Deep pipe irrigation

Author:
David A. Bainbridge
Associate Professor
Alliant International University
10455 Pomerado Road
San Diego, CA 92131
dbainbridge@alliant.edu

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PO Box 428
Holualoa, HI 96725 USA
Tel: 808-324-4427; Fax: 808-324-4129
E-mail: par@agroforestry.net
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One of the great challenges for agriculture, agroforestry, forestry and restoration is establishing plants on seasonally or continually dry sites (Kolarkar and Muthana, 1984; Bainbridge, 1991). This becomes even more difficult at remote sites where water must be carried in by hand, animal or truck. Traditional irrigation methods such as furrow or basin watering, sprinklers and even drip irrigation demand too much water and require filtered and pressurized water, as well as regular maintenance. In areas where the need for plant establishment is greatest, these requirements are usually too costly, technical or time consuming to manage. What can we do?

The goal is to develop very low cost, water-efficient irrigation systems that can sustain plants through dry periods, work with low quality water, and can easily be installed and managed by unskilled workers (Bainbridge et al., 1995; Bainbridge et al., 2001; Bainbridge, 2006). The ideal is to use so little water that plants can be kept supplied by hand-carried water even several kilometers from water sources. The leading candidate, and winner of most comparative studies, is deep pipe irrigation.

Deep pipe irrigation is a very effective, yet little known, irrigation system that uses an open vertical or near vertical pipe to deliver irrigation water to the deep root zone (Sawaf, 1980;

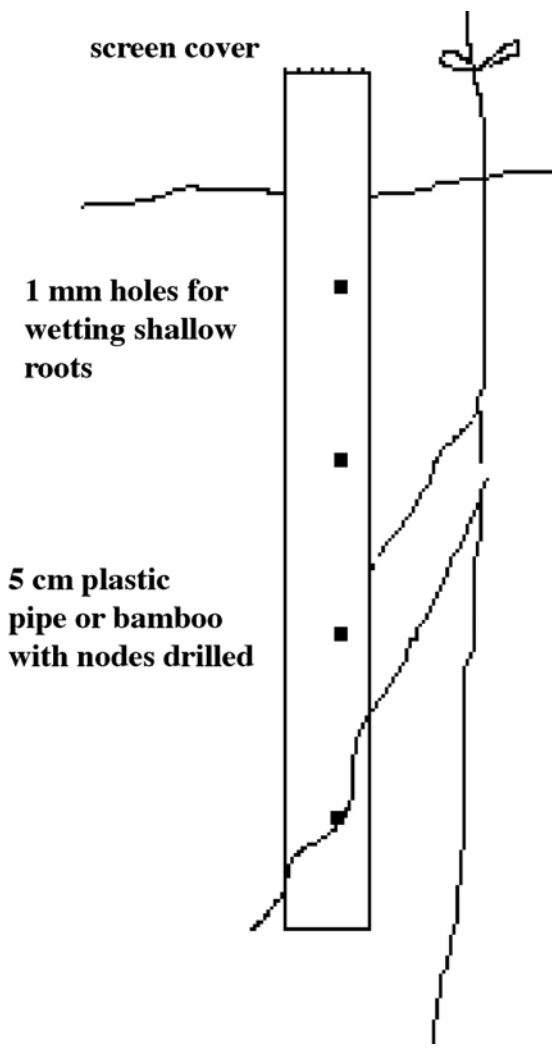
Sahu, 1984; Kolarkar and Muthana, 1984; Mathew, 1987; Bainbridge and Virginia, 1990; Bainbridge, 1992). Deep pipe irrigation fosters a much larger root volume than other forms of irrigation and helps develop a plant that is better adapted to survive after watering is terminated following establishment. The deep pipes can be collected at the end of the season to allow for field tillage operations, and they can be easily transported from site to site for reuse.

Deep pipe irrigation is commonly done with 2.5-5 cm diameter plastic pipe placed vertically 30-50 cm deep in the soil near a tree seedling. A screen cover (1 mm mesh) can be added to keep out lizards and animals (Figure 1). Alternatively, bamboo with the node partitions drilled or punched out, rolled veneer, or a slat box can be used. If none of these are available a bundle of tightly tied straight twigs can be used. The seedling should be fairly close to the deep pipe (2.5-7.5 cm inches for a young plant). The deep pipe should be set fairly close to small seedling (2.5-7.5 cm away), while the pipe can be set further from larger plants. Several pipes may be used for a larger tree. These can be arranged around the tree to encourage symmetrical root growth to resist windthrow. By delivering irrigation water through deep pipes rather than on the surface, tree roots tend to grow down rather than at the surface where grains or vegetables may be seasonally intercropped.

Figure 1. Deep Pipe Installation with tree shelter and mesquite

A series of 1-2 mm holes or slots should be spaced about 5-7.5 cm apart down the side of the pipe nearest the plant to allow water to weep into the soil at all levels (not only at the bottom) to facilitate root growth in the early stages of development (Figure 2). If shallow-rooted plants from containers are planted next to a deep pipe without weep holes, the roots may not make contact with the wetted soil. By the same token, a young seedling can be left high and dry if a drip emitter is used to deliver water into the pipe, even if it has weep holes. Growing plants in deep containers can minimize this problem.

Figure 2. Deep pipe diagram



Deep pipes are typically filled from a water jug, but they can also be filled from a hose or fitted with a drip emitter (Sawaf, 1980; Bainbridge and Virginia, 1990). If a drip emitter is used then the deep pipe can be smaller diameter (~1 cm). In order to ensure that water seeps through the pipe at all levels, the drip water rate must be fast enough to fill the pipe. Alternatively, the pipe can be tilted so that water seeps through the upper weep as it flows down the pipe. Weighted emitters can be used to keep them in place. A battery-powered remote timer combined with a water tank can be set up at a remote site deep pipe irrigation system to irrigate once a week and this has led to excellent survival rates.

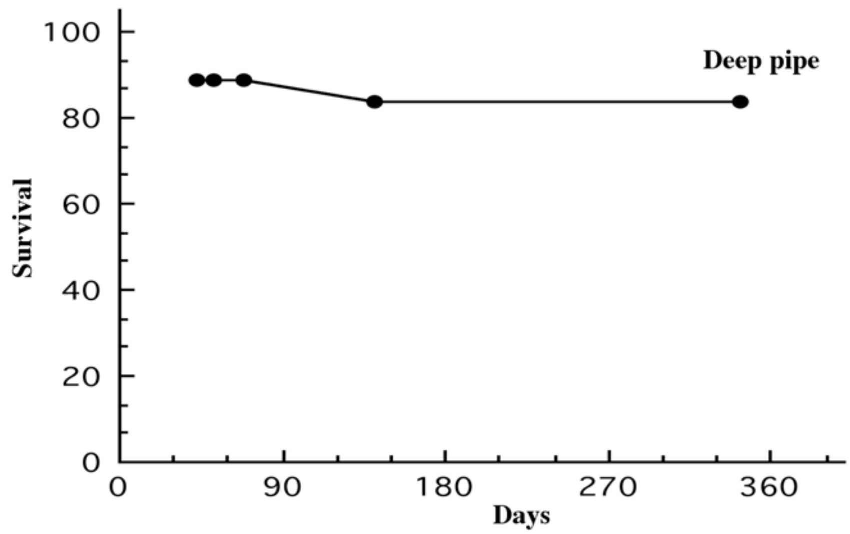
Deep pipe irrigation can be used with low quality water. It is possible to set up with simple materials and unskilled labor without extensive support systems (pressurized filtered water is not needed). The deep pipes provide better water use efficiency (due to reduced evaporation) and reduce weed growth and competition. They also enable water to be applied quickly and efficiently with no wasted runoff even on steep slopes.

Deep pipe irrigation is better than buried drip systems in several respects. The drip fed deep pipe system provides the same benefits of greater water use efficiency (due to reduced evaporation) and weed control. However, because the drip lines can be kept on the surface when combined with deep pipes, the drip system can be monitored and repaired (e.g., unclogged) much more easily than buried emitters.

Experiments have demonstrated that deep pipe drip systems are very effective and more efficient than surface drip or conventional surface irrigation. Crop weight with the deep pipe drip system in Africa was more than double that of surface drip, and six times larger than conventional surface irrigation (Sawaf, 1980). Root spread reached 60 cm with surface drip, 100 cm with conventional surface irrigation, and 175 cm with deep pipe drip irrigation.

Deep pipe irrigation develops a much larger effective rooting volume than other irrigation systems and results in plants better adapted to survive on their own. Survival of trees irrigated with deep pipes at a severe site in the California desert was good even after minimal irrigation and delays in starting irrigation (Figure 3). In a recent study in the Sonoran Desert of California, survival was tolerable with a total of only 10 liters delivered to each tree over the first 3 years (Bainbridge, 2006). Trees survived a 3-year drought, compared to total failure of surface irrigated trees given the same amount of water within four months. After 5 years tree survival in another deep pipe experiment with drip emitters remained excellent and the trees were large and growing fast (Bainbridge, 2007) (Figure 4).

Figure 3. Mesquite survival on deep pipes, Colorado Desert, California



Planted in midsummer, temp. 40°C. Water delivery delays hurt early survival.

Deep pipe irrigation works very well by itself, but long term survival and growth can be improved by including microcatchments to increase effective rainfall (Edwards et al., 2000; Shanan and Tadmor, 1979). Careful placement of deep pipe irrigated trees in low areas where runoff is concentrated can provide benefits as well. Tree shelters can further reduce water demand and improve survival, even in the desert (Bainbridge and MacAller, 1996). The very low water use demand required with deep pipes

Deep pipe is a little known, but very effective method of irrigation. It can substantially reduce the quantity of irrigation water needed, and can make it possible to establish trees far from water sources, even when water has to be hand carried. It is very effective on steep slopes as well as flat land. Deep pipe irrigation should be more widely used and considered for agroforestry, forestry, restoration and landscaping (Bainbridge, 2007).

Figure 4. Trees on deep pipes with drip emitters

1990

1995

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