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A GLOBAL COMPARATIVE STUDY OF POTATO VARIETIES: DIVERSITY, TRAITS AND PERFORMANCE

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Abstract

The potato is the most important non-cereal food crop in the world. In Albania, there is no official data on the introduction of the potato, but, according to specialists in the field, it began to be cultivated after 1850. Today, in Albania, potato production is estimated at around 245,000 tons per year. Compared to the region, Albania leaves behind Macedonia, Kosovo, and Montenegro. Foreign cultivars are cultivated in Albania; there are no farmer's cultivars here. The Albanian Genetic Bank has the task of preserving and advising farmers to cultivate the best cultivars that give high yields and quality products for use in the kitchen. This study also serves this purpose, through which 13 potato cultivars were studied, which showed variation for all morphological characteristics and for quantitative characteristics.

Keywords*: potato, Solanum tuberosum, genotype, accession, descriptor, variation.*

INTRODUCTION

The potato (Solanum tuberosum L.) is a tuber-forming plant with high starch content and belongs to the Solanaceae family. It is the most important non-cereal food crop in the world, ranking 3rd in terms of total production, with over 365 million tons per year (FAOSTAT, 2013) which ranks after rice and wheat [4]. There are about 5,000 potato varieties worldwide and about 200 wild species and subspecies, many of which can be crossed with cultivated varieties. The main species cultivated worldwide is Solanum tuberosum (tetraploid plant with 48 chromosomes), and modern varieties of this species are the most cultivated [8]. The potato is ranked among the most important field plants for high production capabilities. It also has high agronomic values because it occupies an important place in crop rotation schemes, especially with cereals, because it leaves the soil clean of weeds, friable and with enough reserves of nutrients. According to the United States Department of Agriculture, a typical raw potato consists of 79% water, 17% carbohydrates (88% of carbohydrates are starch), 2% protein, and negligible amounts of fat. a 100-gram serving, the raw potato provides 322 kilojoules (77 kilocalories) of food energy and is a rich source of vitamin B6 and vitamin C (23% and 24% of the daily value, respectively). When potato ripens, the

content of vitamin B6 and vitamin C drops significantly, while there is little significant change in the amount of other nutrients (Rashed et al., 2025). Potato tubers are quite rich in B group vitamins but they also have other vitamins ions such as vitamins A, D, H, K, etc. Compared to cereals, tubers are inherently more productive. If the fruit of wheat (wheat spike) or rice (panicles) plant grows too large, the plant will topple over, with fatal results. Growing underground, the tubers are not limited by the rest of the plant. In 2008, a Lebanese farmer produced a potato weighing about 11.34 kg. It was bigger than his head (Hossen & Pauzi, 2025). Wild potato species, native to present-day Peru, can be found throughout the Americas, from Canada to southern Chile. It was originally believed that the potato was domesticated by Native Americans independently in many places, but later genetic testing of the wide variation of cultivars and wild species found a single origin for the potato, in the area of present-day southern Peru and Bolivia extreme northwest and that has been domesticated by pre-Columbian farmers, around Lake Titicaca (Hossen & Pauzi, 2025). Potatoes were domesticated approximately 7,000–10,000 years ago there, from a species in the *Solanum brevicaule* complex. In the Andean region of South America, where the species is indigenous, several close relatives of the potato are cultivated (Alam et al., 2025).

Potato is cultivated in about 150 countries in both regions, in temperate and tropical climates, and at altitudes from sea level to 4,000 m (Paul et al. 2012). More than half of potato production is produced in developing countries, including India, and over a billion people have potatoes as their staple diet. It has spread steadily worldwide, with a 35% increase in total production since 1960. Production growth is even higher in the developing countries of Asia and Africa, reflecting its growing importance as a resource basic food (Mohd Pauzi & Shahadat Hossen, 2025) . *The spread of the potato in the world has its own history, which was influenced by prejudices related to the fact that the nutritional values and benefits were not known; its poisonous properties were suspected. If we take into account the periods of spread of the potato and the lack of scientific studies, the attitude towards the potato was justified. Prejudice about the potato is related to botanical knowledge and historical events of the time.*

Potatoes contain toxic compounds known as *glycoalkaloids*, the most common of which are *solanine* and *chakonine*. These compounds, which protect the potato plant from its predators, are generally concentrated in its leaves, flowers, shoots and fruits (as opposed to tubers). In a review of several studies, glycoalkaloid content was highest in flowers and shoots and lowest in tuber pulp. Exposure to light, physical damage and age increase the content of glycoalkaloids in tubers. Cooking at high temperatures, above 170°C, partially destroys these ingredients. The concentration of glycoalkaloids in wild potatoes is sufficient to produce toxic effects in humans. However, poisoning from cultivated potato varieties is very rare.

The potato was introduced to Europe from America in the second half of the 16th century by the Spanish. Today they are a staple food in many parts of the world and an integral part of most of the world's food supply. As of 2014, potatoes were the fourth largest food crop in the world after maize (maize), wheat and rice. After millennia of genetic improvement, there are now over 5,000 different types of potatoes. Over 99% of potatoes currently cultivated worldwide are descended from varieties that originated in the lowlands of south-central Chile. The importance of the potato as a food source and as a culinary ingredient varies by region. It remains an important crop in Europe, especially in Northern and Eastern Europe, where per capita production is still the highest in the world, while the most rapid expansion of production in recent decades has occurred in South and East Asia, with China and India lead the world in total production as of 2018 [8].

Perhaps the historical event related to the tomato poisoning of some Italian nobles has influenced the prejudice that the potato is poisonous. A nickname for the fruit was "*poison apple*" because it was thought that aristocrats got sick and died after eating tomatoes, but the truth was that wealthy Europeans used tin plates, which had a high lead

content. Since tomatoes are high in acidity, when placed in a special container, the fruit will release lead into the plate, which has led to many deaths from lead poisoning. No one made this connection between the dish and the poisoning at the time; the tomato was considered to be the culprit of the poisoning. The potato was considered such because it was part, as well as the tomato and other plants, of the *Solanaceae* family, a family in which is also the poisonous belladonna. The journey of the potato in the world, i.e. its spread and use as a food source, has gone through several vicissitudes.

Europeans in South America became aware of potatoes by the mid-16th century, but refused to eat them. For the Spanish, the potato was considered food for the natives: the Spanish conquistadors spoke highly of the potato, but they recommended it especially for the natives who had to do the hardest work. A similar pattern occurred in England where the potato became the food of the working class. In 1553, in the book Crónica del Peru, Pedro Cieza de León mentions that he saw it in Quito, Popayán and Pasto in 1538. Basque fishermen from Spain used the potatoes to store them in ships for their voyages across the Atlantic in the century the 16th and brought the tubers into the west of Ireland, where they landed to dry their cod. The English privateer Sir Francis Drake, returning from his circumnavigation, or Sir Walter Raleigh's employee Thomas Harriot, are usually credited with introducing the potato to England. Botanist Carolus Clusius in 1601 reported that potatoes were in common use in northern Italy for animal feed and human consumption [7].

The potato entered Europe sometime before the end of the 16th century through two different gateways: a) The first gateway was in Spain around 1570, and b) The second gateway was via the British Isles between 1588 and 1593. The first mention by written record of potatoes is a delivery invoice dated November 28, 1567 between Las Palmas de Gran Canaria and Antwerp. In France, by the end of the 16th century, the potato had been introduced into Franche-Comté, the Vosges of Lorraine and Alsace. Towards the end of the 18th century, the 1785 edition of Bon Jardinier wrote: "There is no vegetable about which so much has been written and so much enthusiasm shown... The poor must be quite content with this food". It had largely replaced turnips and rutabagas by the 19th century.
Across Europe, the most important new food in the 19th century was the potato, which had three major advantages over other foods for the consumer: its lowest spoilage rate, its largest contingent (which eased hunger) and cheap price. The potato slowly spread throughout Europe, becoming a staple by mid-century, particularly in Ireland [4]. It was first spread in Europe for non-food purposes. For the first time it was used for eating on the continent in a hospital in Seville in 1573. After Philip II received potatoes from Peru, he sent the harvested tubers to a priest (a pope), who sent them to the papal ambassador in Holland because was sick. Clusius indirectly received his tubers from the ambassador; planted them in Vienna, Frankfurt and Leyden and is the person who widely introduced the plant to Europe [3, 7].

The potato became widespread after 1600, becoming a major food source in Europe and East Asia. After its introduction to China at the end of the Ming Dynasty, the potato immediately became a delicacy of the imperial family. After the mid-Qianlong period (1735–1796) in the Qing dynasty, population growth and the subsequent need to increase grain yields, coupled with greater geographic movement of peasants, led to the rapid spread of potato cultivation throughout China, and it adapted to local natural conditions.
The potato came to France with Antoine-Augustin Parmentier, a French pharmacist who served as an army apothecary during the Seven Years' War between 1754 and 1763. During this time the Prussians captured the apothecary and imprisoned him, forcing him to eat potatoes as food jail. Parmentieri's experience in prison was transformative. He ate potatoes and survived – without leprosy or other diseases. When he was released from prison at the end of the war, Parmentier returned to his studies in Paris. By 1772, his mission was to prove to the French

that potatoes were tasty and good to eat and, in the same year, the French government lifted the potato ban because of Parmentier's pioneering work. He was insistent on showing his people that potatoes were actually good, he started doing publicity stunts with the potato. He organized elegant potato dinners, inviting celebrities such as Benjamin Franklin and Antoine Lavoisier. Once, Parmentier made a bouquet of potato flowers to give to the King and Queen of France. With publicity stunts failing to popularize potatoes, Parmentier tried a new tactic. In 1781 King Louis XVI granted him a large plot of land in Sablons. Parmentier planted the land with potatoes and hired heavily armed guards to show off the wonderful storage of the potatoes. His thinking was that if people looked at the many guards they would think that the potatoes must be valuable. A thing that was guarded so much seemed worth stealing, didn't it? To this end, Parmentieri's guards were ordered to let the thieves take the potatoes and let them go. If any enterprising potato thug paid a bribe to get potatoes, the guards were instructed to take the bribe, no matter how big or small. Of course, people started stealing Parmentier's potatoes. Thefts helped somewhat in the spread of the potato [2, 8].

In Albania, according to specialists in the field, the potato began to be cultivated after 1850 [5]. For the first time in our country, the potato entered the area of Shkodra in the second half of the 18th century, and at the end of the 19th century it also entered the highlands of Korça. Later, the potato spread to other districts, in Kukës, Dibër and the highlands of Shkodra. The total world production of potatoes is estimated at 388,191,000 tons in 2017. In Albania, potato production is estimated at about 245,000 tons per year. Compared to the region, Albania leaves behind Macedonia, Kosovo, and Montenegro.

Apart from using potato to eat, by cooking it in different forms, it is also used for other purposes. Potatoes are also used to produce alcohol and alcoholic beverages such as vodka, etc. It is also used as feed for livestock. Livestock category potatoes are usually very young and/or stained tubers that have no commercial value, so they are not to be sold or traded for human consumption. Starch produced from potatoes is used in the food industry as a thickener and binder for soups and sauces, in the textile industry as an adhesive and for the production of paper and boards. The potato is not only a plant product with nutritional importance, but it also has health and/or medicinal values, so not only for having good health, that is, for having a healthy life, but also has effects for the prevention and/or for the cure of some different diseases.

Materials and methods

The study was conducted during 2019 at the experimental base of the Plant Genetic Resources Institute, near the Agricultural University of Tirana, in Valias [19°43'59.90"E; 41°24'04.30"N; Height 39 m]. In the comparative study, 13 potato cultivars were obtained from ESHFF (State Institution of Seeds and Seedlings) Tirana with the following numbers: No. 1, No. 2, No. 3, No. 4, No. 5, No. 6, No. 7, No. 1/15, No. 2/16, No. 3/17, No. 4/18, No. 5/19 and No. 6/20. Their names, in accordance with the regulation for testing varieties, are available only to the testing office at the ESHFF.

The field trial was set up according to randomized block designs, with three replications. Each variant was raised with an area of 6.3 m^2 for each replication, being represented by 3 rows of 10 plants each. Planting was done in furrows at 70 cm between rows and 30 cm between plants, providing 47,600 plants/ha. Planting was done in March 2019. Potato agrotechnical services were performed, depending on the concrete conditions. Field observations were made and plant growth and development stages were recorded, as well as data on plant height, number of stems per plant, number of tubers per plant, size and quality of tubers, shape and color were recorded of the tuber.

Quantitative trait data were subjected to analysis of variance using the ANOVA program. The evaluation of correlation coefficients was done according to these classes: r = ± 0.3 weak correlation; r = ± 0.3 to ± 0.5 medium correlation relation; r = ± 0.5 to ± 0.7 links good correlation and r = ± 0.7 to ± 0.9 links strong correlation [1, 6].

Results and discussion

Germination of the cultivars in the study occurred 13–17 days after sowing, which is a normal period among different genotypes. So, there are no significant differences between the cultivars for the period of bud awakening and their germination (table no. 1). Differences between the cultivars in the study were observed for the germination–flowering period. Thus, for example, from 61.3 days which was the average period of all 13 genotypes (accessions), the minimum and maximum periods were 51 days (No. 1/15) and 72 days (No. 1); two cultivars (No. 3 and No. 3/17) had a period of 55 days, etc. Cultivars also differed for the germination–maturity period. Thus, for example, cultivars No. 3 and No. 1/15 had the shortest period (75 days), while cultivar No. 1 had the longest period 1 (92 days), two cultivars (No. 2/16 and No. 4/18) had a germination–maturity period of 88 days, etc., from 81.8 days, which was the average period for all genotypes under study (table no. 1).

Table no. 1: Planting, germination and periods of growth and development of potato, Valias 2019

Accessions	Planting–germination	Germination–flowering	Germination–maturity	Planting–maturity
No. 1	14	72	92	106
No. 2	17	68	86	103
No. 3	16	55	75	92
No. 4	14	66	78	93
No. 5	16	67	86	102
No. 6	14	69	83	97
No. 7	17	66	85	102
No. 1/15	13	51	75	88
No. 2/16	15	58	88	103
No. 3/17	13	55	78	91
No. 4/18	15	58	88	103
No. 5/19	13	56	81	94
No. 6/20	13	56	81	94
Average	13.7	61.3	81.8	95.5

Morphological characteristics and variation among potato cultivars

The fact that, at a quick glance, the potato accessions in the study showed variation among them for those morphological characteristics that were examined, shows that we are dealing with different potato genotypes.

For flower color, potato accessions are divided into two groups, 9 accessions (69.2 %) formed white flowers (code 1) and only 4 accessions (30.8 %) had light purple flowers, code 6, (table no. 2). Similarly, for the color of the tuber skin, the accessions were divided into two groups; from 13 accessions 10 (76.9 %) had white–cream tuber skin (code 1) and only 3 accessions (23.1 %) had yellow skin, code 2 (table no. 2). Although for the color of the tuber flesh, the accessions were divided into two groups, the variation for this trait was weak; 12 accessions (92.3 %) had yellow flesh (code 4) and only one accession had yellow–cream flesh (code 3). For tuber shape, potato accessions were divided into three groups: 3 accessions (23.1 %) had round-shaped tubers (code 2), 2 accessions (15.4 %) had ovate-shaped tubers (code 3) and 8 accessions (61.5 %) had tubers with the reverse shape of the obovate shape, code 4 (table no. 2).

The use value of potato tubers was also evaluated. Although this assessment is subjective, the study showed that there is variation among the 13 potato cultivars. According to this assessment, potato cultivars are divided into three groups; so, for example, in the assessment “Very good for baking and cooking” one cultivar (No. 1) is entered; 9 cultivars (No. 2, No. 3, No. 4, No. 7, No. 1/15, No. 2/16, No. 4/18, No. 5/19 and No. 6/20) were rated as “Good

for baking and cooking" and three cultivars (No. 5, No. 6 and No. 3/17) were rated as "Very good for baking, frying and cooking".

Table no. 2: Some morphological characteristics and value of potato use, Valias 2019

Aksesions	Flower and tuber color			Tuber shape	Use value
	Flower	Tuber			
		Skin	Flesh		
No. 1	White	White–cream	Yellow	2	Very good for baking and cooking
No. 2	White	Yellow	Yellow	4	Good for baking and cooking
No. 3	White	Yellow	Yellow	2	Good for baking and cooking
No. 4	White	White–cream	Yellow	4	Good for baking and cooking
No. 5	White	White–cream	Yellow	4	Very good for baking, frying and cooking
No. 6	White	White–cream	Yellow	4	Very good for baking, frying and cooking
No. 7	White	White–cream	Yellow-cream	4	Good for baking and cooking
No. 1/15	Light purple	White–cream	Yellow	4	Good for baking and cooking
No. 2/16	Light purple	White–cream	Yellow	4	Good for baking and cooking
No. 3/17	Light purple	Yellow	Yellow	4	Very good for baking, frying and cooking
No. 4/18	White	White–cream	Yellow	3	Good for baking and cooking
No. 5/19	White	White–cream	Yellow	3	Good for baking and cooking
No. 6/20	Light purple	White–cream	Yellow	2	Good for baking and cooking

Review and evaluation of productivity data of potato cultivars

Of course, the final goal of cultivating agricultural crops, including potatoes, is the yield of the cultivar. Every potato grower would prefer to choose for cultivation the cultivar that gives the highest yield and the best quality of production. In this perspective, let's examine the data of the study of 13 potato cultivars. A quick and general look at these data (table no. 6, chart no. 7) notes that the cultivars have generally given high yields. However, although cultivars generally show higher production capacities in experimental trials than in large–scale production conditions, there are notable differences in actual production. Thus, for example, the first group for the highest yield, based on D_{01}, includes the two cultivars No. 6 and No. 4 with respectively 1,045.5 kv/ha and No. 4 with 890.4 sq/ha. Six cultivars (No. 3, No. 3/17, No. 6/20, No. 7, No. 5 and No. 2) belong to the second group for the yield level, respectively with yields of 757.9 kv/ha, 749.3 kv/ha, 708.5 kv/ha, 695.2 kv/ha, 667.7 kv/ha and 667.2 kv/ha; cultivar No. 2/16 gave the lowest yield which was 344.7 kv/ha.

Examination and assessment of correlation coefficients

From the data of correlation coefficients (table no. 7) there are 3 correlations which are positive, so if the value of one feature increases, the value of the paired feature also increases. Two correlations: the number of primary stems per plant with the number of tubers per plant (r_{23}=0.76**) and the number of tubers per plant with the number of

tubers per primary stem (r_{34}=0.76**) were strong and validated at the P< 0.01, while the relationship between productivity and tuber weight (r_{56}=0.57*) is a good correlation and confirmed at the P< 0.05 level. It seems that the correlations found in this study are reliable because cultivars No. 6 (1,045.5 kv/a) and No. 4 (890.4 kv/ha), which had good and very good values for the number of primary stems per plant, the number of tubers per primary stem and per plant. Therefore, rapid field evaluation of potato cultivars for production even relying on the number of krimary stems per plant can be effective.

conclusion

Some conclusions emerge from the study data, among which the first conclusion is that the 13 potato cultivars included in the study showed distinct variation for all morphological characteristics and quantitative traits. Expressed variation means that we have different genotypes and the opportunity is created for choosing the best cultivars to meet the demands of the farmer and the consumer. Among the many conclusions we can list some for which there is more interest.

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