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Research review paper

The history of tomato: From domestication to biopharming

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ABSTRACT

Imported from the Andean region to Europe in the 16th century, today tomato is widespread throughout the world and represents the most economically important vegetable crop worldwide. Tomato is not only traded in the fresh market but is also used in the processing industry in soups, as paste, concentrate, juice, and ketchup. It is an incredible source of important nutrients such as lycopene, β-carotene and vitamin C, which all have positive impacts on human health. Its production and consumption is increasing with population growth. In this review, we report how tomato was already domesticated by the ancient Incan and Aztec civilizations, and how it came to Europe, where its breeding history started. The development of genetic, molecular biology and plant biotechnology have opened the doors towards the modern genetic engineering of tomato. The different goals of tomato genetic engineering are presented, as well as examples of successfully engineered tomatoes in terms of resistance to biotic and abiotic stresses, and fruit quality. The development of GM tomato for biopharming is also described.

Contents

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1. Introduction to tomato

1.1. Economic importance of tomato and its botanical description

Today, tomato is not only sold fresh but also processed as paste, soup, juice, sauce, powder, concentrate or whole. Tomato is one of the most consumed vegetables in the world, after potatoes and before onions (FAOSTAT, http://faostat3.fao.org/home/index.html), and probably the most preferred garden crop. With worldwide production reaching almost 160 million tons in 2011, tomato is the seventh most important crop species after maize, rice, wheat, potatoes, soybeans and cassava. During the last 20 years, tomato production, as well as the area dedicated to its culture, has doubled (Fig. 1A). Surprisingly, whereas 20 years ago, Europe and the Americas represented the most important producers, today Asia dominates the tomato market with China ranking first, followed in decreasing order by India, USA, Turkey, Egypt, Iran, Italy, Brazil, Spain and Uzbekistan (Fig. 1B–C). Interestingly the countries harboring the highest yield are from northern Europe, where the climatic conditions are not favorable to the culture of tomato and where the area dedicated to tomato culture is very small (Table 1). It is noteworthy that these countries produce most of their tomatoes under controlled greenhouse conditions. The recent increase in tomato production responds to the increased consumption of tomatoes during the same period (Fig. 1A), reaching an average consumption of 20.5 kg/capita/year in 2009. The three countries where tomato is consumed the most are Libya, Egypt and Greece, with consumption exceeding 100 kg/capita/year. From a general point of view, it is in the Mediterranean and Arabian countries that the consumption of tomatoes is the highest with averages between 40 and 100 kg/capita/year (Table 2).

From the botanical point of view, tomato (*Solanum lycopersicum* L.) is a fruit berry, and not a vegetable. This misunderstanding was a question of debates during the 19th century in USA, with the special case of Nix vs. Hedden — 149 U.S. 304 (1893). In 1887, Nix contested the decision of the tax collector of the port of New York to recover taxes on tomatoes imported from the West Indies in the spring of 1886, which the collector assessed as a vegetable. The court opined: "Botanically speaking, tomatoes are the fruit of a vine, just as are cucumbers, squashes, beans, and peas. But in the common language of the people, […] all these are vegetables which are grown in kitchen gardens, and which, whether eaten cooked or raw, are, like potatoes, carrots, parsnips, turnips, beets, cauliflower, cabbage, celery, and lettuce, usually served at

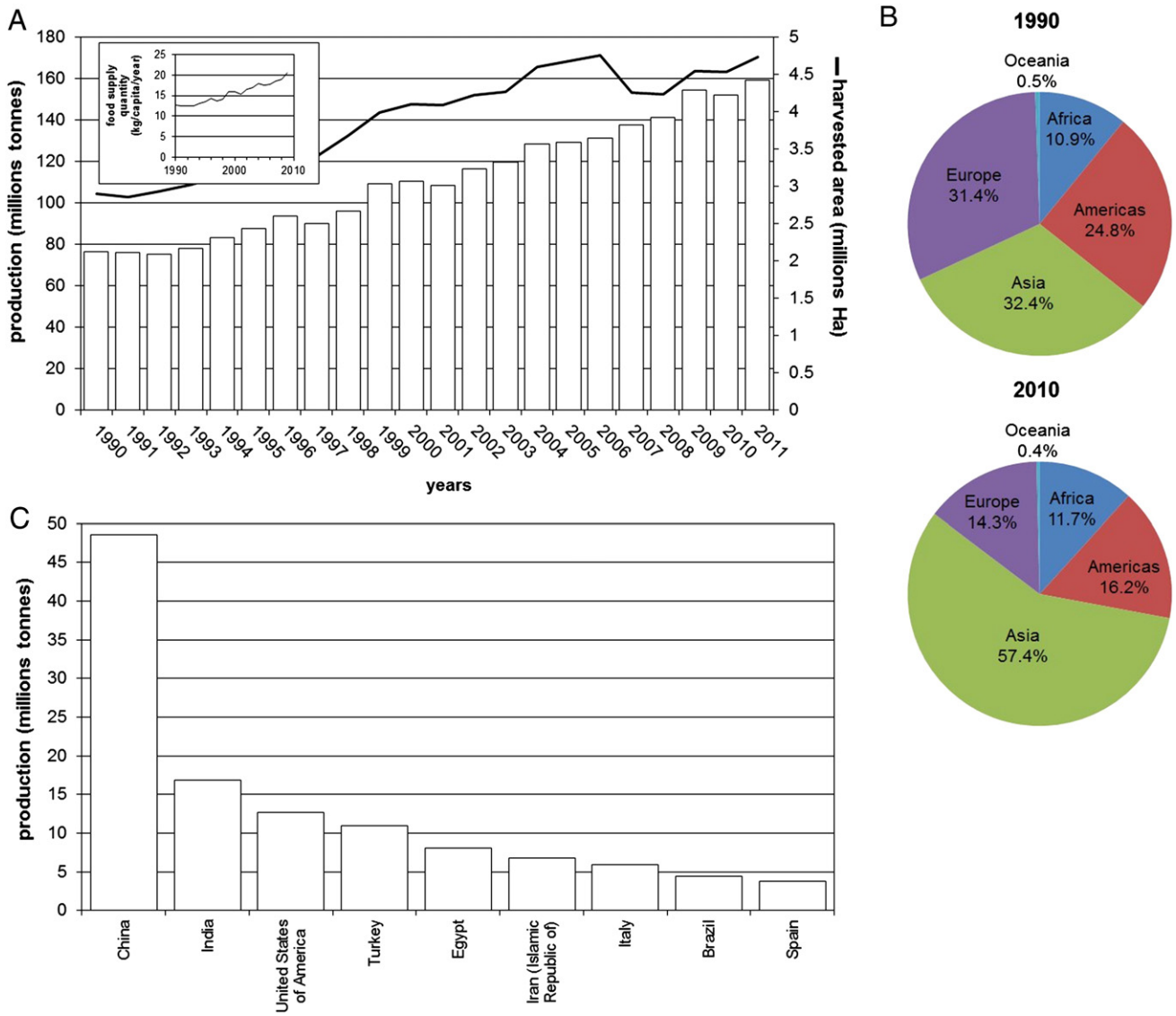

Fig. 1. Metrics of tomato production in the world. 1A— Tomato production and the area dedicated to tomato culture worldwide for the period 1990–2011 The frame depicts the increase in tomato consumption for the same period. 1B— Weight (in %) of the different continents in tomato production, comparison between 1990 and 2010. 1C— Production of the nine leading producers (source: FAO Statistics; http://faostat3.fao.org/home/index.html).