

Unlocking the Potential of Rainfed Agriculture

PHOTO: G. VENKATRAMANI

Rainfed agriculture can be productive and highly profitable, if the right technologies are used.

Theib Oweis rarely gets excited — except when he talks about water. As head of ICARDA's research program on land and water, he has worked in dryland areas for 30 years, developing and promoting technologies that help farmers use water more efficiently, and more sustainably. Such technologies are important everywhere, but they're absolutely vital in dry areas, where water scarcity is approaching critical levels.

Water productivity

For many years, both farmers and researchers aimed to maximize yield per unit of land. ICARDA focuses, instead, on maximizing yield per unit of water, because it is water — not land — that is often the critical limiting factor in dry areas. Partly due to ICARDA's pioneering work, this new approach has been integrated into national policy in many developing countries that face water shortages.

Water productivity is a measure of what can be produced (how many tons of grain, or grams of protein, or dollars of profit) per liter of water. In practice, how should we go about increasing water productivity? Two issues are involved: where should researchers focus their efforts, and what technologies should be used. Where to focus: rainfed (non-irrigated) areas, which have the least water resources, the poorest farmers, and the largest 'yield gaps', i.e. the largest difference between potential and actual yields. In addition, rainfed areas usually offer good returns on investment, because large improvements are possible with limited investments. What technologies? Several are available, notably the optimized supplemental irrigation methods being promoted by ICARDA.

Rainfed or irrigated?

"For the past 50 years, research, extension, and infrastructure have been targeted mostly at irrigated areas," Dr Oweis explains. "Yet rainfed areas occupy 80% of the world's farmland, and support over 95% of the world's farmers. The best way for poor countries to achieve food security is to unlock the potential of rainfed agriculture."

ICARDA has been helping to do just that, with supplemental irrigation, a simple low-cost technology that dramatically improves crop yields as well as water productivity. Irrigation usually means watering your

fields at regular intervals throughout the season. Supplemental irrigation achieves the same results with much less water. The aim is not to supply all the water that a crop needs, but only to supplement rainfall with small amounts of water at critical stages of growth, when plants are extra-sensitive to water stress.

Dr Oweis and his team have spent 20 years putting this concept into practice. They've refined and optimized traditional supplemental irrigation methods; developed technology 'packages' combining supplemental irrigation with other improved technologies; and conducted training programs for farmers and extension staff. The technology is now being used by tens of thousands of farmers in dry rainfed areas in several countries.

ICARDA's research on supplemental irrigation focuses on four areas:

- **Water sources.** How to obtain water for supplemental irrigation without

depleting scarce resources; new methods to identify, evaluate and compare alternative sources

- **Irrigation schedules.** When to irrigate, and how much, to maximize water productivity
- **Water delivery.** New irrigation methods that deliver water more effectively, at low cost, with minimal 'transit losses'
- **Technology packages.** Combining different technologies (new varieties, crop management, irrigation, soil fertility) to maximize the returns from supplemental irrigation.

"Supplemental irrigation, as opposed to purely rainfed or fully irrigated agriculture, offers huge gains in water productivity," Dr Oweis explains. On wheat farms, average water productivity (the quantity of grain produced per cubic meter of water) is about half a kilogram under rainfed farming, three-fourths of a kilogram under full irrigation, and an astonishing 2.5 kilograms under supplemental irrigation. In a large-scale irrigation project in Iraq, for example, yields increased from 2.2 tons to 4.6 tons per hectare with just 68 millimeters of well-timed supplemental irrigation. Neighboring farmers who used full rather than supplemental irrigation, achieved lower yields despite using nearly three times as much water.

User-friendly methods

For farmers to successfully use supplemental irrigation, they must know how to calculate the optimal water levels needed. To help them do this, ICARDA's water management experts worked with



Simple, low-cost gates and valves can help control irrigation flows, and dramatically increase water productivity.

PHOTO: G. VENKATRAMANI

national research centers in eight countries, conducting field trials on different crops for several years. They used the results to develop a simple set of charts showing the optimal level of supplemental irrigation under different rainfall and price scenarios (see box).

But inputs such as water, fertilizer and seed require investments; farmers must consider both costs and benefits. Field trials in Syria have helped quantify the trade-offs and identify optimal levels of inputs to help farmers maximize returns on their investment. For example, water productivity curves peak when supplemental irrigation is combined with about 100 kilograms of nitrogen per hectare. Most farmers use more fertilizer, and more water, than optimal. ICARDA's work is showing them how they can cut costs and save water, and still obtain a good harvest.

Plant early, beat frost

Supplemental irrigation increases yields not only directly (by providing water) but also indirectly, by enabling farmers to plant their crop early. ICARDA research in Morocco and Turkey has shown that in some cases, the indirect benefits may be even more important than the direct ones.

A few years ago, farmers would wait for adequate rain before they planted their crops. Result? Crop yields fall drastically due to environmental stresses: late-season drought in hot, dry areas; early-season frost in cold, dry areas. Today, farmers use supplemental irrigation to advance the planting season by three weeks, protecting their crops from both types of stress, and increasing yields by up to 30%.

Optimal use of water

Yield increases with more irrigation, up to a point. Beyond this optimum, yield actually falls because the crop is over-irrigated. Most farmers do not know where the optimum lies, so they play safe by over-irrigating. They're not only wasting water but also increasing their production costs.

How much supplemental irrigation is optimal? To find out, ICARDA researchers conducted field trials to measure yields under different levels of supplemental irrigation (first chart). Then they factored in crop and water prices (second chart) to help farmers answer the question: at today's prices, and given the rainfall in my area, how much supplemental irrigation should I apply to maximize the return on my investment?

Charts like the ones below (which is only a graphical summary of far more detailed research) are valuable extension tools. Farmers can make irrigation decisions simply by reading optimal values off the chart.

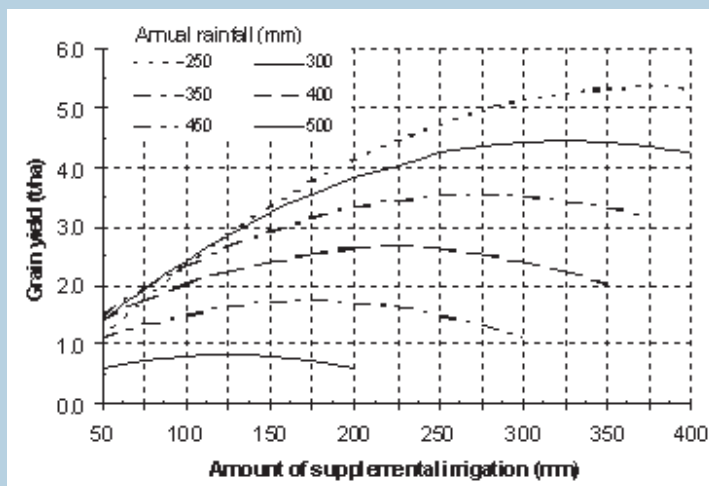


Figure 1. Optimal supplemental irrigation for rainfed wheat in northern Syria, considering biophysical factors only.

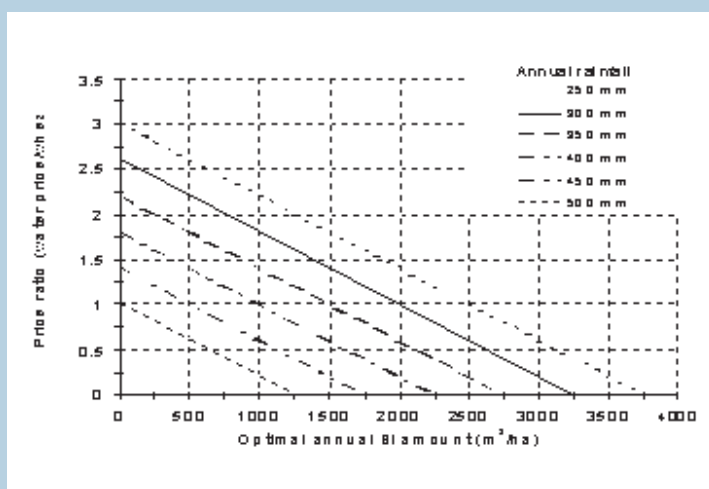


Figure 2. Optimal supplemental irrigation for rainfed wheat in northern Syria, considering biophysical factors as well as crop and water prices.

Supplemental irrigation using sprinklers. ICARDA has helped promote the concept and refine the method.

Promoting supplemental irrigation

Small amounts of supplemental irrigation can substantially increase yield and incomes – a powerful message in water-scarce areas. The technology is available and well researched. The benefits are evident. Clearly, investments in supplemental irrigation – supportive policies, equipment, farmer training – will pay off handsomely. If it's done right, with communities fully involved and supportive, the technology will spread quickly, improving food security and livelihoods, protecting water resources, and helping to unlock the huge potential of rainfed agriculture.

People, technology, institutions

Syria provides a good example of how new technologies can be scaled out. A new technology package – a new wheat variety plus nitrogen fertilizer and supplemental irrigation – was tested for 5 years at 14 locations across the country. Scientists experimented with different levels of water and fertilizer to identify the optimal combination. The final package was then scaled out through demonstrations and training programs implemented jointly by the national research and extension agencies, ICARDA and local NGOs. Most important, the program was driven by individual small-scale farmers who had seen the benefits for themselves.

- On a typical 5-hectare farm, the supplemental irrigation package increased net household income by \$1600 per year.
- Supplemental irrigation gave the same yields as full irrigation, but used only one-third of the water. The 'saved' water was used to irrigate other crops.
- Between 1991 and 2004, area under supplemental irrigation increased several-fold, and the country's wheat production rose from 2.1 million to 4.5 million tons.

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