AGRICULTURE IN ISRAEL

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Annotation. Agriculture is a highly developed industry in Israel. Only 20% of the land area is naturally arable. Due to the diversity of the land and climate across the nation, Israel is able to grow a wide range of crops including wheat, sorghum, and corn. Israel has overcome many challenges (such as limited land and water resources) to emerge as a world leader in agriculture and water management technologies. Israel's agriculture experience and success is an invaluable tool that can benefit other developing countries in Africa and beyond. Many farmers around the world look up to Israel on how to manage and flourish in adverse, inhospitable conditions. This paper introduces the reader to the practice of agriculture in Israel.

Key word: agriculture, farming, Israel, Gaza, Palestine, Jews, Hebrews, Israeli agriculture, traditional agriculture.

INTRODUCTION

Israel borders the Mediterranean Sea and is between Egypt and Lebanon in the Middle East. Jerusalem is the capital of Israel and the official language there is Hebrew and Arabic. Israel is a small country of 22,072 sq. km. In 2023, the population was 9.2 million people [1]. The political map of Israel is shown in Figure 1 [2]. Only 20% of Israel's land is good for farming. The unique geographical location of Israel enables the farmers to grow a wide variety of produce throughout the year. Since Israel attained its independence in 1948, the number of agricultural communities has grown from 400 to 900. Because the territory of Palestine is a contested space the conflict over land and water is one of the main drivers behind land use. For many in the world, Israel is most often discussed in the context of the Israel/Palestine dispute and hopes for its peaceful conclusion. In spite of the continual conflict, Israel has emerged as a successful, modern, and innovative nation. Despite many challenges, Israel succeeded in transforming its agriculture sector and emerged as a world leader in agriculture and water management technologies. Other developing nations in Africa and Asia have learned from Israel's agricultural miracle [3].

Agriculture in Israel is a highly developed industry. Israel is a unique country whose history, politics, and geography shaped the mindset of its people and its leaders. Producers, food processors, wholesalers, retailers, food service operators, and food importers are all part of a well-developed agriculture sector. The Israeli food processing industry is innovative, constantly introducing new products to the market. It constitutes an important player in the domestic economy. The food retail

market is made up of supermarket chains, convenience stores, gas stations, neighborhood grocery stores, and markets.

Agriculture represents 2.4% of the Gross Domestic Product and 4% of exports. It provides almost the sole means of livelihood for the population in certain areas, such as the Arava and the Jordan Valley. Israel is a major exporter of fresh produce and a world-leader in agricultural technologies despite the fact that more than half of the land is desert and is not naturally suitable for farming. Israel is one of the world's leading fresh citrus producers and exports including oranges, grapefruit, and tangerines. Israel produced 95% of its own food requirements, supplementing this with imports of grain, oilseeds, meat, coffee, coco, and sugar. Tomatoes, cucumbers, peppers and zucchini are grown commonly throughout the country. Cattle (cows) in Israel produces the highest amounts of milk per animal in the world. The Mediterranean Sea is a source of salt-water fishing. Israel produces vast quantities of flowers for export. Organic produce makes up 1.5% of Israeli agricultural output, but it accounts for 13% of agricultural exports. Israel is second largest marketer and manufacturer of soft drinks. Israel produces almost 70% of its food requirements. It imports sugar, coffee, cocoa, oilseeds, meat, and fish.

Israel has two unique forms of agricultural communities: kibbutz and moshav. The kibbutz is a collective community in which the means of production are communally owned and each member's work benefits all. The moshav is a farming village where each family maintains its own household and works its own land. After seventy years, three-fourths of the country’s total crop area is still overseen by kibbutzim and moshavim, farming collaboratives. Today, between kibbutzim and moshavim, 76% of the country's fresh produce is output. Israel records the highest cow-milk productivity in the world, the highest tomato yield and the lowest post-harvest grain loss globally.

FACTS ABOUT ISRAELI AGRICULTURE

Israel's agriculture is a phenomenon in that low natural potential for the development of the industry is compensated by high intensity and efficiency of innovation. The following ten facts about Israeli agriculture are worthy of note [4]:

1. 76% of Israel's of agricultural product exports are sent to the EU.
2. Israeli farmers are able to change the flavor quality of fruits and vegetables.
3. Vegetables are sorted by means of photographic equipment and computers.
4. Almonds and figs are not harvested by hand, but rather with a special processor.
5. The government subsidies up to 40% of the purchase price of equipment and there is a steady introduction of new technologies.
6. Very low loss in grape harvest.
7. Milk yield increased by pouring cold water on cows.
8. Egg production of hens increased by means of multi-colored toys.
9. The struggle against insects is more global and systemic in Israel than in other countries.
10. The potato storage period is extended by treatment of adventitious buds with essential oils.

Israeli government has consistently shown visionary leadership in a long-term commitment to agriculture and water. In its early years, 30 percent of its national budget was devoted to agricultural and water. The export market was always a key driver in Israel’s agriculture research. This is how

Israel has come to lead the world in numerous products including dates, pomegranates, oranges, and tomatoes.

HISTORY OF ISRAELI AGRICULTURE

Israel has a long and proud history of innovation, from biblical times to the modern-day. A great deal of Israeli's agricultural success is tied to its history. Some archaeologists date the beginnings of agriculture in Israel/Palestine to the Mesolithic period. To that same period belong the sickles, mortars, and pestles which have been discovered in other localities in Palestine. While Palestinian farmers maintained their family-oriented, labor-intensive production, Jewish farmers focused on high value crops and livestock oriented towards the market [5].

The Jewish people have had strong ties to agriculture since Biblical times. Abraham's and Lot's shepherds quarreled with each other while the "Canaanite and Perizzite dwelt then in the land" (Genesis 13:7). Having wandered in the desert for many years, the children of Israel could hardly have been expected to succeed in mastering the intensive farming which obtained in the newly conquered territory. During the period of the conquest, livestock was raised in the forests. With time, the Israelites gradually mastered the cultivation of the soil. The Bible portrays the land of Canaan as "flowing with milk and honey." Jewish agriculture was based on the small single family holding [6]. During the reign of Solomon, some 20,000 measures of wheat were shipped to Hiram in exchange for timber, while the Tyrians traded grain for wares.

An exodus from village to city ensued in which the process of the displacement of the Jewish farmer began. The state of agriculture fluctuated constantly in accordance with the policies of the Roman conquerors. The Crusader conquest wreaked further damage on local agriculture. The Jews suffered less than the Muslims at the hands of the crusaders. At the end of the 14th century, Jews expelled from France settled in Ereẓ Israel. A marked improvement in agriculture and an increase in population occurred under Ottoman rule, at the end of the 16th century. From 1882 and until today the extent of Jewish agricultural settlement has been constantly expanding [6].

The development of modern agriculture was closely tied to the Zionist movement and Jewish immigration to Palestine in the late nineteenth century. Jews who immigrated purchased land. Cultivation was based mainly in the northern coastal plains, the hills of the interior, and the upper Jordan Valley. From the beginning, Israel's farmers were either organized in well-managed and effective cooperatives (kibbutzim and moshavim) or were private farmers represented by a farmers' association. Israeli farms relied mostly on Palestinian workers up until the 1990s, when there was a crackdown on Palestinian workers' freedom to work outside the occupied territories. Then Israel began to look at other areas for workers. By 2023 there were between 30,000 to 40,000 Thai workers working in the Israeli agriculture sector. After the 7 October 2023 attacks by Hamas, many Thai nationals returned to their home country [1].

In the 19th century, the Israeli's desired to transform the land from its barren state into one for development of agricultural uses. Agriculture research began during 1870 and an agriculture station was set up in Tel Aviv in 1921. Continuous, application-oriented research, and development (R&D) has been carried out in the country since the beginning of the last century.

Following the First World War, Palestine was designated as a mandated territory to Britain to rule the country until it become ready for independence. Before Israeli independence in 1948, the territory that eventually comprised Israel went through a succession of empires, including the British, Ottoman, and Byzantine. Since independence in 1948, the total area under cultivation has increased. After its independence, the country pursued an aggressive strategy of agricultural development. The nation inherited a sophisticated system of infrastructure from Britain. In 2022,

Israel's Ministry of Agriculture and Rural Development announced a plan to increase the total number of agricultural lands cultivated. In 2023, after the October 7 attacks by Hamas on Israel many farmers faced large scale losses due to their workers being killed.

MODERN AGRICULTURE

Traditional farming methods do not actually apply in Israel. A high level of innovative technologies helps maximize the productivity of the industry with minimal resource costs. Israel is a world leader in agricultural research and development, which has led to dramatic increases in the quantity and quality of the country's crops. In 1973, two Israeli scientists, Haim Rabinowitch and Nachum Kedar, developed a variety of tomato with slower ripening. Their research led to the development of the world's first long shelf-life commercial tomato varieties. The Agritech Exhibition, held once every three years, is a leading international event to showcase Israel and international agriculture technologies. It attracts many Ministers of Agriculture, decision-makers, experts, practitioners, and thousands of visitors [1].

No other place on earth has captured the world’s heart and imagination like the ancient land of the Bible. Despite the fact that over half the country's land area is desert, Israel's agricultural output is sufficient to cover the requirements of its inhabitants. The constant growth in agricultural production is due to the close cooperation between researchers, farmers, Israeli government, and agriculture-related industries. Israel’s agriculture is a success story, reflecting a continuous struggle to overcome unfavorable local conditions. Today, smallholder farmers in Africa and Asia see Israel as the source of solutions. Figure 2 shows a typical intensive fish-farming class in Israel for professionals from 15 countries [7].

The Israeli food legislation and standardization system is largely harmonized to European standards, which may differ from those in the United States, resulting in a challenging import licensing process. Kosher certification is not a legal requirement for importing food into Israel, except for beef, poultry, and other meat products. Manufacturers who produce kosher products must satisfy Israeli rabbinical supervisors’ demands and meet kosher standards [8].

BENEFITS

Israeli farmers are an outstanding example of agricultural technology throughout the world. The most revered developments in Israeli agriculture have been drip irrigation and greenhouse utilization. Drip irrigation systems, automatic and controlled mechanization, high quality seeds and plants, and other products are exported to a host of countries in addition to the export of agricultural products [9]. Other benefits of Israeli agriculture include the following [10,11]:

- *Technology:* Israel has undertaken a tremendous agricultural transformation to become a world leader in the field. No other single country, as tiny as Israel, has contributed more breakthroughs in agriculture than Israel. Israel has developed cutting edge technologies to solve real-world issues. As a result, Israel has fortified national food security, established lucrative export markets, and revolutionized agriculture and water management on a global scale.
- *Innovation:* Since its independence in 1948, Israel has never stopped inventing agricultural technologies that greatly improve farming everywhere. Israel is a traditional hub for technological innovation. The density of startups in Israel is on par with the San Francisco Bay Area in the US; the country has a high proportion of patents per capita. Research and development comes part of the national psyche. Israeli startups are tempting investors and policymakers with a dizzying array of ideas.

- *Government Involvement:* The Ministry of Agriculture supports and supervises the activities of the nation's agricultural sector. The success of Israeli agriculture over 70 years of independence is due largely to the incredible investment in agriculture by the government. The Israeli government has held a steadfast commitment to developing the agricultural industry from day one and continues into the modern era. This has contributed immensely to the country's success. Israeli government secured a constant stream of water for its people despite the bone-dry climate.
- *Drip Irrigation:* Farming in Israel would be virtually impossible without irrigation. Irrigation is perhaps the hottest topic in Israel's agriculture technology, given the importance of water to the country as a whole. The drive to increase yields and crop quality has led to the development of new innovations such as drip irrigation, the flagship technology. Figure 3 shows a typical irrigation in Israel [11]. Netafim is the world leader in drip irrigation, offering a wide array of products and services to help farmers make the most of limited water supplies. It is an irrigation company that finds smart water solutions to obtain a sustainable future in greenhouse production. Israeli precision drip irrigation is a critical tool for farmers facing a drier, hotter world and continues to transform farming across the globe. Many farmers in India have adopted drip irrigation. Many nations like Ethiopia, Nigeria, and Ghana have benefitted from Israeli expertise in drip irrigation.
- *Greenhouses:* One of the biggest achievements of Israeli agriculture has been the ability of farmers to utilize the country's desert areas as greenhouses. Greenhouses were adopted as a growing method that has greatly increased control of the growing conditions. Figure 4 shows a typical greenhouse [12]. The Jewish National Fund (JNF) has played a critical role in the success of desert agriculture, funding the preparation of 8,000 acres a year for use.
- *Precision Agriculture:* This includes devices such as satellite imagery and drones to monitor vegetation growth and amend with precision-applied fertilizers and pesticides, a significant problem due to lack of efficiency as well as health concerns for workers. In addition to the implementation of precision agriculture and incorporating the internet of things, cloud-based farm management systems play a growing role in improving farm production within Israel.
- *Dairy Farming:* Dairy and beef herds account for 17 percent of the country's total agricultural production. Israel is considered to have one of the most efficient dairy production systems in the world, with average milk production per cow exceeding 12,000 kg. Israeli dairy farming has to factor in climatic conditions relative to grazing and forage. It also must take into consideration Jewish dietary laws that restrict how milk is obtained from cows.

CHALLENGES

Growing populations, fluctuations in worldwide markets, and climate change all pose challenges to further innovations for Israel's agriculture sector. Food security is a critical concern as the global population expands and natural resources dwindle. The geography and the climate of Israel are not naturally conducive to agriculture. More than half of the land area is desert, and lack of water resources do not favor farming. Since 60 percent of its land area is desert, plus the need for residential, commercial, industrial zones on the remaining 40 percent, agricultural land is very small. Farming in the Israeli desert continues to be the final frontier and challenge for Israeli agriculture. More than 40 percent of the country's vegetables and field crops are grown in the desert area. Figure 5 shows farming in the Israeli desert [11]. Other challenges of Israeli agriculture include the following:

- *Water shortage:* Water scarcity is a main limiting factor in Israeli agriculture. The cost of extracting water from wells is high. Precipitation has always been a life-and-death issue in Israel. Rain falls between September and April, with an uneven distribution across the country. Israel is the sixteenth most water stressed country in the world. Farmers have learned to grow more with less water, using 12% less water to grow 26% more produce. Some researchers believe that the best and cheapest solution for agriculture is desalinated seawater. Desalination has been the key to topping up urban supplies. Some refer to Israel as the Silicon Valley of water technology. IDE Technologies has constructed over 400 desalination plants worldwide, making it a global leader in the field.
- *Climate Change*: Farmers in arid areas of Israel need no convincing that the climate is changing under their feet. Summers are getting hotter. Ever since the days of Noah, floods have been devastating to humanity. Rising temperatures and accelerated desertification will put tremendous strain on the world's food and water supply. Many farmers around the world look to Israel as a model of how to manage and flourish in conditions of water scarcity and a hotter, drier climate.
- *Labor Shortage*: There is currently a shortage of about 40,000 farm laborers. This is the worst manpower crisis for agriculture in Israel's history. Hamas murdered 32 Thai farm laborers and kidnapped 23. In response to shortages in agricultural labor necessary to pick fruit crops, robots and drones are being used. Israeli companies are pioneers in the development of drones to pick fruits and other agricultural products. Figure 6 shows how robots can ease chronic labor shortages in agriculture [13]. Agriculture robots are becoming a common yet useful assistant of farmers in various works.

CONCLUSION

As typically shown in Figure 7, Israel is not a natural place for agriculture, with two-thirds of the land semi-arid and a shortage of natural water resources [9]. Israeli farmers have come a long way since the first pioneers began clearing away rock-strewn fields. Necessity has been the mother of invention. In spite of numerous challenges, Israelis have found innovative new ways to cultivate crops. Israel succeeded in transforming its agriculture sector and emerged as a world leader in agriculture and water management. As a result of the incredible achievements, many developing countries in Africa, Asia, and beyond are turning to Israel to learn from its agricultural practices. They are using the powerful lessons to transform agriculture in their countries. Although certain principles and insights are universal, each country needs to chart its own path to success based on its unique characteristics and competitive advantages. Israel is helping farmers in many nations learn how to grow crops in conditions of water scarcity and a hotter, drier climate. Figure 8 shows Israeli researcher teaching Indian farmers [14]. More information about agriculture in Israel can be found in the book in [15-20].

REFERENCES

1. S. Windland, "Sustainable horticultural crop production in Israel," https://conservancy.umn.edu/bitstream/handle/11299/57119/Israel.pdf;sequence=1
2. "Israel map," August 2017, https://www.guideoftheworld.com/israel-map.html
3. D. Abraham et al., "How Israel became a world leader in agriculture and water," September 2019, Unknown Source
4. "Agriculture in Israel," *Wikipedia*, the free encyclopedia https://en.wikipedia.org/wiki/Agriculture_in_Israel

5. L. Temper, "Creating facts on the ground: Agriculture in Israel and Palestine (1882-2000)," *Historia Agraria,* vol. 48, 2009, pp. 75-100.
6. "Agriculture in Israel: History & overview," https://www.jewishvirtuallibrary.org/history-and-overview-of-agriculture-in-israel
7. A. K. Leichman, "The top 12 ways Israel is feeding the world," September 2022, https://www.israel21c.org/the-top-12-ways-israel-feeds-the-world/
8. "Agriculture," https://www.trade.gov/country-commercial-guides/israel-agriculture
9. M. Markou and M. G. Stavri, "Market and trade policies for mediterranean agriculture: The case of fruit/vegetable and olive oil," January 2006, https://www.researchgate.net/publication/271847481_Market_and_Trade_Policies_for_Mediterranean_Agriculture_The_case_of_fruitvegetable_and_olive_oil
10. "How Israeli agriculture technology is changing the world for the better," April 2021, https://www.touchpointisrael.com/2021/04/13/how-israeli-agriculture-technology-is-changing-the-world-for-the-better/
11. "Agriculture in Israel: History and current agriculture technologies," https://aboutjewishpeople.com/agriculture-in-israel/
12. M. Wagner, "As crops wither, farmers say fields will soon be barren without foreign workers," November 2023, https://www.timesofisrael.com/as-crops-wither-farmers-say-fields-will-soon-be-barren-without-foreign-workers/
13. S. Srivastava, "Robotic agriculture will provide sustainable assistance to farmers in feeding the mouths," April 2019, https://www.analyticsinsight.net/robotic-agriculture-will-provide-sustainable-assistance-to-farmers-in-feeding-the-mouths/
14. A. K. Leichman, "Why the future of agriculture lies in Israel's desert," March 2020, https://www.israel21c.org/why-the-future-of-agriculture-lies-in-israels-desert/
15. O. Borowski, *Agriculture in Iron Age Israel*. University of Michigan, 1979.
16. H. Halperin, *Changing Patterns ii Israel Agriculture*. Routledge, 2019.
17. A. Singer, *The Soils of Israel the Soils of Israel*. Springer Berlin Heidelberg. http://doi.org/10.1007/978-3-540-71734-8, 2007.
18. R. Weitz and A. Rokach, *Agricultural Development: Planning and Implementation: Israel Case Study*. Springer Science & Business Media, 2013.
19. D. Rosen et al. (eds.), *Modern Agriculture and the Environment: Proceedings of an International Conference, held in Rehovot, Israel, 2–6 October 1994*. Springer Science & Business Media, 2012.
20. T. Hiebert, *The Yahwist's Landscape: Nature and Religion in Early Israel*. Oxford University Press, 1996.

Figure 1 The political map of Israel [2].

Figure 2 An intensive fish-farming class in Israel for professionals from 15 countries [6].

Figure 3 A typical irrigation in Israel [11].

Figure 4 A typical greenhouse in Israel [12].

Figure 5 Farming in the Israeli desert [11].

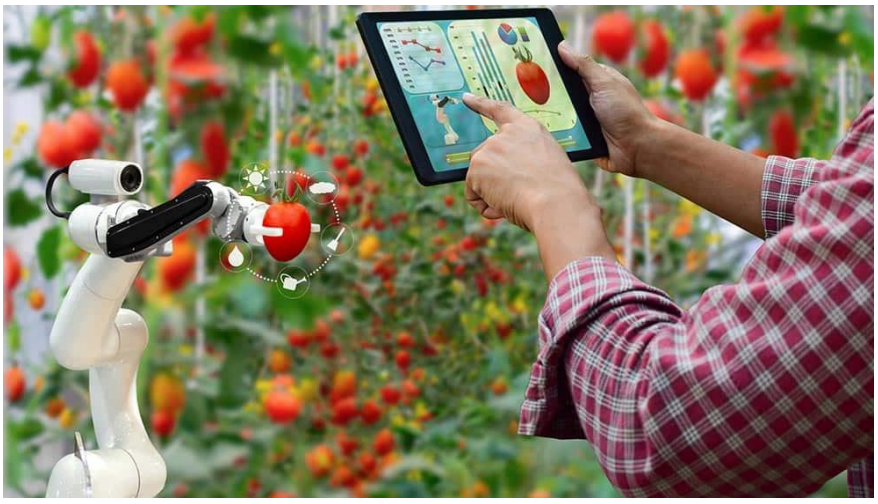

Figure 6 Robots can ease chronic labor shortages in agriculture [13].

Figure 7 Israel is not a natural place for agriculture [9].

Figure 8 Israeli researcher teaches Indian farmers [14].