New Irrigation Technologies for Smallholders:

Revealed Through an Innovative Contest[1]

An *Innovative Irrigation Ideas and Technologies for Smallholders* contest was launched in November during the 2000 Irrigation Association's (IA) annual Convention and Trade Show. The objectives for (and reasons for the interest of the World Bank's Rural Development Department in supporting) the technology contest were: 1) to raise public awareness of the needs for innovation in irrigation technologies for poor smallholders in developing countries; 2) to encourage individuals, the irrigation supply industries, and research institutes to develop irrigation technologies that are appropriate and affordable for smallholders; and (3) to identify new technologies that the World Bank and others in the development community can promote.

The Contest was launched as a pilot effort to stimulate development of irrigation technology for agricultural smallholders. The Irrigation Association, Winrock International, International Development Enterprises, and the World Bank initiated the contest with support from the International Program for Technology and Research in Irrigation and Drainage (IPTRID) of the Food and Agricultural Organization of the United Nation (FAO), and now the Third World Water Forum also cosponsors this pilot event. Winrock International contributed the $10,000 for prize money. Dr. Sandra Postel launched the Contest during her Keynote presentation at the IA Breakfast meeting on Nov 13, 2000 in Phoenix, Arizona.

After one year (Oct. 1, 2001), the application list was closed. A total of 115 eligible applications were received from all parts of the world. The scoring for the competition was based on an evaluation of the originality of each entrant's submission and how well the irrigation equipment, technology or management can potentially serve the world's small agricultural holders. The selection criteria used by the judges included affordability, novelty or creativity in approach, ease of application or operation, practical usefulness in upgrading smallholders capabilities, durability, and explicability.

The sections that follow provide a short review/appraisal of the technologies proposed in the contest focusing on the ideas of five finalists. The innovation and superiority of these technologies as compared to conventional technologies is highlighted. Their potential benefits and conditions for spreading these technologies are also touched upon.

Contest Finalists

A panel of five judges[2] reviewed all of the submissions of the Contest entrants and used a standard evaluation procedure to select the five finalists. A brief description of the submissions of each of the five finalists is presented below

[1] By Jack Keller, Professor Emeritus, Utah State University and CEO Keller-Bliesner Engineering, Logan, Utah, USA. Also a member of the Board of International Development Enterprises, an NGO specializing in applying a Business Development Approach to disseminating modern pressurized irrigation technologies to smallholders.

[2] There were five judges: Herb Blank, Winrock International; Tom Brabben, AGLU; Fernando Gonzales, World Bank; Jack Keller, K-B Engineering; and Bob Names, International Development Enterprises/Nepal. Itaru Minami of the World Bank was Chief Teller.

Tote-a-Way© Small Farm Irrigation System[3]

A complete sprinkler irrigation system that utilizes durable lay-flat flexible pipe and fits in a plastic tote box that can be easily carried from one field to another. It operates at 10 to 13 meters of pressure head at the pump and provides high long-term water-use efficiency of 80%. The system is available in various sizes to cover from 250 to 2500 square meters and costs $ 25 to $250 ex-works USA. It is composed of components selected from ten different manufacturers and is available through international distributors. This was the First Place winner.

South African "KIT" Treadle Pump[4]

A low cost, quality treadle (suction/pressure) pump in kit form. It is fabricated from "off the shelf" plastic pipe and fittings that locally available in South Africa where the price structure differs from surrounding countries. The performance of the pump is competitive but it is lower in cost compared to treadle pumps available from South Asia and other African countries. It is easy to operate and requires less energy than many treadle pumps because it utilizes simple low friction-loss valves. This entry tied for Second Place.

Stone Hammer Modified Sludge Drilling[5]

Two low-cost manual drilling techniques for developing shallow tube-wells in areas with hard subsurface strata. In North Bengal, India the stone hammer technique has been successfully used to reduce the cost to less than half the cost for developing shallow dug wells. In Nicaragua the modified sludge method has been successfully used to reduce the cost to half the cost for developing shallow dug-wells in similar terrain. This entry tied for Second Place.

Dream Drip Kits Irrigation Innovation For Small-scale Farmers[6]

Development and marketing of low-head (0.8-meter) drip irrigation kits that are assembled from components manufactured in Kenya. The systems addresses the limitations Kenyan farmers have identified in the other locally available drip kits: e.g. a double screen filter and a silt trap, the header connector is provided with removable end plugs for flushing small sediments, and a gate valve for regulating the flow of water. This entry tied for Third Place.

Pitcher (or Pot) Irrigation[7]

Development of pitcher (sometimes referred to as pot) irrigation utilizing locally manufactured unglazed 5 to 8 liter capacity clay pitchers. The researchers have thoroughly researched the techniques for manufacturing the pitchers, installing them and the garden farming methods to take best advantage of the technology. The technology is completely indigenous, cost effective, technical feasible, and economically viable. Furthermore, pitcher irrigation provides a means for obtaining maximum production of fruit trees and vegetables from very limited water supplies and from saline water supplies. This entry tied for Third Place.

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[3] By Gary Underhill, Underhill International Corporation, USA
[4] By Caryn Kedge, Institute for Agricultural Engineering, South Africa
[5] By Practica Foundation, Bennekom, The Netherlands
[6] By Stephen Ngigi, University of Nairobi, Kenya
[7] By S.K.Gupta and S.K. Dubey, Central Soil Salinity Research Institute, Karnal India

Innovativeness, Superiority, and Benefits of Technologies

The judges selected the five contest finalists and the winners based on the innovativeness and superiority of the technologies compared to conventional technologies available on the market as well as their potential for improving irrigation performance for smallholders. The set of contest finalists represented three methods of irrigation that are suitable for smallholders sprinkle, drip, and pitcher (pot) irrigation; and two innovations related to water supply, low-cost well drilling and manual pumping. Following is the logic underlying the selection of the contest winners.

Sprinkler System

The Tote-a-Way© Small Farm Irrigation System is simply a carefully thought through out, very flexible low-pressure sprinkler irrigation system. It is composed of standard "off the shelf" components that have been assembled in a convenient manner for use by smallholders. It can be used for irrigation, leaching, and for germination in conjunction with drip irrigation. The standard components are easy to assemble, with the only tools needed being a screwdriver and scissors. Dealers or farmers can tailor the system to fit any land configuration or combine systems to adapt it to farms of various sizes.

The system uniquely overcomes the two major objectives to utilizing sprinkle irrigation for small land holdings, pressure and portability. Most portable sprinkler systems use rigid lateral pipes and operate at three bars of pressure (30 meters of pressure head or 45 pounds per square inch). Such systems require large pumps and are difficult for smallholders to transport and store.

The Tot-a-Way system utilizes relatively large lay-flat hose (that is commonly used for mainline pipes and sub-mains in large semi-fixed drip irrigation systems) for all mains and laterals to minimize friction losses in the pipe network. The sprinklers are commonly used in commercial greenhouses and only require an operating pressure head of 7 to 10 meters while still producing a high level of uniformity and low application rate when spaced on a 4 m by 5 m up to a 6 m by 6 m grid. The system uniquely combines these and other standard components that are available from top-quality manufacturers.

The cost of the system to dealers is in the neighborhood of $0.10 US per square meter irrigated and the cost is relatively insensitive to the size of the area irrigated. Furthermore, all system components should have an economic life of at least 8 years.

Drip System

"Bucket" and "drum drip kits" are becoming very popular in many developed countries. In Kenya bucket drip kits were first introduced by an American NGO several years ago and have been slowly gaining in popularity. However, the materials for the kits are imported and the performance of the systems is problematic.

The unique aspect of the Dream Drip Kits Irrigation Innovation For Small-scale Farmers is that the system utilizes locally produced high quality drip tubing that is designed for large-scale commercial farming operations. The designers of the Dream Drip Kits have optimized the system components using all locally available components. They have even optimized the height of the bucket (0.8-meter) so it can be conveniently filled and they have designed an efficient

double-screen filtering and silt trap system along with convenient end plugs for flushing the laterals to reduce clogging problems.

The small 20-liter "bucket kits" are available for kitchen and small gardens ranging in size from 15 to 30 square meters for about $14 US. Larger 200-liter "drum" kits are also available for small commercial growers who irrigate 200 to 400 square meter plots for roughly $0.50 US/square meter.

Pitcher (or Pot) Irrigation

Historically speaking, pitcher irrigation is the oldest form of what might be called drip or trickle irrigation as it has been practiced for several centuries. The unique aspect of this entry is that it documents the scientific aspect of pitcher irrigation. For the pitchers (water containers), locally manufactured unglazed 5 to 8 liter capacity clay pitchers (pots) can be utilized. A very unique aspects of pitcher irrigation is that it is suitable for any size or shape of small irrigable area, is a very efficient means of irrigating, can obtain high yields using saline water, and can be produced locally.

The researchers who submitted the entry have thoroughly researched the techniques for manufacturing the pitchers, installing them and the garden farming methods to take best advantage of the technology. They have researched the following aspects of pitcher irrigation:

- Size of the pitchers and methodology for installing them;
- Pitcher filling schedules for different crops and water qualities;
- Fertilizing with the irrigation water and appropriate placement of plants;
- Life of pitchers and economics of instillation and operation; and
- Pitcher spacing and production for different crops.

As mentioned above, the technology is completely indigenous, cost effective, technical feasible, and economically viable. The installed cost of a 8 liter pitcher is in the neighborhood of $0.25 to $0.50 US and each pitcher can serve a crop area of 2 to 4 square meters. Some average yields in kilograms obtained form each pitcher are: 5.8 Kg for tomatoes; 5.2 Kg for cauliflower; 4.8 Kg for cabbage; 11.3 Kg for watermelon; and 3.5 Kg for grapes. Furthermore, tomato yields were unaffected by water having a salinity up to 5.7 dS/m, and the yields of the other crops were unaffected by water having a salinity as high as 9 dS/m. Thus pitcher irrigation provides a means for obtaining maximum production from very limited water supplies and even from saline water supplies.

Well Drilling

Low-cost hand-drilled shallow tube wells for irrigation have become very popular in many parts of the world, but their spread is largely confined to areas with sandy or loamy substrata. In large tracks of land with hard layers the traditional techniques for installing tube-wells, such as the hand-sludge method, which is so popular in Bangladesh, are unworkable.

The unique aspect of the Stone Hammer Drilling method is that it is a manual operated hammer well drilling technique that is relatively low cost for developing shallow tube-wells in areas where there are layers of hard clay, gravel, or even sandstone. The technique utilizes locally crafted drilling tools made of 3-inch iron pipe with teeth made of the steel from car springs. The

pounding is accomplished by a weight that is raised using a bamboo lever arm and dropped repeatedly onto an iron shoe welded inside of the drilling tool. The hammering along with a twisting action accomplishes the drilling.

The traditional method for tapping groundwater in such areas was to use hand-dug open wells, which are considerably more costly and difficult to construct and double the cost of the Stone Hammer Drilling method.

Treadle Pump

Treadle pumps are well established as a very suitable devise for smallholders where access to shallow groundwater or surfaces water is available and underdeveloped. The unique aspects of the South African "Kit" Treadle Pump design are that plastic pipe is used for the cylinders and other off the shelf plastic parts are used for the rest of the pump, thus no metal fabrication is necessary. Furthermore, the pump is in kit form and can be easily assembled by dealers or even by farmers with the assistance of dealers or local artisans.

Because it is in kit form it can be easily packaged. The pump utilizes very low friction loss valves that are also low in cost. Because of the low friction loss through the valves the pump is as efficient as treadle pumps with metal pistons and cylinders but considerably lower in cost than imported or locally manufactured metal pumps that are available in South Africa. The unassembled pump kit only cost $28 US. In addition to the items in the kit, wooden poles for use for the pump's treadles must be purchased locally for approximately $7 US, which brings the total cost of the to pump parts to $35 US.

Based on pump tests the South African "Kit Pumps are capable of producing roughly 0.5 liters per second at total head of 10 meters for suction lifts up to 4 meters, i.e. if the suction head is 4 meters, the delivery head would be (10 – 4) = 6 meters.

Spreading the Technologies

Identifying new and useful technologies to provide the benefits of irrigation or improved irrigation performance to smallholders is important. However, the technologies must be promoted and adapted to be of significant benefit to them. None of the contest entrants are in a particularly good position to promote and spread their innovations to the communities of potential smallholder customers throughout the world or even in their local regions.

Cooperative efforts will be necessary to enable smallholders to realize the potential benefits of these new and innovative technologies. To accomplish this I favor the business approach to development. This will require cooperative efforts involving: a) financial assistance of donors such as the World Bank; b) marketing and technical assistance of such non-government organizations as International Development Enterprises or Enterprise Works; c) promotional and educational support of local governmental services; and d) collaboration with various local manufacturing and business communities.