaded internal or external ½–1 inch.

To ensure satisfactory sprinkling with impact rotating conventional sprinklers, the minimum operating pressure should be at least 2.0 bars.

DESIGN CRITERIA AND CONSIDERATIONS

The water discharged from a single sprinkler is not uniformly distributed over the entire area; a greater quantity falls near the sprinkler and less in the periphery. To ensure a uniform precipitation over the entire area under irrigation, the sprinklers are always placed so that they overlap each other from both directions. This setting is termed sprinkler spacing. The spacing of the sprinklers along the lateral lines is known as SL, and the spacing between two lines as Sm. The spacing pattern is square, rectangular or triangular, with SL = Sm.

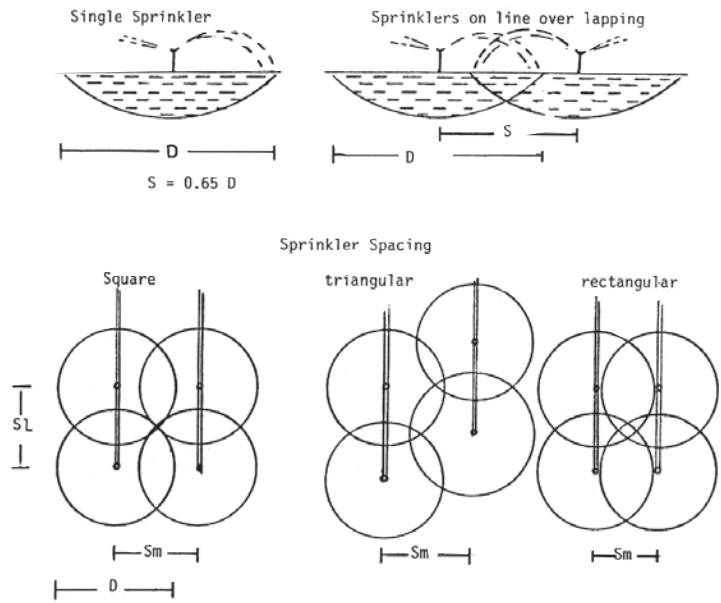
In order to obtain good distribution uniformity by overlapping, the sprinkler spacing (Sm) should not exceed 65 percent of the sprinkler diameter coverage under light to moderate wind conditions in the square and rectangular patterns. In the triangular pattern, the spacing can be extended up to 70 percent of the diameter coverage. In strong wind conditions, the spacing should be 50 percent of the diameter coverage with the lateral direction perpendicular to the wind direction. With a wind strength of over 3.5 m/s, sprinkling is not recommended (Figure 8.2).

The average application (precipitation) rate is a function of the sprinkler discharge and the spacing of the sprinklers:

Precipitation rate (mm/h) = sprinkler discharge (litres/h) ÷ SL *x* Sm (m)

The rate of precipitation should not exceed the soil intake (infiltration) rate (25 mm/h in light soils, 8–16 mm/h in loams and 2–8 mm/h in clays).

FIGURE 8.2 - Profile of wetted soil under sprinklers



D = Diameter Coverage, Sl = spacing along the line, Sm = spacing between the lines. Under normal wind conditions (wind speed 2m/sec) S=0.60D. In strong wind (2.5-3.5 m/sec) S=0.50D.

WIND CONDITIONS

Wind directions and velocities must be recorded and classified accordingly, (0–0.7 m/sec Nil wind, 0.7–2.5 m/sec Light, 2.5–3.5 m/sec Moderate to Strong, and > 3.5 m/sec very Strong). Sprinkling is not recommended under strong wind conditions.

The common sprinkler spacing in low-medium pressure systems is 6, 9, or12 m along the laterals and 12 or 18 m between the laterals. Initially, these spacings were convenient given the standard length of the quick coupling pipe (6 m). However, they have proved most practical as the close spacing, low discharge and precipitation rates of 8–14 mm/h give better results. The height of the sprinklers above ground should be a minimum of 60 cm for low-growing crops. For high-growing crops, the height should be adjusted accordingly.

The light portable quick coupling pipes (steel or aluminium) can be used not only as sprinkler lateral lines but also as water conveyance and distribution lines. These pipes maintain their value for a considerable length of time. There are cases where farmers have sold many of these pipes at a profit even after extensive use.

The design procedure is the same as for the pipe-move sprinkler systems. The sprinkler laterals are laid across the field perpendicular to the manifold line (mains or submains) on lateral positions in accordance with the designed Sm spacing, every 6, 12 or 18 m. The number of laterals operating simultaneously, capable of delivering the flow of the system, is called the set of lateral lines; these lines are fewer in number than their positions. Therefore, after the completion of their operation at one position, the set of laterals is moved to the next position and so on. The number of lateral positions should be a multiple of the number of lateral lines per set. The quotient of the two numbers is the number of movements or shifts per irrigation cycle.

In hose-move sprinkler systems, the sprinklers can be extended on both sides of the lateral line to cover a distance of up to 60 m, which corresponds to six lateral positions at 12 m Sm spacing. Instead of the lateral positions and movements, there are sprinkler positions and movements (shifts). Thus, one lateral line may cover up to six sprinkler positions. Two sets of complete lateral lines with their hoses and sprinklers, one in operation and one on stand-by, can cover an entire field area just by moving the sprinklers from one position to another.

The maximum permissible length of the lateral lines is a function of the size of the pipe, the number of the sprinklers (the spacing) and their discharge. The loss of pressure due to friction in the lateral line should not exceed 20 percent of the pressure at its entrance. Based on this assumption, some indicative figures for quick coupling light steel or aluminium laterals are presented in Table 8.1.

TABLE 8.1 - Maximum number of low-medium pressure sprinklers on quick coupling lateral pipes

Sprinkler pressure bars	Sprinkler discharge m^3/h	50 mm		70 mm		89 mm	
		SL spacing					
		6 m	12 m	6 m	12 m	6 m	12 m
2.5 3.0 3.5	1.5 1.65 1.8	12	10	23	18	36	28
2.5 3.0 3.5	2.0 2.2 2.3	10	8	19	15	30	23

IRRIGATION SCHEDULING PROGRAMME

With sprinkler irrigation, the whole area is wetted and, thus, a larger volume of soil is wetted. This allows a relatively higher water content in the soil to be maintained than is the case with localized methods, thereby increasing the irrigation interval. The larger the volume of wetted soil, the later the crop goes into deficit. The preparation of the irrigation programme follows the standard procedure, i.e. taking into consideration the soil moisture holding capacity, the plant physiology (root depth, growing stages, crop coefficient, etc.) and the climate. The irrigation efficiency is about 75 percent. In general, the irrigation dosage application depth for deep rooted field crops under sprinkling ranges from 40 to 100 mm. With a precipitation rate of about 14 mm/h, the operating time at each position is approximately 3 to 7 hours. Irrigation intervals of two weeks are common in sprinkler irrigation.

COST

The total cost for the installation of the system in 2.0 ha (as in the example design) is US$1 790, or less than US$1 000/ha. A cost analysis shows that the head control costs about US$70. The major cost items are the plastic pipes, PVC and PE tubes, for the system's network which amount to US$1 177, 65.7 percent of the total cost. Imported sophisticated equipment, such as the sprinklers, rarely exceeds 10 percent of the total cost.

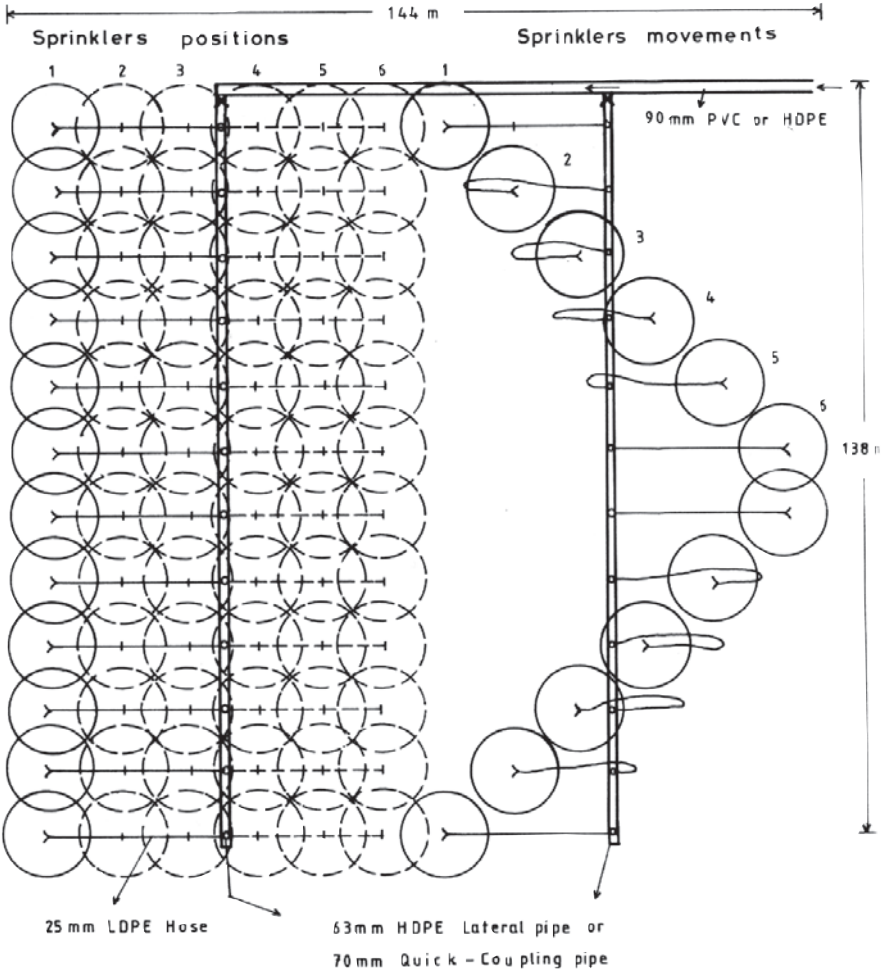
ADVANTAGES

- High irrigation application efficiency – 75 percent.
- Easy design, simple installation and operation.
- Adaptability for all types of soils, many kinds of field crops and small irregular plots.
- Less expensive than many other modern irrigation systems.
- Involves unskilled labour.

DISADVANTAGES

- Moving the hoses with the sprinklers is heavy and unpleasant work (Figure 8.3).
- Long duration for the irrigation cycle.

FIGURE 8.3 - Hose move sprinkler irrigation (Sample design) 2.0 ha



EXAMPLE DESIGN – Hose-move sprinkler for cotton

Area and crop

An area of approximately 2.0 ha planted with cotton at the beginning of August. The field is square and level.

Soil, water and climate

Medium texture soil of good structure, with good infiltration and internal drainage. The soil available moisture (Sa) is 110 mm/m depth. The water is of good quality with no salinity or toxicity hazards; the source is a tube-well equipped with a pumping unit delivering 36 m^3/h. The peak irrigation demand is in October, at the midseason growth stage of the crop.

Crop water requirements and irrigation scheduling

The pan average readings in October are 5.6 mm/d. This figure multiplied by 0.66 (pan correction factor) gives an ETo of 3.7 mm/d. The crop factor kc for cotton at this stage is taken as 1.05, the root depth 1.0 m and the moisture depletion 50 percent. Then, ETc cotton = 3.7 *x* 1.05 = 3.88 mm/d. The net application depth is Sa 110 mm *x* root depth 1.0 m *x* depletion 0.5 = 55 mm. The maximum permissible irrigation interval in October is 55 mm ÷ 3.88 mm/d = 14 days. The irrigation frequency depends on many factors and in no case should exceed the maximum permissible irrigation interval. The system's application efficiency is 75 percent, therefore, the gross application depth at peak is: 55 mm ÷ 0.75 = 73.3 mm. The gross irrigation dose is: 73.3 mm *x* 10 *x* 2.0 ha = 1 466 m^3.

System layout, performance and hydraulics

A 90 mm rigid PVC main pipeline is buried along the northern boundary of the field. Two 63 mm HDPE lateral pipelines are placed perpendicular to the mains, from north to south, 60 m apart and connected with the mains through offtake surface hydrants. On the lateral lines and at a regular spacing of 12 m, 25 mm flexible PE hoses 30 m long are fitted and extended on the sides. At the other end of the hoses are sprinklers on tripod stands (Tables 8.2 and 8.3 and Figure 8.4).

- sprinkler characteristics and performance: low pressure, two-nozzle sprinklers, discharge = 1.5 m^3/h at 2.5 bars operating pressure, diameter coverage = 26 m;
- sprinkler spacing: 12 *x* 12 m;
- precipitation rate: 10.4 mm/h;

- number of sprinklers per lateral: 12;
- number of laterals: 2;
- total number of sprinklers: 24 (operating simultaneously);
- lateral discharge: 18 m^3/h;
- system discharge: 36 m^3/h;
- number of (lateral) sprinklers positions (shifts): 6;
- duration of application per shift: 73.3 mm ÷ 10.4 = 7 hours;
- duration of irrigation cycle: 42 hours.

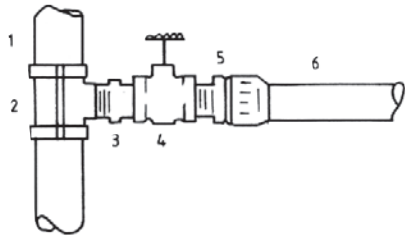
TABLE 8.2 - Total dynamic head required

	bars
Pressure required at sprinkler	2.50
Friction losses in the 25 mm LDPE sprinkler hose, 30 m	0.33
Friction losses along the 63 mm HDPE lateral line	0.47
Friction losses along the 90 mm PVC main line	0.15
Minor local and other losses	**0.25**
Total dynamic head required	3.70

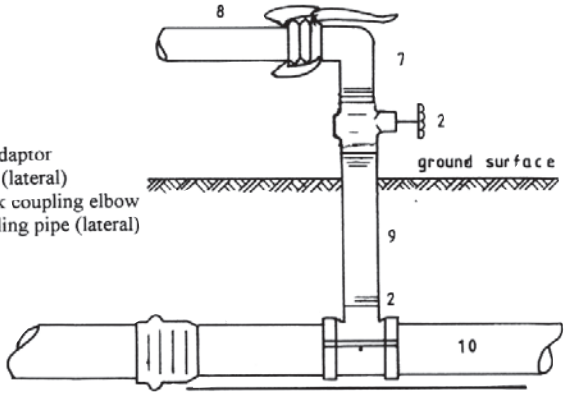
TABLE 8.3 - List of the equipment required for the hose-move sprinkler system installation (bill of quantities)

Item	**Description**	**Quantity**	**Unit price US$**	**Total price US$**
	System distribution network			
1.	90 mm rigid PVC pipe, 6 bars	110 m	2.50	275.00
2.	63 mm HDPE pipe, 6 bars	280 m	1.80	504.00
3.	3-in x 90 mm PP adaptor	1 pc	10.00	10.00
4.	2 ½-in x 63 mm PP adaptor	2 pcs	5.00	10.00
5.	90 mm PP end plug	1 pc	10.00	10.00
6.	63 mm PP end plug	2 pcs	5.00	10.00
7.	90 mm x 2 ½ in PP clamp saddle	2 pcs	3.00	6.00
8.	63 mm x ¾ in PP clamp saddle	24 pcs	1.30	31.20
9.	¾ in x 25 mm PP adaptor	48 pcs	1.00	48.00
10.	2 ½ in threaded riser pipe, 60 cm	2 pcs	4.00	8.00
11.	2 ½ in gate valve	2 pcs	13.00	26.00
12.	2 ½ in nipple	2 pcs	1.00	2.00
13.	Tripod sprinkler stand	24 pcs	8.00	192.00
14.	Sprinkler two nozzle, 1.5 m^3/h at 2.5 bars	24 pcs	8.00	192.00
15.	25 mm LDPE hose, 4 bars	720 m	0.40	288.00
	Trench excavation and backfilling	110 m	1.00	110.00
	Sub-total			**1722.20**
	Head control			
16.	2 ½ in brass check valve	1 pc	15.00	15.00
17.	2 ½ in brass shut-off valve	2 pcs	13.00	26.00
18.	2 ½ in tee (galvanized iron, or PVC)	3 pcs	3.50	10.50
19.	2 ½ in nipple	4 pcs	1.00	4.00
20.	1 in single air valve	1 pc	12.00	12.00
	Sub-total			**67.50**
	TOTAL COST			**1789.70**

FIGURE 8.4 - Hose move sprinkler jointing techniques



1. 90 mm HDPE Pipe (main)
2. 90 mm x 2½" PP Clamp saddle
3. 2½" Nipple



4. 2½" Gate valve
5. 2½" x 63 mm PP Adaptor
6. 63 mm HDPE Pipe (lateral)
7. 2½" x 70 mm Quick coupling elbow
8. 70 mm Quick coupling pipe (lateral)

9. 2½" Threaded riser pipe
10. 90 mm rigid PVC pipe (buried)
11. 63 mm x ¾" PP Clamp saddle
12. ¾" x 25 mm PP Adaptor
13. 25 mm LDPE hose
14. ¾" G. I. Elbow
15. Tripod stand
16. Sprinkler (two nozzle)