

## Agro-Technology

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*Israel is one of the most densely populated countries in the world, and yet only 20% of the land is arable - and half of that has to be irrigated. More than half of Israel is arid or semi-arid, and the rest of the country is dominated by steep hillsides and forests. Yet thanks to cutting-edge technology, Israel not only produces most of its own food, but also exports \$1.3 billion worth of agricultural produce annually. This includes farm products as well as some \$1.2 billion worth of agricultural inputs and technology sold overseas every year.*

*Because Israeli farmers and scientists have had to contend with a difficult environment and limited water resources, their experience is especially relevant to the developing world. Development of greenhouse equipment, seed and livestock propagation, fertilizers and pesticides have enabled Israeli agriculture to prosper in adversity. In addition, farmers have learned to develop high value-added and innovative farm products that enable them to compete in markets with lower-cost producers. Water management, recycling, desalination and transportation in the National Water Carrier have enabled the country to overcome drastic shortages.*

*Every three years, the country's accomplishments are showcased in the national Agritech exhibition; in September 1999, the exhibition drew a record 9,000 overseas visitors from more than 100 countries.*

### Water Problems and Possibilities

Israel has striking rainfall inequalities. While the north of the country enjoys a relatively generous rainfall of 700 millimeters each year, the central region receives only 400-600 millimeters and the south sees a meager 25 millimeters annually. The National Water Carrier, which transports water from north to south, has helped to remedy these regional imbalances.

Beyond transportation, Israel has developed effective solutions for the dearth of water in some areas. Efficient water management has increased agricultural output 12-fold during the past 50 years, while water consumption has remained constant through rigorous maintenance of infrastructure, replenishing of aquifers and the allocation of appropriate quotas and pricing to discourage wasteful consumption.

The use of recycled water has provided another solution. Out of 1.1 billion cubic meters of water used for agriculture in 1998, approximately 250 million cubic meters were recycled effluents. The Water Commission forecasts that by 2010 one third of all crops will be irrigated with "cleaned" water. Twenty-four desalination plants in Eilat, the Dead Sea region and the Arava Desert supply another 161 million cubic meters of irrigation water each year.

Another 70 million cubic meters of water are generated annually from underground sources; geothermal waters found beneath the surface of the Negev desert are also

used. Farmers have found that salt water produces "sweeter" crops than regular water. "Desert sweet" tomatoes and melons, for instance, fetch premium prices on European markets.

Cloud seeding (injecting clouds with iodine to increase the percentage of water that each cloud yields) has proven effective. Exploration (using sophisticated seismological techniques), prevention of pollution, soil conservation and drainage have all maximized water use. Landscaping to redirect floodwaters, computerized calculations to chart routes of runoff water and the strategic placement of trees and crops have also prevented desertification.

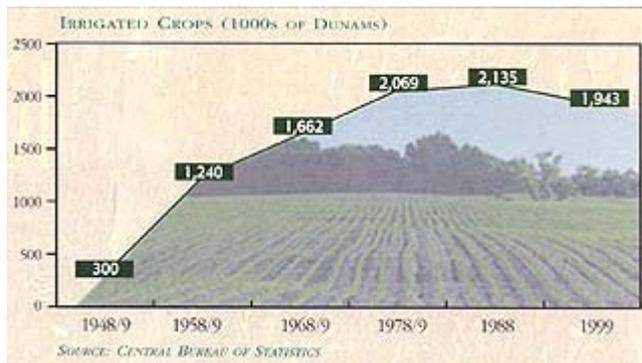
### **Every Drop Counts**

Perhaps the most innovative development in water utilization has been drip irrigation, conceived in Israel some 35 years ago. Today, networks of plastic pipes with small openings for each plant or tree are strategically placed across fields. Via the drippers, controlled amounts of fertilizer can be pumped through the irrigation pipes to the plants a system known as "fertigation".

Traditionally, drip irrigation has been used in regions where water is scarce, but it has also been effective where rainfall is high because of its precision. For example, experiments in Northern California in "precision" irrigation caused some types of tree to grow three times faster. Fast-growing trees can increase profits for timber growers and at the same time minimize environmental damage by reducing the number of trees that need to be felled.

Half a dozen Israeli companies sell plastic piping and a full range of accessories for drip irrigation. Many also specialize in designing customized irrigation systems for gardens, parks, farms and entire regions, installing them and then providing consultation and maintenance. Exports of irrigation equipment totaled almost \$300 million in 1998.

Other types of irrigation include: pressure irrigation methods; buried irrigation, which prevents infiltration by tiny roots; spray irrigation, which is suitable for orchards; and sprinklers used for entire fields. These systems can be very simple or high-tech. Options range from the basic turn on/off variety with volume clocks, to more sophisticated computerized systems, which include sensors to monitor the moisture level of the soil and check changes in the diameter of the stem or fruit. Other accessories include filter traps to sweep dirt away and low flow drip emitters for soil-less media in greenhouses. Minute or ultra-low-rate (ULR) irrigation methods have been developed to apply water at rates of less than one millimeter per hour.



## Bugs at Bay

Plagues of insects, fungi and weeds beset farmers worldwide, and Israeli companies have developed a range of pesticides and herbicides as well as non-chemical and biological control methods. Israel is home to the world's largest producer of generic agro-chemicals. In 1999, Israel exported over \$117 million worth of these pesticides and growth regulators.

Manufacturers produce large quantities of methyl bromide and formaline for disinfecting the soil. Environmentally friendly detergents, which coat leaves, have been developed to create a physical barrier between the parasite and the leaf without harming the leaf. Fungicides to prevent rotting in grapes as well as chemicals to combat pests in citrus fruit and powdery mildew in groves and vineyards are also produced. Other recent developments include a defoliant for cotton and herbicides for early treatment of weeds.

With environmental protection in mind, biological pesticides have been developed. Natural predators, which wipe out a particular pest without damaging the crop itself, are also cultivated. One kibbutz breeds tiny spiders, which prey on mites that can destroy strawberries, and exports them by the million to California. A Jerusalem-based biotechnology company developed fungi designed to attack powdery mildew, and bacteria to destroy moths. Another company developed a polyethylene film, which acts as an insect repellent by blocking ultra-violet rays.

## Growth Industry

The Dead Sea region, which provides bromine for pesticides, is also rich in potassium, phosphor and magnesium, which are ingredients for agricultural fertilizers. Israel exports both ready-to-use fertilizers and raw materials to manufacture fertilizer worldwide.

Foliage fertilizers from potassium phosphate, potassium sulfide and nitrogen potassium phosphate are manufactured locally. Israel is also one of the world's largest producers of potassium nitrate, a highly soluble fertilizer suitable for a variety of plants and crops. Two additional highly soluble fertilizers, mono-ammonium phosphate and mono-potassium phosphate, are also produced.

Fertigation has led to the development of a new generation of soluble fertilizers for injection into irrigation systems. Basic chemicals such as nitrogen or ammoniac nitrogen with trace elements of iron, quartz, manganese and copper, which enrich the

soil and enhance the growth of plants, have been combined to develop soluble fertilizers.

### **Greenhouses for Hot Climates**

Invented by the Dutch for cooler climates in Northern Europe, the greenhouse has been adapted by Israel for use in arid regions. Some 3,000 hectares of greenhouse cultivation enable farmers to overcome restrictions imposed by soil quality, arid climate and limited water supply.

Greenhouses can be erected in places where the soil is unsuitable. Irrigation systems overcome the problem of water scarcity, and curtains and skylights can be regulated to filter out or admit sunlight and provide temperature control. Plastic covering provides for thermal disinfecting of the soil prior to planting, covers the soil for heat collection, prevents growth of weeds and pests, and minimizes evaporation and the escape of fertilizers. Netting above the plants can keep out scales, mites and other pests while more sophisticated netting can act as a thermal screen, cooling plants during the day and keeping them warm at night. Fogging systems can be used for climate control.

All these systems can be operated by computer programs designed to generate a micro-environment on the cutting edge of 21st-century farming. Several Israeli companies manufacture and export woven high-tech plastic sheeting and specialize in custom greenhouse projects, including consultation, installation and maintenance. Because of the high initial investment, greenhouses are best suited for high value-added crops such as vegetables, flowers, ornamental plants and spices, and for intensive farming. Israeli greenhouses, for instance, average three million roses per hectare and yield an average of 300 tons of tomatoes per hectare each season.

### **Best of the Breed**

Israeli scientists have developed seed varieties that are resistant to disease, provide higher and better-quality yields with less water even in hot climates, and produce food with a longer shelf life. In 1998, Israel exported over \$35 million worth of such seeds.

The process of developing a new seed can take five years or more, but the latest biotechnological methods have reduced this time by 20%. Recent innovations include a variety of hybrid cotton with longer, stronger fibers, which gives a higher yield while requiring less water; some varieties are grown in natural colors of brown or green.

Sophisticated methods of crossbreeding have developed seeds that minimize the need for fertilizers and pesticides, producing high added-value crops, e.g., cherry tomatoes, greenhouse tomatoes and Galia melons. Seedless, cantaloupe-sized and black-skinned watermelons as well as saucer-shaped zucchini are profitable new developments.

In an effort to develop the most appropriate animals for the Middle East's hot and arid climate, Israeli breeders have found that the European Holstein cow adapts well. It boasts very high milk yields that are rich in protein and fat. The Holsteins' output has

been aided by computerized feeding and milking systems, enabling the local dairy and beef industry to supply most local needs.

The emphasis in poultry breeding has been on disease-resistant chickens and turkeys that can survive in extreme heat. Israeli layers have among the world's highest annual egg output at some 280 per bird. In addition, 195,000 tons of chicken and 121,000 tons of turkey meat are produced each year. Israel is also the second-largest breeder of ostriches in the world after South Africa, but the meat, which is not kosher, is exported. Israeli foie gras is of such high quality that it is exported even to France.

Breeders have also been successful in developing improved strains of sheep and goats, which are especially important in the Arab and Bedouin sectors as a source of milk and meat. The hybrid Awassi sheep is larger, woollier, has higher milk yields and can be raised in arid, semi-arid and sub-tropical climates. The Assaf sheep is a cross between the Awassi and the German Friesian and has improved milk and meat production; most importantly, the Assaf has three lambings every two years, which is 50% higher than in regular Awassis. Male Saanen goats imported from Europe and crossbred with the local Mamber breed produce a high milk yield goat. Israeli breeders can supply reproductive material (frozen semen and embryos) from improved breeds of sheep and goats that are especially suitable for arid regions of Asia, Africa and America.

Israel is also a world leader in fish breeding. Fish are bred in small ponds, which produce up to 500 kilograms of fish per cubic meter of water annually. Innovative recirculation systems enable water in these super-intensive farms to be recycled.

### **Upgrading Global Agriculture**

Eighty percent of farms are owned and run by kibbutzim (collective villages) and moshavim (cooperative villages). The remaining 20% are mainly citrus groves in the center of the country owned by large private companies. Kibbutzim often develop, design, manufacture and market their own agro-technology inputs. Drip irrigation was developed in a kibbutz and all major manufacturers of the equipment are kibbutz-based.

These farmers work closely with the country's ten agricultural research institutes, including the Agricultural Research Organization (ARO) and the Hebrew University's Faculty of Agriculture in Rehovot. Twenty-five professional and marketing associations also fund R&D, as do various government bodies and hundreds of private firms in the biotechnology and computer software sectors.

Manufacturers of agro-technological inputs and their customers increasingly realize that their products are most effective when accompanied by professional services. Drip irrigation systems and greenhouses are more productive when the infrastructure is custom designed, installed and later maintained to meet a customer's specific needs. Productivity of fertilizers, pesticides and genetically developed seeds and livestock can be maximized by consultation with professionals.

Experts are now specializing in upgrading agricultural production for entire regions. Companies take on turnkey projects that incorporate more efficient water use,

irrigation systems, crop and seed choice. They also advise on seasonal timing to fetch the best prices on world markets, on choice of fertilizer and pesticide to minimize environmental damage, and on the selection of livestock. Farmers of a particular region are then trained to use their newly acquired technologies.

## **Sustainability**

Israeli agro-technology, from irrigation and efficient water management to fertilization techniques and genetically improved seeds and livestock, has dramatically improved local yields, and could go a long way towards feeding a hungry world.

Israeli professionals are currently planning rural development projects in Thailand, the Philippines and Brazil. In the Gap region of Turkey, an area half the size of Israel, experts are upgrading the province's agriculture based on more efficient use of water from the Tigris River. The key word in these projects is sustainability. Companies stress that agro-technologies must not only be appropriate for a particular region or climate, but local farmers must also be trained to use and maintain the systems they purchase.

## **A Few Good Ideas**

### **Weighty Considerations**

Poultry growers can ensure higher profits by producing a flock of the same size and weight. Scientists at Israel's Agricultural Research Organization's department of environmental engineering have developed a device that sorts live fowl, enabling breeders to produce flocks of uniform size. Birds are moved on a conveyor belt fitted with sophisticated hooks which hold the birds as they are weighed and sorted by size via a precise electronic weighing system. A small flag in one of four colors attached to the hook indicates the bird's weight. The chicks are removed manually from the conveyor and placed in different pens according to the flags. Up to 2,600 birds an hour can be sorted in this manner, yielding big savings and thus enabling the system to pay for itself within 12 - 14 months.

### **Cutting Edge Technology**

A range of manual pruners developed by Haifa-based Easy Cut Ltd, for use in both commercial agriculture and home gardening makes it easier to pick delicate fruits, vegetables and flowers without damaging them, thereby increasing output by 20-50%. Based on the bio-mechanics of the human hand, the pruners have a lightweight gripper mechanism that enables the picker to hold a branch or fruit, without flattening or crushing its stem. The gripper mechanism can also be sold as an independent component, and attached to ordinary pruning shears or clippers. The pruners' designs vary according to the type of fruit, quality and size being cut, but all are designed to grip, cut and harvest fruit using one hand. The pruners also make it possible for the picked fruit to be conveyed to the collecting mechanism without hand contact. This is very important for consumers in certain countries like Japan.

### **No More Bad Apples**

Fruitonics Ltd. has unveiled a new automatic fruit sorting system. While weight and color may be judged automatically, until now quality grading for blemishes has always had to be done by hand. Optigrade II performs all these functions simultaneously, comparing each piece of fruit to an ideal image and charting its variation from the ideal, according to thousands of images. The system can detect blemishes only a millimeter or two in size - hardly visible to the naked eye. It not only looks at the skin but can also detect brown spots under the skin. It can even be taught to recognize unique or unusual blemishes by using artificial intelligence. Infrared and the latest sensing technology sort up to

10 pieces of fruit per second and the criteria for quality can be adjusted to the type of market for which the fruit is destined. Fruitonics claims that the labor-saving system pays for itself in less than two years.

### **Firm Understanding**

Most apple, pear, kiwi and persimmon crops are stored for long periods of time in controlled-atmosphere, cold-storage rooms. Because the oxygen level in these rooms is very low, it is difficult to monitor the quality of the fruits. However, Eshet Eilon of Kibbutz Eilon has recently completed the development of a central, remote-controlled system for monitoring the firmness of fruits inside cold-storage rooms, based on acoustical technology. In each room, a sample of fruits is placed on small monitoring units containing a small thumper and a piezo-electric sensor. Computer analysis of the vibration created inside the fruits by the tiny thumpers provides a continuous, clear picture of the fruits' firmness. The system can also monitor and even control the ripening process of fruit which was harvested while still green.