ECO-IRRIGATION: AN EBB AND FLOW SYSTEM FOR LARGE SCALE COMMERCIAL APPLICATIONS

From the dawn of civilization until slightly over a century ago, the sole form of irrigation was subsurface. Water was allowed to enter a planted field, and then drained. From Mesopotamia to the Nile Valley to the plains of India, food supplies were irrigated by drainage ditches and natural flooding. Surface water from accumulated rain or snow was the only water source. During the last hundred years, with the advent of deep wells, pumps, and engines, mankind gained the ability to remove vast quantities of aquifer water. This technology has allowed for various types of high-pressure irrigation systems, such as micro- and spray irrigation. Until the last two decades, the aquifer was generally considered an inexhaustible source, and the use of surface water assumed a secondary role in many areas. Now that worldwide population has exploded and water consumption has dramatically increased, fresh water supplies are becoming very taxed. Because agriculture consumes the majority of the world’s fresh water, it is essential to reconsider any method of conserving water in crop production.

The single largest limitation for the application of modern irrigation technology, from a water source point of view, is the fact that most water applied to crops is not utilized by the plant; the excess water either evaporates, runs off into surface water, or slowly leaches back into the aquifer system. This water is unavoidably contaminated by agricultural runoff or non-point-source pollution.

Seven years ago, after spending several years in the containerized horticultural nursery business near Orlando, Florida, I was feeling very unhappy with our systems of microjet and overhead spray irrigation. These systems presented so many difficulties with pumps, filters, emitters, and water distribution that I began to explore the possibility of locating another, better method. I reviewed the practice of sub-irrigation in ancient times, recalling as I did that my mother had watered her patio plants from the bottom up, by pouring water into the saucer every several days.

In order to test this method of irrigation, three baby swimming pools were set up for experimentation; and large containerized plants were placed in two of the pools, while a water source was established in the third pool, or reservoir. A small pump was used to fill the plant-containing pools nearly to the tops of the containers, and then the water from the plant-containing pools was drained back into the reservoir. To my great surprise, plants irrigated by this technique required markedly less frequent irrigations; the plants not only thrived, but appeared to grow more quickly than with the conventional overhead or micro-irrigation systems that we employed at our tree farm. All sub-irrigated plants were wetted equally, and the medium was saturated with each irrigation event.

In order to evaluate the saturation of the containers in the three methods of irrigation—sub-irrigation, microjet, and overhead—the plants were weighed before and after irrigation. The plants that were sub-irrigated consistently gained more weight during the irrigation cycle than did those that were microjet or spray irrigated. Interestingly, those plants that were irrigated by microjet or spray were then sub-irrigated, with a significant increase in weight. These facts convinced us that field capacity was not being reached with our current irrigation practices. With a subsurface irrigation cycle, there was no maldistribution of water, and each plant container weighed the same after an irrigation event. Rather than watering twice a day, we used this irrigation technique about every two or three days; and the plants thrived.

While exploring the idea of rain harvesting and water reuse as an alternative irrigation method, I designed a system of rain harvesting by covering a five-acre contoured field with polyethylene liner, and separating the area into several irrigation beds along with a large collecting reservoir. Rainwater accumulated over the entire polyethylene-lined area and drained into the lined reservoir, from which a low-pressure pump supplied water to the plant bays. Gravity was used to drain the water after the desired depth was achieved. This created a closed-loop system that harvested and stored rain, and prevented non-point-source pollution.

For the next two years, data was carefully collected. To my surprise, rain harvesting resulted in more collected water than the plants on the system could use; and we began to supply other portions of our nursery with this surplus water. Even though all the agricultural effluent was collected, there was no significant increase in total dissolvable solids, and no accumulation of toxic herbicides, insecticides, heavy metals, or other byproducts. Algae growth was intermittent; and since we had introduced herbivorous fish—tilapia—into the reservoir, there were no weeds and the algae was quickly consumed. Ospreys and herons were noted to harvest the fish, and have continued to do so. This, we believe, completed the cycle of the removal of any increased salts or nitrates.

Because of the excellent results on the smaller five-acre system, this rain harvesting and sub-irrigation system has been increased to approximately sixteen acres, and several plant crops have been raised and harvested.

In Florida, we have rainfall of about 53" per year; and even during our severe drought that ended about two years ago, we had no need of aquifer water to irrigate our plants on the subsurface system. Where rain exceeds 30" per year, no other water source is considered necessary. Even though we have heavy evaporation losses in Florida, those losses are essentially confined to the surface of the reservoir, allowing a huge net increase in the water surplus from rain harvesting.

The amount of water necessary to irrigate, by conventional methods, an acre of ornamental horticultural product in containers, is between three and six million gallons per acre per year. Six million gallons of water is a cube measuring approximately 90' per side.

The amount of rainfall over a small area is astounding. As an example, on a 200-acre farm in Central Florida, enough rain falls annually to float ten large aircraft carriers. This rain-harvested water can be repeatedly re-used by either subsurface technology, microjet systems, or overhead sprays. We prefer subsurface irrigation, for reasons that I shall explain in a moment.

Some may ask whether aquifer recharging is prevented by covering a recharge area with a polyethylene liner, thus preventing a certain percentage of rainfall from returning to the aquifer. In Florida, where annual rainfall per acre is about 1½ million gallons, approximately 20% of the rainfall, or 300,000 gallons, reaches the aquifer. When the land is covered by an impermeable membrane such as that used in this system, the tradeoff is greatly in favor of rain harvesting, which prevents the withdrawal of some 3 to 6 million gallons of water per acre per year from the aquifer—the approximate amount used for micro-irrigation or overhead spray systems.

The advantages of sub-irrigation include: 1) reduction in weeds (because the top layer of soil is wetted only by rains, and not by irrigation water); 2) reduction in fungal foliage disease because of reduced foliar wetting (and therefore a dramatic reduction in the necessity for fungicides); 3) marked reduction in insects because of reflected light from the white liner (thus reducing the necessity for insecticides); 4) a dramatic savings in labor when contrasted to micro-irrigation, since there are no emitters to check or repair, no filters to change, and no small pipes and tubes (which in our area are likely to be chewed open by rabbits); 5) more uniform crops than with conventional irrigation methods, since the containers are all equally saturated with each irrigation event. In addition, we believe that fertilizer use will be reduced: the reason for this is that with each sub-irrigation event, the water in the container rises and falls, carrying with it the fertilizer molecules that—instead of constant leaching from top-down irrigation—are made more accessible to the plant roots. Perhaps as great an advantage as any is that a grower can be guaranteed of 100% effectiveness of the irrigation, by simply looking across the field, noting the water level, and knowing that all plants are equally irrigated.

The disadvantage of the system lies primarily in two areas. The first, and perhaps most important, is the necessary change in farming habits. The second is the expense of the initial installation of the system.

During the years that we have been developing our technology, we have gained the grant support of the state water districts, the Environmental Protection Agency, state departments of Environmental Protection and Agriculture, and the United States Congress. Four years ago, the University of Florida invited us to be a research partner; a two-year study has just been completed, and a Ph.D. thesis has been written comparing the results of sub-irrigation, micro-irrigation, and overhead spray irrigation on our farm..

The process of change is sometimes agonizingly slow; but more and more agencies realize that in order to stem the huge waste of agricultural water, it will be necessary for governments to supply a majority of the funding for the changeover. This has been occurring in Florida for a number of years, and has almost reached the acceptance point that water saved is less expensive than is any alternative water source, even if the agencies fund 80-85% of the initial installation cost of the rain-harvesting system. Since plant growth is more efficient with sub-irrigation, the grower makes a higher profit than with conventional systems. Energy savings are between 50-75%, as documented in the University of Florida's independent study. Huge amounts of aquifer water are saved for the needs of an ever-increasing urban environment.

The system has not been proven in arid climates; but water from snow melts and seasonal river excesses can be harvested and stored much as they are today in many areas of the country, with the added advantage that agricultural runoff can be almost eliminated.

Since the water shortages resulting from seasonal droughts can be mitigated, thus making water available for irrigation to the grower in all seasons, production of all plants—whether food or ornamental—can be assured.

The key to water conservation, in my opinion, is the combining of agriculture, government, and academia into a single force. With this combination working together, vast quantities of currently-wasted irrigation water can be saved to insure fresh water resources for generations to come.

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