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The big five in the world of plants – the species that have changed the course of history

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Abstract. Following the big five of plant families presented by Hammer et al. (2015) an attempt was undertaken to select the big five of crop plants and genes. A large number of species (7 thousand of crops among 250 thousand of higher plants) as well as accepted criteria cause difficulties. Three cereals (wheat, rice, corn), potatoes (source of carbohydrates plus an influence on a history of three states) and soybean (main source of protein in animal feeds) were counted as plants having the greatest importance in human nutrition. Considered were also the genes, to a great extent influenced the productivity and use of those crops, making easier cropping and harvesting (genes *Rht* and *Glu* in wheat, *Sd1* in rice, resistance to herbicide in soyabean), improving grain quality (*Glu* and *Gli* in wheat and genes for beta carotene synthesis in rice) as well as resistance to pests (*Bt* in corn) and diseases (*R* in potatoes). Five species were also presented which played an outstanding role in nations, states or even continents history (cinchona, sugar cane, tee bush, cotton, cocaine bush). According to the authors' opinion as well as that of Hobhouse's (2005), Molenda's (2011), and Laws' (2016) these plants changed the course of the world's history.

Keywords: cotton, cocaine bush, cinchona, tea bush, sugar cane, soybean, wheat, rice, maize, potato

INTRODUCTION

The plants have played and continue to play a significant role in the development of civilisation and human nutrition. During the Neolithic period, the man changed from a gatherer and hunter to a farmer and embarked on the domestication and improvement of plants through selection (Nowiński, 1970). Other species were adapted and improved for cultivation (Fig. 1). It was Mendel's law, the principle of gamete purity and cross-breeding, and the assumption that the value of the progeny determines the value of parental forms for cross-breeding obtained that provided the basis for scientific plant breeding (Święcicki, Surma, 2002). Enormous progress in improvement, cultivation range, and productivity of individual species was brought by the 20th century. Using molecular biology, physics, and chemistry achievements, new breeding methods were developed to extend genetic variability by mutation and shorten the breeding cycle using *in vitro* cultures (e.g., Jain et al., 1997; Maluszynski, Szarejko, 2005). Four revolutionary transformations in agriculture – mechanisation (after World War I) and chemisation (after World War II), the so-called Green Revolution of Borlaug and the gene revolution – were of great importance for feeding the dynamically growing population (Święcicki, Surma, 2002; Maluszynski, Szarejko, 2005; Święcicki et al., 2011). Thanks to modern technologies, the production of cereals in the second half of the 20th century grew faster than the population. The process of improving crops, which lasted for thousands of years, was summed up in one sentence by Prof. Tadeusz Wolski – the creator of the first winter triticale cultivar: The progress of plant improvement is similar to a chain, whose first links disappear in the darkness of history, while the last ones reach infinity (lecture on the occasion of awarding the degree of doctor h.c., Warsaw University of Life Sciences 1998).

Nowadays, about 250,000 species of higher plants worldwide, including nearly 7,000 cultivated ones (excluding ornamentals) are described (Khoshbakht, Hammer, 2008). In the botanical classification, species belonging to more than 300 families, Hammer et al. (2015) selected the five with the highest number of species (minimum 10,000). These five most numerous families comprise more than 35% of all higher plant species and about 1/3 of cultivated ones.

This study aimed to present two groups of the most important plant species selected by the authors based on two criteria: (1) the role they have played in the history of nations and states and (2) their importance in human nutrition.

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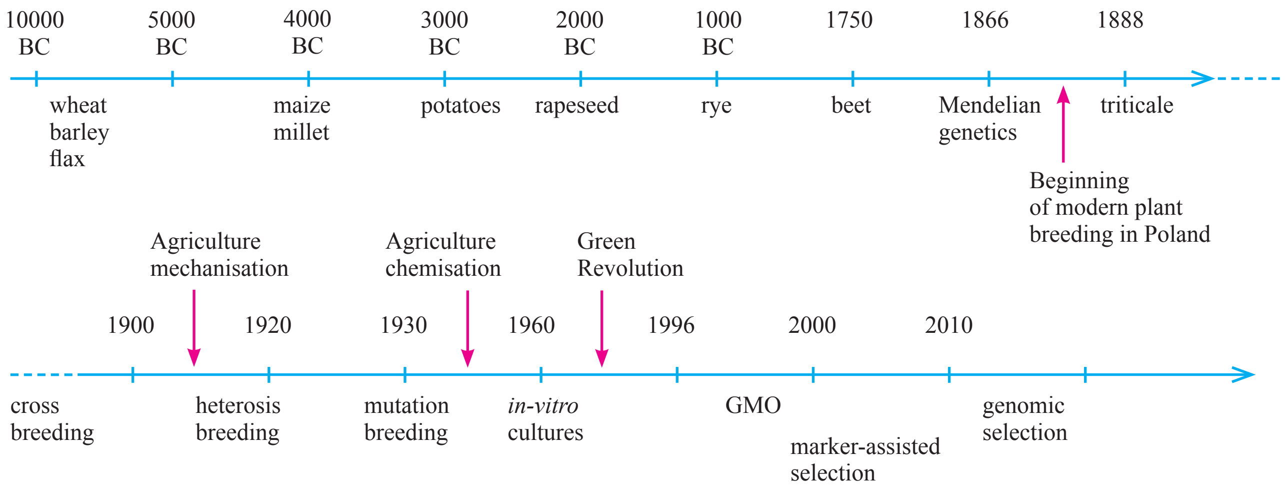

Figure 1. Introduction of new crops and breeeding methods.

MOST IMPORTANT PLANT FAMILIES

The most numerous is the family of Asteraceae (*Compositae* Giseke), containing 25 thousand species, including 265 taxa cultivated for various purposes (e.g., sunflower for oil production, vegetables – lettuce, artichoke, spices and medicinal plants, gum trees, for pesticide production, ornamental plants – chrysanthemum, gerbera, dahlia, aster, and also forest plants). The second most abundant family, comprising about 20,000 species, is Fabaceae (*Leguminosae* Juss.). The importance of species belonging to the above family results from two distinctive and essential features – the high seed protein content and the fixation on atmospheric nitrogen by root bacteria. The Leguminous family includes 81 cultivated species with a wide range of potential uses – for food (source of protein, fat, and starch), fodder, spices, rubber and fibre, and ornamental and forest plants. A similarly numerous family are the Orchidaceae (*Orchidaceae* Juss.) (about 20 thousand species), comprising 41 cultivated taxa, primarily from the genera *Dendrobium* and *Cymbidium*, but also cultivated for food (orchid tubers), beverages, fodder, spices, aphrodisiacs (*Dendrobium*), and cosmetics (*Holcoglossum falcatum*, *Dendrobium moniliforme*, *Vanilla albida*) (Oplt, Kaplicka, 1973). These species are of great economic importance; the world leader in orchid production is the USA, where the so-called “orchid industry” is developed. There are more than 13,000 species in the family of Rubiaceae (*Rubiaceae* Juss.). They are mainly trees, shrubs, and numerous pharmaceutical plants, often containing repellents. They have a wide distribution range from the polar to the tropics, with the most remarkable diversity in Madagascar and the Andes. Some species of the family Rubiaceae are used as food for humans, for the production of fodder, drinks, cosmetics, dyes, tannins, and substitute opium (*Mitragyna speciosa*). From an economic point of view, the most important species is coffee. The big five families also include grasses or Gramineae (*Gramineae* Juss., 10,000 species), the most prominent family within the monocotyledonous plants. The three subfamilies most important for a man – *Bambusoideae, Pooideae,* and *Panicoideae* – are distinguished here, and their species are used as food and fodder to produce sugar, oil, and paper, as well as vegetable and spice plants.

Among such an abundant and plentiful diversity, Hammer (1999) and Khoshbakht and Hammer (2008) singled out 38 species of importance in human and animal nutrition, medicine, industry, and the environment, while Small (2009) lists 100 of the most important species for human food and Laws (2016) described 50 plants that he believes have changed the course of history. About 200 plants are mentioned in the Bible, such as the olive, the date palm, pomegranates, the fig, the grapevine, and wheat, barley, and lentils. These are plants of economic importance and are symbols of prosperity, happiness, and divine protection. Botanists and Bible scholars have attempted to identify the species of mentioned plants to learn about the lives of the people of those times and better understand the message contained. For example, Nowiński (1970) suggests that the biblical lentil is probably not *Lens culinaris* Medik. but *Vicia ervilia* Willd., widely known as ervil, bitter vetch, or lentil vetch.

The difficulty in selecting the most important plants for humans is due to many species and the criteria adopted. Among the species that have provided man with wealth, coffee (*Coffea* sp.) occupies a leading position. The genus *Coffea* covers 225 species, including 12 cultivated species, the most important of which is *C. arabica*. The annual coffee harvest reached more than 10 million tonnes in 2019, and the yearly coffee market turnover ranged between USD 80–90 billion, ranking second in such respect only to crude oil (FAO, 2021; FAOSTAT).

Some species have played a significant role in the history of nations, states, and even continents. The awareness of their role in human history is essential. For instance, the two American continents were discovered while searching for pepper, a spice allowing us to eat meat heavily salted for preservation. Did such an ordinary circumstance cause the rise of what is now the world's greatest superpower? With a few other examples of plants, we can venture to say that they have been able to change the course of world history (Molenda, 2011; Laws, 2016), although not always in a beneficial direction.

SPECIES THAT HAVE PLAYED A PROMINENT ROLE IN THE HISTORY OF NATIONS AND STATES

Cinchona (*Cinchona* L.)

The genus *Cinchona* includes about 60 species found in tropical climates. An extract from the bark of the Cinchona containing the alkaloid quinine has proven to be an effective treatment for malaria. During the first 150 years of white man's settlement in America, the absence of quinine led to a very high mortality rate among Indians with no previous exposure to malaria. The first case of a cured patient was recorded in 1638. She was a European woman, the wife of the Viceroy of Peru, Countess Cinchon (hence the name of the tree), treated with a local specific – quinquina. The remedy was successfully applied after her return to Europe on the Countess's estate near Madrid. The Cinchona bark was also called the Jesuit bark because the Jesuit Order organised the first harvests of Cinchona in Peru, Bolivia, and Ecuador. The rapidly growing demand for quinine and, at the same time, a limited source of imported Cinchona bark has led to an interest in the possibility of growing the Cinchona tree in other parts of the world. The British were at the forefront of this endeavour, as the sharp increase in malaria in British overseas possessions was driving up the cost of importing Cinchona bark. To prevent this, research on the adaptation of Andean cultivars of Cinchona trees to growing conditions in India was carried out. It led to the production of one's own raw material, reducing the daily quinine prophylactic dose by several dozen times. The Dutch followed a similar path, and by introducing the Cinchona trees to Java, they supplied the European market and dominated the world's quinine trade in the 20th century (Hobhouse, 2005).

Quinine proved to be a natural remedy for several centuries, curing people of a deadly disease. It enabled the white man to explore the tropics, establish empires, and resettle and settle millions of people as cheap labour. Quinine also had a considerable impact on the socio-economic situation of areas where malaria was prevalent. For example:

- quinine allowed the settlement of Europeans in Indochina, Siam, and Burma, the exploitation of the Congo, Equatorial, East and West Africa, and the East Indies,
- it became possible to grow tea and rice over large areas in India,
- the domination of the black population over Caribbean indigenous peoples is the result of the genetic resistance to malaria of slaves imported from Africa,
- during the American Civil War (1861–1865), the blockade of the South by federal troops led to a shortage of quinine, an increase in disease in the Confederate army, and, significantly, to their defeat at Gettysburg (1–3 July 1863), which signalled the beginning of the end of the Civil War,
- the limited volume of imported Jesuit bark and its high price stimulated the development of research into synthetic drugs. Production of the first antimalarial drug (Pamachina) did not begin until 1926 in Germany.

Sugar cane (*Saccharum officinarum* L.)

Sugar cane originates from Polynesia. It was cultivated by the Persians and then introduced to Syria, Palestine, Egypt, Cyprus, Crete and Sicily, North Africa, and Spain. It appeared in the New World in the 18th century.

In the Middle Ages, Venice controlled the sugar trade, and the first supplies of such raw material arrived in Europe in the 14th century. Between 1690 and 1790, 12 million tonnes of sugar were imported to Europe, the production of which cost the lives of 12 million slaves. Until the 19th century, 80% of world sugar production came from sugar cane grown in the Caribbean. Between 1450 and 1900, roughly 20 million slaves (many with genetic immunity to malaria) were brought from Africa to manufacture the sugar. Consequently, the Caribbean is now dominated by black people "at the expense" of the indigenous Indians.

The competition at the beginning of the 19th century was sugar imported from India, for which the (difficult to imagine nowadays) advertisement "... made by free people" was used.

When consumed in large quantities, sugar is well known to be harmful and addictive to the consumer – it is considered the most harmful stimulant after drugs. The cost of sugar cane cultivation in the past must be morally questionable due to the slave labour of millions of people, but at present, the only (fortunately) "slaves" are the sugar consumers. It is worth mentioning that England's blockade of Europe during the Napoleonic wars caused a shortage of sugar, which consequently resulted in creating a new crop, the sugar beet. The first sugar factory from the beet plant was established in Częstocice (Poland) in 1827 (Święcicki, Surma, 2002; Hobhouse, 2005).

Tea bush (*Camellia sinensis* (L.) Kuntze)

Tea is a distinct species or cultivars of one species – Chinese tea (*Camellia sinensis*). It is grown in the intertropical zone, mainly in South and Southeast Asia, humid and warm.

China is the home country of tea. It began to be imported to Europe in the 16th century: shipments arrived in Lisbon from 1580, Amsterdam from 1606, and London from 1652. Although tea was brought from China to Europe in ever-increasing quantities – from 50 tonnes in 1700 to 15,000 tonnes in 1800 – for almost two hundred years (until 1830), the way it was produced: the cultivation method, the processing, and the blending were unknown outside China. The dissemination of tea technology in other countries accelerated the decline of China's prominence, which in the pre-industrial era was several centuries ahead of Europe in terms of technical progress (Temple, 1994).

Tea became the most widely consumed non-alcoholic beverage in Europe from the early eighteenth century. Along with coffee and cocoa, it revolutionised mores, brought about changes in social life both at home and in pubs, as a stimulating but alcohol-free drink and safe because it was brewed with boiled water.

The custom of drinking tea also contributed to the development of porcelain production – the tea kettle and the cup with ears, for example, are a European idea.

Tea played a significant role in America's war for independence. After the English imposed a tariff on imported tea, Americans in Boston harbour dumped the entire cargo of tea from their ships into the water. This incident was one of the causes triggering the American Revolution and consequently led to the adoption of the United States Declaration of Independence on 4 July 1776.

China was considered the leading supplier of tea to Europe between the 16th and 19th centuries. During that period, it was a highly developed country, self-sufficient in producing food and other necessities of life. In the tea trade with Europeans, the Chinese only considered silver, gold, and copper. Opium, the production and smoking banned in China since 1729, was also a desirable commodity in a trade settlement. The opium trade was controlled by the British, who produced poppies and processed them in their colony in India. Thus, the demand for the mild stimulant – tea, increased the demand for silver as a means of payment and, in turn, the high price and scarcity of silver led to a substitute means of payment, opium. In the second half of the 19th-century, opium was the scourge of Chinese society. The Chinese government started to fight against the opium trade by burning its stocks in the Guangzhou harbour, leading to a conflict with the British and the so-called Opium War in 1839–1842. The above circumstances became the beginning of the collapse of the central authority in China, its economy, culture, and civilisation.

Tea has also significantly influenced the economy of India. 1840 is considered to be the beginning of its cultivation and export in India. Currently, China and India are the world's largest producers of tea (FAO, 2021; FAOSTAT).

Cotton (*Gossypium* L.)

The genus *Gossypium* consists of approximately 30 annual and perennial species, easily crossing with each other. Various species of cotton were planted in South America and India several thousand years ago. Around 900, cotton began to be cultivated in Spain and in the 13th–14th centuries in China and Japan. Certain wild species found in South America reached the West Indies and then North America – Virginia, Georgia, and North and South Carolina, where they were previously unknown. Before the 19th century, cotton was imported to Europe from Brazil, the Middle East, India, Egypt, and Africa.

Cotton cultivation and trade have made an undelible mark upon the history of the United States. Until the Civil War, cotton was the most important export commodity, exceeding the exports of all other items in value. Cotton cultivation was linked to the history of slavery in the American South – it probably prolonged its duration. Cotton growers made very high profits; however, this required a large amount of cheap labour, which was due to the particular labour intensity of cotton processing – 26–31 person-days were needed to produce 1 kg of cotton thread, compared to 2–15 for wool yarn, 4.5–15 for flax and 6 person-days for silk. Slaves, either imported or purchased, were exploited to grow cotton and produce cotton thread and became the planters' property. Slavery caused the outbreak of the Civil War (1861–1865), the most significant armed conflict between the Napoleonic Wars and World War I. However, the ultimate effect was positive – it led to the formation of the American nation and the rise of the world's greatest superpower (Hobhouse, 2005).

Cocaine bush (*Erythroxylum coca* Lam.)

The cocaine bush, also known as *Erythroxylum coca*, is believed to have originated from the Andes region. Today, the central growing areas are South America, Java, and Cameroon. Two products from the Cocaine bush have made a worldwide career – a drug and a refreshing drink. The life span of the shrub is at least 20 years. The leaves are harvested three times a year – a total of about 2 tonnes can be obtained from 1 ha. As the alkaloid content is about 1% of the dry weight of the leaves, on average from 1 ha, several kilograms of powdered cocaine can be obtained (even with primitive purification technology), whose value (on the streets of American cities) reaches 2.5 million dollars. The illegal production of cocaine in Bolivia, Ecuador, Peru, and Colombia probably accounts for around one-third of GDP.

Erythroxylum coca leaves played a significant role in the lives of the Andean Indians, especially those living at high altitudes. In 100 g of leaves, there is 2000 mg of calcium, 400 mg of phosphorus, 10 mg of iron, vitamins B1, B2, A, E, C as well as potassium, copper, and zinc, thus chewing the leaves gave a better performance in conditions of oxygen deficiency, reduced the feeling of hunger, increased mental and physical efficiency. In the Inca culture, the coca leaves were only accessible for the privileged people, which gave them an advantage over the poor, who had no access to cocaine plants. After the Spanish conquest of South America, the colonisers exploited the Indians' addiction to coca, putting them in forced labour in the mines. In mines located at an altitude of over 5,000 metres in the Peruvian Andes, miners chew coca leaves to provide themselves with energy to work, although unfortunately, their life expectancy is only 30–35 years on average (Hobhouse, 2005).

The stimulant effect of the alkaloids from *Erythroxylum coca* leaves also had less drastic effects. At the beginning of the 20th century, about 2–4% additions of cocaine to "medicines" in England and the United States were supposed to stimulate productivity, treat melancholy, depressive states, cure smokers and alcoholics. The leaves also served as an additive to drinks, cigarettes, and chewing gum for toothaches. At the turn of the 19th and 20th centuries, cocaine was recognised as a substance that enhanced physical and mental performance. During this period, "Mariani wine" became popular in Europe – *Erythroxylum coca* leaves soaked for 6 months in red wine brought its creator, the Corsican Angelo Mariani, great fame and recognition. Also noteworthy was John Pemberton, an Atlanta pharmacist, and creator of Coca-Cola. The invention was prompted by the ban on the sale of alcohol in the United States (1885), resulting in a search for a stimulating, non-alcoholic drink. The detailed recipe, including proportions, is unknown, yet the main ingredients are sugar, caramel, caffeine, *Erythroxylum coca* leaves extract, fig tree juice, cinnamon, nutmeg, vanilla, glycerine, and ground kola nuts. Having no mercantile sense, Pemberton sold his product to another pharmacist, Asa Candler, who made a fortune of tens of millions of dollars in the late 1920s (Hobhouse, 2005). Today the Coca-Cola Group and its beverage are recognised all over the world.

PLANT SPECIES IMPORTANT IN HUMAN NUTRITION

Khoshbakht and Hammer (2008) have undertaken an attempt to identify 38 species of importance in human and animal nutrition, medicine, industry, and the environment. The species included wheat, rice, maize, oats and millet, soybean, sunflower, beet and potato, peas and beans, but also onion, citrus, coffee and cocoa, and cassava. Small (2009), on the other hand, lists 100 of the most important species for human nutrition. Taking into account additionally the size of the sown area and certain events in the history of their cultivation and use, the authors of this study recommended the number of the five most important species (Table 1). Attention has also been paid to genes that have significantly contributed to plant productivity and use, facilitating cultivation and harvesting, improving seed quality or resistance to pests and diseases.

Table 1. Cultivated area and production of selected crops in 2019 (based on FAOSTAT data).

Family/species		Area [mln ha]	Production [mln t]
Gramineae Juss.			
Triticum spp.	Wheat	216	765
Zea mays L.	Maize	196	1141
Oryza spp.	Rice	162	749
Leguminosae Juss.			
Glycine max (L.) Merr.	Soybean	122	336
Solanaceae Juss.			
Solanum tuberosum L.	Potato	16	355

Wheat (*Triticum* sp. L.)

The oldest historical evidence of the *Triticum dicoccum* and *Triticum durum* species cultivation comes from the Middle East from more than 7000 BC. Later on, common wheat (*Triticum aestivum* subsp. *vulgare*) began to be cultivated. In Europe, wheat appeared in the Neolithic, around 5000 BC, and in Poland, *T. dicoccum* was produced as early as 2000–1000 BC. It is assumed that diploid wheat (*T. monococcum*) is the ancestor of common wheat, hexaploid, originating from the Central Asian region (India, Afghanistan, Persia) due to crosses between *T. monococcum* or *T. beoticum* and *Aegilops* ssp. (Nawracała, 2004).

Wheat is ranked first in the world among cereals in the cultivated area (over 215 million ha in 2019, in Poland about 2.5 million ha) (Statistical Yearbook..., 2020). Annual grain production in the world in 2019 amounted to 765 million tonnes (China – 133 million tonnes, India – 104 million tonnes, USA – 52 million tonnes, and Russia – 74 million tonnes), with highly variable yield levels ranging from 0.31 t ha^{-1} in Venezuela to 9.86 t ha^{-1} in Ireland (FAO, 2021; FAOSTAT). The world record in wheat yield was achieved in 2020 in New Zealand – 17.398 t ha^{-1} (https://www.fwi.co.uk).

Wheat is used in the diet of about 35% of the world's human population. The improvement of wheat cultivars as a basic bread cereal was particularly dynamic in the second half of the 20th century. World average yields in 1400 were 5 q ha^{-1} and in 1900 14 q ha^{-1}, while another tripling of yields – from 25 q ha^{-1} to 75 q ha^{-1} – was achieved in just 50 years – 1950–2000 (Święcicki, Surma, 2002). This was partly due to the introduction of semi-dwarfing genes from the *Rht* group into cultivars, especially *Rht1* and *Rht2* genes, causing shortening of internodes without negative changes in the ear. The breeding and introduction of such cultivars in India and

Pakistan eradicated famine and was called the Green Revolution, and their author, Dr. Norman Borlaug, was awarded the Nobel Peace Prize in 1970. A total of 13 mutations of the *Rht* gene with different effects on plant morphology were described, of which *Rht11* and *Rht14* were used to breed durum wheat (Maluszynski, Szarejko, 2005).

Wheat grain is predominantly used for baking bread, constituting, next to potatoes, the main component of food in many countries of the world. Depending on the cultivar and growing conditions, it contains about 60–70% of carbohydrates, several percent of protein, about 2% of fat, and a relatively high content of mineral components, especially potassium, phosphorus, and magnesium (Nawracała, 2004). The quality of bread depends on the composition of grain reserve proteins, especially glutenins and gliadins, which together with water form gluten. The baking value of flour is decisively influenced (of course not taking into account the food enhancers added to flour) by high molecular weight glutenin proteins (HMW), encoded by genes at the *Glu-1* loci, located in chromosomes of the first homeologous group of all three wheat genomes (*GluA-1, GluB-1, GluD-1*) (Salmanowicz et al., 2008; Surma et al., 2012). Among the many alleles of these genes (about 200), some encode particularly beneficial, from the gluten quality point of view, HMW protein subunits. The baking value of flour also depends on the composition of gliadin protein subunits encoded by genes located in the first and sixth homeologous groups (*Gli*-loci). Roughly 170 alleles are known, and this number is constantly on the rise.

Gliadin protein subunits are implicated in gluten intolerance, which affects approximately 1% of people. A genetic gastrointestinal disease caused by gluten allergy is celiac disease, leading to anaemia, osteoporosis, depression, and infertility (Bartosik, 2013). Research on gliadin proteins modification, using the latest technologies (e.g. CRISPR/Cas) to such an extent that they do not cause disease but retain the baking properties of wheat grain are under development. Sources of "good" gliadins in nature are also being sought (Grunewald, Bury, 2014).

Rice (*Oryza sativa* L.)

Rice was domesticated 13 500–8 200 years ago in China. The species arrived in Europe (Greece) at the time of Alexander the Great and on the American continents by the colonisers (Sharma, 2010).

The currently cultivated cultivars are divided into four functional types – japonica, indica, aus, and basmati, differing in colour, grain thickness and length, stickiness (when cooked), and adaptation to specific environmental conditions. For instance, the japonica type, grown mainly in Japan and Korea, produces a round, coarse and glutinous grain, while the basmati type, grown in India and Pakistan, yields a long-grain, white or brown, with a characteristic aroma (GRiSP, 2013).

Rice is the staple food for about a third of the world's population. In terms of global cultivated area (it ranks third among cereals, with an annual harvest of 750 million tonnes in 2019, 95% of which was for food (FAO, 2021; FAOSTAT). Rice grain, partially hulled, contains about 8% protein and 30% carbohydrates and is also a thiamine, niacin, and riboflavin source. A severe vitamin A deficiency has occurred in countries where rice is a staple food, resulting in the death of hundreds of thousands of children under the age of five. Using GMO techniques, a variety of „Golden Rice" capable of biosynthesising beta-carotene, a precursor of vitamin A, has been developed. Three genes responsible for the production of beta-carotene in the endosperm were introduced into the breeding materials, and subsequently, in 2005, the cultivar „Golden Rice 2" was bred with 23 times higher beta-carotene content (Dubock, 2019).

During the Green Revolution, associated primarily with the breeding and use of dwarf wheat, so-called miracle rice was bred, characterised by increased productivity and a shortened, strong stem. The shortened stem length resulted from a mutation at the *sd1* locus, which Rutger (1992) called the „mystique gene." Plants with the gene mentioned above show an insensitivity to photoperiod and exhibit better fertiliser utilisation. A spontaneous rice semi-dwarf mutation was also selected in the WG cultivar (indica type) in the late 1950s, and the derived Japanese cultivar Jikkoku is still a popular semi-dwarf donor in breeding today. In India, short-stemmed cultivars were widely cultivated in the 1960s, which increased the production of rice but also resulted in a considerable narrowing of the species' biodiversity. Suffice it to mention that initially, about 110,000 populations of indigenous rice were grown in India, which were both nutrient-rich and resistant to environmental stresses. The Green Revolution led to about 90% disappearance of these populations from cultivated fields (Sharma, 2010).

The rice genome (2n=12, genome size – 430 Mbp) was sequenced between 1997 and 2004, making the species one of the few among higher plants considered a model for genetic engineering. Approximately 37 544 genes have been identified, and the sequencing information and the described genes are being used to study other cereal plants (e.g., maize, wheat, barley) (Sasaki, Antonio, 2004).

Maize (*Zea mays* L.)

Maize has been cultivated for about 10,000 years. It originated in Mexico, and according to Mayan legends, the man was fashioned from corn flour. The species was brought to Europe with Columbus's expedition in 1493 – first, it went to Spain and Portugal, and then to Asia and Africa. In Poland, maize appeared in the 18th century, brought from Romania or Hungary. Nowadays, due to its adaptation to various environmental conditions, the crop is widely cultivated. It is grown, for example, on the American continents from southern Argentina and Chile to Canada (Arseniuk, Oleksiak, 2017).

The *Zea mays* species' progenitor is probably the Mexican teosinte grass, belonging to the *Zea* genus (*Zea mexicana* = *Euchlaena luxurians* = *E. mexicana*). It is the most closely related species to the present-day maize. The teosinte phenotype is different from maize, although genetically, the two plants differ only slightly (De Wet et al., 1971). This is a not uncommon example where minor, even single-gene modifications in the genetic material induce considerable differences in the phenotype, e.g. the *fil* gene in *Pisum* (Święcicki, 2019).

The valuable components of maize grain are magnesium and iron: 100 g of grain meets one-third of the daily human requirement for Mg and one-fifth for Fe, while it contains small amounts of niacin – vitamin B3. A diet exclusively based on maize may lead to a deficiency of this vitamin and consequently trigger pelagic fever (Michalski, 2006).

At present, maize has an extensive range of applications in human and animal nutrition and the production of alcohol, bioethanol, and biogas. The agricultural cultivars of maize adapted to different uses are divided into several groups: amylacea, everta (cracking), indentata (horse's tooth), indurata (hard – fodder, flour, groats), and saccharata (sugar – frozen, canned) (Adamczyk, 2017; Arseniuk, Oleksiak, 2017). Given the importance of the species and the range of cultivation, the genetic modification of maize deserves attention, involving the introduction of the *Bt* gene from the bacterium *Bacillus thuringiensis*, responsible for the production of a plant protein toxic to two pests – the European corn borer and the corn rootworm (Bravo et al., 2007; Sears et al., 2001).

There are approximately 220 maize cultivars registered in Poland, mainly single-cross- and three-component hybrids. The area under maize for grain is between 600–700 thousand ha. The harvest in 2019 was over 4 million tonnes (Statistical Yearbook..., 2020). Of the roughly 200 million ha under cultivation globally, over 1140 million tonnes of maize grain were harvested in 2019, including more than 40% from the US area (FAO, 2021; FAOSTAT).

Potato (*Solanum tuberosum* L.)

The potato is clearly behind the three cereal species discussed above regarding cultivated area and production volume. It is considered one of the essential components of the human diet. Its tubers, apart from starch constituting several percent of its fresh weight, contain large amounts of mineral components (0.5–2% of tuber weight), mainly potassium and magnesium, as well as vitamins A, B1, B2, B6, D, E, H, PP, and C. The potato is cultivated on approx. 500,000 ha in Poland, and the annual harvest reaches 9 million tonnes (Statistical Yearbook..., 2020). Apart from its prominent role in nutrition, the potato has contributed to a demographic explosion, changed the future of two European countries (England and Ireland) and the USA population composition, the largest, richest and most important former colony (Hobhouse, 2005). Here in Poland, there is a monument to the potato (9 m high) in Biesiekierz near Koszalin.

The potato's homeland lies in South America – the high, cold Andes mountains (5,000 metres above sea level) and warm central Chile. Of the approximately 200 species of the genus *Solanum*, *S. brevicaule* was the initial species in cultivation and has been known in Peru for about 7–10 thousand years. It is assumed that the potato took two routes to Europe – from Peru to Spain (*S. tuberosum* subsp. *andigenum*) and from Chile to England (*S. tuberosum* subsp. *tuberosum*), and from England to North America. The potato then appeared in Germany and Prussia (Birecki, 1958).

The potato first arrived in Poland in 1683 with King Sobieski's army returning from Vienna but did not gain importance until after the Great Famine of 1816. The potato played a significant role in Ireland, where the environmental and social conditions of primitive agriculture were more conducive to growing a less demanding root crop than cereal species. The potato enabled the rapidly increasing population of Ireland to be fed at the turn of the 18th and 19th centuries (Birecki, 1958). Unfortunately, potato cultivation in monoculture resulted in the development of the bacterial disease – blackleg and fungal one – potato blight, consequently causing famine (1845–1847), in which about 1 million people died and 1.5 million Irish emigrated to America (Birecki, 1958). A total of almost 5.5 million people emigrated from Ireland by the outbreak of the First World War, fundamentally affecting the history of Britain and the USA. The WASP (White Anglo-Saxon Protestants) dominated the United States until the mid-19th century. The Catholic Irish gradually formed an increasingly large, dense community in certain cities (e.g., New York, Boston), comprising about 30% of the population. The Irish were characterised by hostility to British imperialism, resulting in the delayed entry of the United States into the world wars. Here the circumstances for an alternative history arise. What would the world look like without the emigration of the Irish caused by the potato blight? During the Irish famine, the United States and the United Kingdom shared a similar population (about 20 million). Presumably, the economic achievements of the two countries would not have been so different and, as Hobhouse (2005) argues, the United States would have been a less exciting country, New York a much less attractive city, and how would both world wars have gone?

As a natural consequence of the potato blight and blackleg epidemics, intensive genetic and breeding research has been carried out since the beginning of the 20th century to identify the sources of resistance and transfer it to cultivated cultivars. The difficulties are encountered in moving resistance genes from wild species, varying in ploidy from cultivated breeding materials. Among 200 species of the genus *Solanum*, resistance genes have been found in 35. *R* genes found in *S. demissum* (11 major genes), *S. berthaultii, S. bulbocastanum, S. mochiquense, S. phureja, S. pinnatisectum*, and *S. tuberosum* are applied in breeding (Śliwka et al., 2006). However, it has to be kept in mind that the transfer of resistance genes from wild potato species is a prolonged process. For instance, it took 40 years to breed the Hungarian cultivar Sarpo Mira with five resistance genes.

Furthermore, the acquired resistance is frequently "broken" by a rapidly changing pathogen (Świeżyński, Zimnoch-Guzowska, 2001). Therefore, the genetic modification method for transferring resistance genes to potato blight is more effective than traditional crossing with wild species. On the other hand, vegetative propagation through tubers is beneficial from the perspective of the anti-GMO sentiment, as it eliminates the risk of genetically altered pollen "escaping" into the environment. Several companies have launched programmes to breed blight-resistant potatoes. BASF bred the Fortuna cultivar with a resistance gene from *S. bulbacastanum*, and the John Innes Centre in Norwich and Sainsbury Laboratory have introduced a resistance gene from the wild species into the Desiree cultivar. Breeding potato blight-resistant cultivars not only prevents yield reductions but allows the number of fungicide sprays to be reduced from a dozen to 2–3 (Grunewald, Bury, 2014).

Soybean (*Glycine max* (L.) Merr.)

The genus *Glycine* Willd., belonging to the Fabaceae family (*Leguminosae* Juss.), is divided into two subgenera: *Glycine* and *Soja*. The subgenus *Glycine* includes 24 perennial species endemic to Australia. Two species are classified in the subgenus *Soja*: *Glycine soja* Sieb and Zucc (wild forms) and *Glycine max* (L.) Merr. (cultivated varieties). The first written sources mention soybeans occurring in China as early as 2838 BC. It is believed that soya, together with rice, wheat, barley, and millet, contributed to the survival of Chinese civilisation. Northeastern China is considered the primary centre of origin for soybeans. In our era, soy spread to central and southern China and the Korean peninsula, and Japan. By the 15th century, soybeans had reached the Philippines, Indonesia, Vietnam, Thailand, Burma, and Nepal – these areas are thought to be the site of secondary dispersal of the species (Miladinovic et al., 2011).

Soybean is distinguished by its high seed fat and protein content and ability to fix atmospheric nitrogen by root bacteria, thus not requiring mineral nitrogen fertilisation. The seeds are not suitable for direct feeding since trypsin inhibitors limit protein absorption. On the other hand, the soya meal produced after oil extraction, deprived of these anti-nutritional compounds, contains over 40% of protein with an amino acid composition similar to egg protein. At the beginning of the 20th century, it was still a little-known plant, but it was already cultivated on 15 million hectares by the middle of that century. As a result of the Bovine Spongiform Encephalopathy (BSE) epidemic in the early 1990s, the ban on meat and bone meal in animal nutrition introduced in many countries, including Poland, made post-extraction soybean meal the primary source of protein for poultry and pigs. The market value of soybean meal is approximately 60 billion USD, which is about three times the main product's value – soybean oil (Święcicki et al., 2020). Soya is grown on 122 million hectares, 70% of which is in the USA, Brazil, and Argentina (FAO, 2021; FAOSTAT). These three countries are also the leading exporters of soybean meal. Considering that China imports more than 66% of the world's soybean seed production, the availability of soybean meal for feed determines food security for poultry and pork production. This is even more so as demand is likely to increase in the future due to population and wealth growth, especially in developing countries. For instance, poultry meat's annual per capita consumption is 50 kg in the USA, 28 kg in Russia, 16 kg in Korea, and 1.8 kg in the Democratic Republic of Korea (FAO, 2021).

In cultivating dicotyledonous crops, especially distinguished – like soybean – by slow initial growth and late maturation, weed development is a severe problem, limiting yield and making harvesting difficult. Selective herbicides are essential for their control (Grunewald, Bury, 2014). A significant achievement in the case of soybeans, which are grown worldwide on 122 million ha, was the genetic modification providing resistance to glyphosate, the active ingredient in the herbicide Roundup. In 1996, Monsanto produced the GM soybean cultivar "Roundup Ready", covering about 90% of the cultivated area in the USA, followed by the cultivar "Roundup Ready 2", additionally yielding higher by 7–11%. The above achievement has significantly enabled the supply of the main protein component of feed, securing world production of poultry and pork meat. The accomplishment can also be looked at from another angle. A considerable proportion of consumers, particularly in Europe, are averse to genetically modified plants. Meanwhile, feeding animals with soybean meal from GM plants, additionally sprayed with an herbicide whose active substance accumulates in the human body and has carcinogenic effects, is accepted (Pieniążek et al., 2004; Kwiatkowska et al., 2013).

CONCLUSION

The difficulty in selecting the most important plants is due to a large number of species and the criteria adopted. Two measures were established, seemingly the most important for human beings regarding their importance in food and their influence on forming societies, nations, and states. The most important genes are hard to select due to their number, even approximate (7,000 cultivated species x 5,000 genes/species). Indeed, the genes or groups of genes whose expression in grown cultivars has significantly increased the prolificacy and use of the five most important species for human nutrition deserve to be highlighted. The authors included additional critical genes determining the grain quality of wheat and rice in this group.

The hallmark of science today is its dynamic progress and ever-narrower specialisation, additionally stimulated by the pursuit of publishing research results in "high-scoring" journals. More and more sophisticated techniques are implemented without a broad view of the research material – its significance, history, and future place in human life. A crisis in agricultural production is predicted to occur shortly due to the overlap of climate change, international trade, and human migration (Hammer et al., 2015). In Italy, for instance, plants unknown to the local population even 10 years ago are present in the fields and trade. For several thousand years, humans have subjugated the plant world, primarily to satisfy hunger. The application of science to improve plants has made it possible to feed a rapidly growing population since the mid-19th century without expanding the area under cultivation (Święcicki, Surma, 2002). And here, the selection of the Big Five most essential plants and traits/genes that dramatically increased yields and their quality – is relatively straightforward. The first group of examples given allows us to look at the plants' world differently. Plants were necessary for man, as more or less harmful stimulants, making clothes, or as invaluable medicine. It turns out that the improvement of these plants and related processing technologies as well as global trade played an essential role in the history of nations and states, including influencing the outcome of wars, not only commercial but also military ones. It is worth considering a holistic view of the plants' world, as they have played an indispensable role in human life, not always a noble one, but certainly an exciting one.

The paper does not describe exhaustively the plant species discussed. Much information is likely to be found on the Internet. While a good browser will throw up thousands of entries on a given topic, however, Hobhouse (2005) notes that not all such entries are reliable or noteworthy, and serious students or scholars will have to travel a long way to make their selections. By the time the truth-seeker reaches what appears to be the end of the road, numerous new buzzwords will force him to resume the unfinished pursuit of the unattainable. Therefore, it is advisable to refer to source publications. In our case, we have drawn heavily from Hobhouse (2005), Molenda (2011), and Laws (2016), which, in turn drew on a vast range of literature from the eighteenth to the twentieth centuries.

To sum up, one can paraphrase Winston Churchill's statement concerning plants that *never was so much owed by so many to so few.*

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