

## CHAPTER 13: Bubbler irrigation of trees

### *INTRODUCTION*

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Bubbler irrigation is a localized, low pressure, solid permanent installation system used in tree groves. Each tree has a round or square basin which is flooded with water during irrigation. The water infiltrates into the soil and wets the root zone. The water is applied through bubblers. These are small emitters placed in the basins which discharge water at flow rates of 100–250 litres/h. Each basin can have one or two bubblers as required.

### *SYSTEM LAYOUT AND COMPONENTS*

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The system layout is the typical one of all pressurized systems. It consists of a simple head control unit without filters and fertilizer apparatus. The mains and the submains are usually buried rigid PVC pipes, with hydrants rising on surface. The manifolds and laterals are also often buried rigid PVC pipes. The bubblers are placed above ground, supported on a stake, and connected to the laterals with a small flexible tube rising on the surface, or they can be fitted on small PVC risers connected to the buried laterals.

The difference between bubbler systems and other micro-irrigation installations is that whereas in the other installations the lateral lines are small (12–32 mm), the bubblers are usually 50 mm (due to the lateral high discharge). This is why the laterals need to be underground.

### *BUBBLER EMITTERS*

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The bubblers are small plastic head emitters with a threaded joint. They were originally designed for use on risers above ground for flood irrigation of small ornamental areas. In recent decades they have been used successfully in several countries for the irrigation of fruit trees. They perform well under a wide range of pressures delivering water in the form of a fountain, small stream or tiny umbrella in the vicinity of the emitter. The main performance characteristics are:

- Operating pressure: 1.0–3.0 bars;
- Flow rate (discharge): 100–250 litres/h (adjustable);
- No filtration is required.

There is a wide range of flow rates up to 800 litres/h; this paper presents only low discharge bubblers.

### ***IRRIGATION SCHEDULING***

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With bubbler irrigation the percentage of the root soil volume wetted is about 80 percent. Thus, there are no restrictions on the way the irrigation programme is prepared. This can be either fixed depletion or fixed interval, taking into consideration the soil water holding capacity, the availability of the irrigation water, the size of flow, etc.

### ***DESIGN CRITERIA AND CONSIDERATIONS***

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Bubbler irrigation is mainly applied in fruit tree orchards. The most important criteria, apart from the routine design criteria, are the system's special features and characteristics.

Bubbler emitters discharge water on the same spot of ground at high rates. Thus, for a uniform distribution over the basin area, a minimum of land preparation is needed. In sandy soils, the water infiltrates at the point of application and high losses occur due to deep percolation. In fine soils with low infiltration rates, the water ponds and evaporation occurs.

Mature trees always take two bubbler emitters, one on each side, in order to ensure an acceptable uniformity of application. The flow rate per tree is relatively high compared with other micro-irrigation techniques at about 500 litres/h. Thus, the diameter of an 80 m-long lateral for a single row of 13 trees spaced at 6 m intervals should be 50 mm.

The common practice is to have one lateral per two rows of trees with small flexible tubes extended on both sides and connected to the bubblers. In this way, the same size of lateral pipe (50 mm), placed (buried) between two rows can serve 12 trees on each side (24 trees in total) spaced at 6 m intervals with 48 bubbler emitters.

The size of the equipment for the installation should always be able to accommodate the flows required for mature trees.

For longer laterals, pressure compensated bubblers can be used, though this involves higher energy consumption and more expensive higher pressure pipes.

## ***COST***

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The cost for a complete permanent installation of this system is about US\$3 900/ha, of which US\$70 are needed for the head control unit, i.e. less than 2 percent. The cost of the pipes (all rigid PVC) is US\$1 250 plus US\$970 for the trench (excavation and backfilling), i.e. approximately 56 percent of the total cost. The bubblers with the connecting small flexible tubes cost US\$980, or 25 percent of the total cost of the system. The cost per tree of the laterals with the bubblers is about US\$6.60.

## ***ADVANTAGES***

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- High irrigation application efficiency, up to 75 percent, resulting in considerable water savings, with absolute control of the irrigation water from the source to the tree basin.
- All the piping network is buried, so there are no field operations problems.
- The technology is simple and no highly sophisticated equipment is used. The system can be operated by unskilled farmers and labourers. No filters or fertilizer injectors are needed.

## ***DISADVANTAGES***

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- High initial purchase cost.
- Small water flows cannot be used as in other micro-irrigation systems.
- In sandy soils with high infiltration rates, it is difficult to achieve a uniform water distribution over the tree basins.

## ***EXAMPLE DESIGN – Bubbler irrigation with fruit trees***

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### ***Area and crop***

The plot dimensions are 120 x 85 m (1.0 ha) with mature guava trees in rows at a spacing of 6 x 6 m. There are 20 rows with 14 trees in each row for a total 280 trees. The slope of the plot is 0.5 percent from west to east and from north to south.

### ***Soil, water and climate***

Medium texture soil with an infiltration rate of approximately 8 mm/h and a soil available moisture of 150 mm/m depth. The source of water is an existing tube-well with a safe output of 25 m<sup>3</sup>/h of suitable quality. The evaporation pan average readings in July are 7 mm/d.

### Crop water requirements and irrigation scheduling

The pan reading of 7.0 mm/d multiplied by 0.66 (pan correction factor) gives an ETo of 4.65 mm/d. The crop factor  $k_c$  is 0.65, thus  $ET_c = 4.65 \times 0.65 = 3.0$  mm/d. The area shaded by the tree canopy is 70 percent and for calculation purposes it is taken as 82 percent. Therefore, the daily water requirements are:  $3.0 \times 0.82 = 2.48$  mm/d net. With a system application efficiency of 75 percent, the gross daily irrigation requirements are:  $2.48 \times 100 \div 75 = 3.3$  mm (33 m<sup>3</sup>). If irrigation takes place every ten days, the gross irrigation dosage is:  $10 \times 33 = 330$  m<sup>3</sup>.

The maximum permissible irrigation interval in July on a 50 percent moisture depletion for a tree root depth of 0.6 m is:  $150 \times 0.6 \times 0.5 \div 3.0 = 15$  days. The irrigation frequency depends on many factors and in no case should exceed the maximum permissible irrigation interval.

### System layout, performance and hydraulics

The main line also serves as a manifold (feeder) line. The laterals are buried 50 mm rigid PVC pipes laid between every other row of trees with 12 mm flexible tubes rising on both sides and extended to the tree basins with two bubblers in each tree basin (Figures 13.1 and 13.2). The main characteristics of the bubblers are (Tables 13.1 and 13.2):

- flow rate: 225 litres/h at 2.0 bars;
- number of bubblers per lateral: 56 (each lateral irrigates two rows of trees, i.e. 28 trees);
- lateral discharge: 12 600 litres/h (12.6 m<sup>3</sup>/h);
- total number of laterals: 10;
- system discharge: 25 m<sup>3</sup>/h;
- number of laterals operating simultaneously: 2;
- number of shifts per irrigation: 5;
- operating hours per shift: 2.64 h (2 h 38 min);
- time to complete one irrigation: 13.2 h (13 h 15 min);

TABLE 13.1 - System's operating pressure

|  | bars        |
|--|-------------|
| Pressure at the bubbler                  | 2.00        |
| Friction losses in the lateral           | 0.34        |
| Friction losses in the main line         | 0.60        |
| Friction losses in the head control unit | 0.20        |
| Minor local losses                       | 0.20        |
| <b>Sub-total</b>                         | <b>3.34</b> |
| Difference in elevation                  | - 0.10      |
| Total dynamic head                       | 3.24        |

FIGURE 13.1 - Bubbler in fruit trees. (example design)

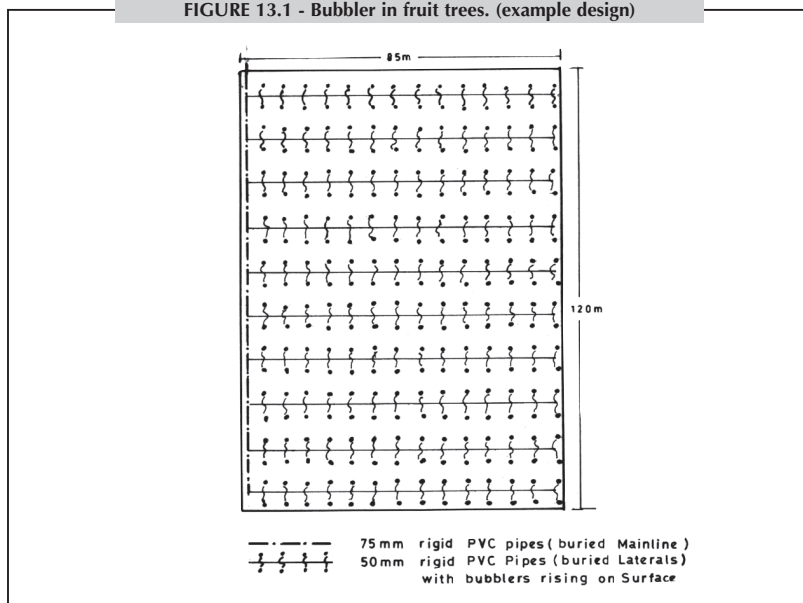
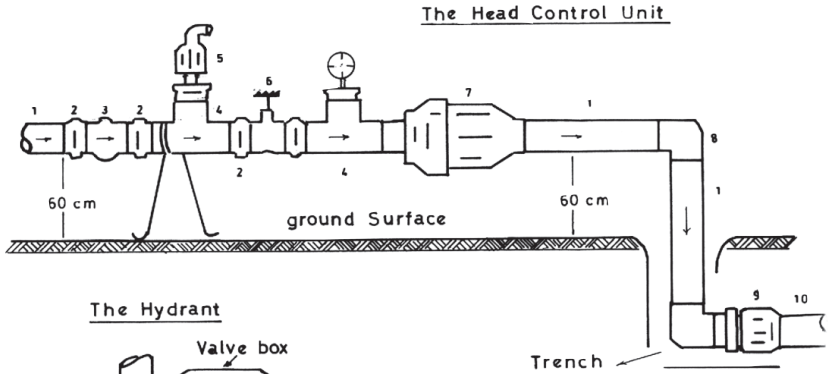


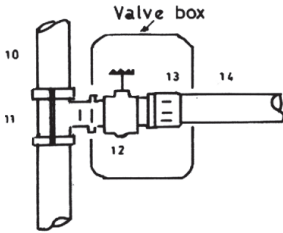
TABLE 13.2 - Equipment required for the system installation

| Item                               | Description  | Quantity | Unit price US\$ | Total price US\$ |
|------------------------------------|--|----------|-----------------|------------------|
| <b>System distribution network</b> |  |          |                 |                  |
| 1.                                 | 75 mm uPVC pipe, 6.0 bars, push-fit joint          | 120 m    | 1.90            | 228.00           |
| 2.                                 | 50 mm uPVC pipe, 6.0 bars, push-fit joint          | 850 m    | 1.20            | 1020.00          |
| 3.                                 | 75 mm x 2 in PP clamp saddle                       | 10 pcs   | 2.25            | 22.50            |
| 4.                                 | 50 mm x 1 in PP clamp saddle                       | 140 pcs  | 1.10            | 154.00           |
| 5.                                 | 75 mm x 2 in PP adaptor                            | 1 pcs    | 9.00            | 9.00             |
| 6.                                 | 50 mm x 2 in PP adaptors                           | 10 pcs   | 4.00            | 40.00            |
| 7.                                 | 75 mm PP end plug                                  | 1 pc     | 9.00            | 9.00             |
| 8.                                 | 50 mm PP end plug                                  | 10 pcs   | 4.00            | 40.00            |
| 9.                                 | 2 in nipple  | 10 pcs   | 1.00            | 10.00            |
| 10.                                | 2 in brass shut-off valve                          | 10 pcs   | 12.00           | 120.00           |
| 11.                                | 1 in PVC tee threaded                              | 140 pcs  | 1.00            | 140.00           |
| 12.                                | 1 in x 1/2 in PVC bushing                          | 280 pcs  | 0.60            | 168.00           |
| 13.                                | 12 mm PP tee barbed                                | 280 pcs  | 0.30            | 84.00            |
| 14.                                | 12 mm x 1/2 in PP adaptor barbed                   | 280 pcs  | 0.25            | 70.00            |
| 15.                                | 12 mm soft flexible PVC tube                       | 1120 m   | 0.25            | 280.00           |
| 16.                                | Bubbler set, 225 litres/h at 2.0 bars (adjustable) | 560 pcs  | 0.70            | 392.00           |
| 17.                                | Valve box, plastic 31 x 50 x 40 cm                 | 10 pcs   | 20.00           | 200.00           |
| 18.                                | Trench excavation and backfilling                  | 970 m    | 1.00            | 970.00           |
|                                    | <b>Sub-total</b>                                   |          |                 | <b>3956.50</b>   |
| <b>Head control</b>                |  |          |                 |                  |
| 19.                                | 2 1/2 in brass check valve                         | 1 pc     | 15.00           | 15.00            |
| 20.                                | 2 1/2 in brass shut-off valve                      | 2 pcs    | 13.00           | 26.00            |
| 21.                                | 2 1/2 in tee (galvanized iron or PVC)              | 3 pcs    | 3.50            | 10.50            |
| 22.                                | 2 in nipple  | 4 pcs    | 1.00            | 4.00             |
| 23.                                | 1 in single air valve                              | 1 pc     | 12.00           | 12.00            |
|                                    | <b>Sub-total</b>                                   |          |                 | <b>67.50</b>     |
|                                    | <b>TOTAL COST</b>                                  |          |                 | <b>4024.00</b>   |

FIGURE 13.2 - Bubbler irrigation jointing techniques.



The Hydrant



- |   |                               |
|---|-------------------------------|
| 1. 2 1/2" Pipe                          | 10. 75mm uPVC Pipe            |
| 2. 2 1/2" Nipple                        | 11. 75mm x 2" PP Clamp Saddle |
| 3. 2 1/2" Check Valve                   | 12. 2" Shut off Valve         |
| 4. 2 1/2" Tee threaded                  | 13. 2"x 50mm PP Compr Adaptor |
| 5. 1" Air Valve                         | 14. 50mm uPVC Pipe            |
| 6. 2 1/2" Shut off Valve                | 15. 50mm x 1" PP Clamp Saddle |
| 7. Disk Filter (optional)               | 16. 1/2" x 12mm PP barbed tee |
| 8. Elbow                                | 17. 12mm flexible PVC Hose    |
| 9. 2 1/2" x 75mm PP compression Adaptor |                               |

The bubbler

