S U M M A R Y

The almond is of particular importance due to its multiple culinary, medical or economic uses and its rich cultural significance. Nuciferous fruits, including almonds, are supposed to have been harvested by hominids since the dawn of mankind. The first evidence of almond gathering dates back to the Pleistocene. The culinary importance of the almond is given by the core of the fruit, sweet or bitter, which is consumed as such, as a snack, but it is also an ingredient very often used in pastries and confectionery. Therefore, almonds are an important food for human nutrition and an important raw material in the food industry, being used in the production of sweets, cereals, biscuits, marzipan, cakes and pastries, vegetable milk, almond butter, etc. Cultural references to the almond are ancient, being referenced in Greek mythology, the Old Testament, and the Torah. The medicinal qualities of almond kernels have historically been recognized as a source of great nutritional and medicinal value, with references in ancient medical treatises from Greece, Persia, China and India, and recent studies have documented a wide range of health benefits. Almond kernels have been identified and promoted since ancient times by the most famous doctors, starting with the father of medicine, Hippocrates and Galen.

In the last 20 years there has been an increase in the area cultivated with almonds worldwide, an increase of about 29%, these being only the official data recorded by the FAO, in reality there is a possibility that the areas cultivated with almonds are larger. In the FAO statistics, it can be observed in the last 20 years, an increase in the production of almonds worldwide, of about 185%. It can be said that such a significant increase in production in relation to a much smaller increase in cultivated area can be achieved through improved cultivation technologies with modern technique and technology, which has led to the significant increases in production achieved in recent times.

The introduction of the almond on the territory of our country was made in several stages, the beginnings probably due to the Greek colonists from the old fortresses on the banks of the Euxine Pontus. The Romans were the second important factor that contributed to the introduction of the almond, after the conquest of Dacia. Later, the Turks, through the long-term political and economic influence they exercised over the Romanian Countries, certainly had an important role from this point of view (Pomologia R.P.R., 1967). There are no statistics of the areas occupied by the almond culture in Romania, this species being included alongside the other nut trees. It should be noted that the interest in the almond culture in Romania is low, while the worldwide interest is increasing, the almond being one of the crops that can be completely mechanized, being a species that lends itself very well to cultivation in an ecological system.

It is said that the super intensive culture system is the future of almond orchards. In recent decades, different researchers in Europe have conducted experiments with the same trends and developed a new culture system for almond orchards (Iglesias, 2019a). In the meantime, low-vigor rootstocks have been created and tested, allowing higher tree densities per hectare to be tested. The novelty of high density almond orchards is to allow full mechanization of orchard management operations (Iglesias, 2019b). Having the opportunity to reduce and solve the labor shortage through mechanization, especially of specialized workers, solves some problems facing modern horticulture. Even greater mechanization of work translates into lower costs, saves time, improves worker safety, reduces labor requirements and production costs, and increases product quality (Carbo et al., 2017). The long-term effects of high density almond plantations are currently unknown, so this culture technology is currently still being tested. The super intensive model offers advantages in the effectiveness of phytosanitary treatments, in the management of irrigation water, minimizes soil maintenance, offers early harvests, offers the possibility of harvesting with machines that cross the row of trees or with robotic harvesting machines, reduces the labor force, and all these advantages lead to an improvement in crop profitability (Gascón et al., 2019).

On the occasion of carrying out this study, the presence of one of the most important pests of almonds, the almond wasp (Eurytoma amygdali Enderlein), was established on the territory of Romania. The insect was first discovered in Bulgaria by Enderlein in 1907. For a long time the almond wasp was confused with Eurytoma schreineri Schr., and it was Nikolskaia in 1961 who established that it was two distinct species (Perju , 2002). In our country, the species was not reported until 2022, when, during this study, the presence of Eurytoma amygdali Enderlein was discovered in the commune of Greci, Tulcea, in the fruits of the local almond population (Cioacă et al., 2022). This being one of the novelties that this thesis offers for almond culture in Romania.

The varieties studied are creations of different breeding programs, both from Romania and from Spain, Italy and France. The varieties created in Romania are achievements of SCDP Constanţa with "Mirela", and the achievements of the University of Oradea, "Ana", "April" and "Nico". The studied varieties from Spain, "Vairo" and "Marinada", are creations of IRTA Catalunia, the "Supernova" variety, created by ISF Rome, Italy, and the "Lauranne" variety made at INRA Bordeaux, in France.

The experimental field is located on the street in Greci commune, Tulcea county, with coordinates 45.188979N, 28.250299E. Greci commune is located in a depressed area, at the foot of the highest peaks in the Măcin Mountains. The surface on which the experimental field is located is found in soil territorial unit (U.S.) no. 27. The soil type is mollic Eutricambosol, moderately deep, loamy/loamy, on hypobasic silicate rocks, arable. The formula of the soil unit is: Molic EC – d4 – l/s – Ss122 – A.

The field experiment consists of three repetitions, each repetition being composed of eight variants (varieties), and within one variant, six plants of the same variety are

studied, resulting in a total number of 144 plants. The method of placing the experience was realized by the method of the Latin square. The shape of the experimental plot is rectangular. The size of the experimental plot is 45 m long and 24 m wide, with an area of 1080 m2, of which the row is 34.5 m long, and the distance between the rows is 4 m, the roads are 2 m wide, and the protective forest curtain has width of 4.5m. For the establishment of the experimental field, the following stages were carried out: The clearing of the land was carried out in September 2019. Bringing 4 tons of manure and spreading it over the entire surface. The operation was carried out on October 15, 2019. The mobilization of the soil in depth, at a depth of 50-60 cm by scarification, was carried out on October 17, 2019. For this operation, a 102 HP Deutz-Fahr DX 110 tractor, equipped with a Maschio scarifier, was used Gaspardo model Pinocchio 250/5, 50-160HP. Incorporation of the manure by plowing was done using a pomicol tractor with a two-hull plow. Picketing and digging pits was done on March 15, 2020. Tree planting took place on March 16, 2020. The planting scheme is 4m between rows and 1.5m between plants per row. About 2-3 kg of manure was added to the bottom of the planting pit. In addition, Osmocote Exact 5-6 month fertilizer was added to the root zone, about 80g/plant.

The observations and determinations made consisted of phenological observations of the studied varieties, the determination of the annual growth achieved by the studied trees, and the physico-chemical characteristics of the fruits: the determination of mineral elements, the determination of the amount of protein, the extraction of oil and the realization of the fatty acid profile following oil extraction, and the physical characteristics of the fruits studied are: The values of the length, width and thickness of the fruit in the shell (mesocarp), and of the length and width of the kernels (endocarp), the average weight of an almond in the shell and peeled, the percentage of kernel/shell , the production per hectare of kernels or almonds in shell.

Conclusions on phenological observations

Varieties Marinada, Lauranne and Vairo require the most hours with temperatures above 7°C for the flower buds to develop and keep the flowers open for the longest time. For the climate of Romania and Tulcea county in particular, they are the varieties that can best avoid the effect of spring frosts and present the highest chances for the flowers to be pollinated, among all the varieties included in this study. On the other hand, the very late flowering that these varieties show exposes them to the hairy flower beetle (Epicometis hirta Poda.).

At the opposite pole are the varieties April and Nico. These cultivars exhibited the fastest flower bud development and among the shortest flower open periods. These aspects make these varieties susceptible to late spring frosts and reduce the chances of the flowers being pollinated due to low temperatures.

Conclusions regarding the determination of annual increases

In the first year after planting, the trees adapted and acclimatized to the new living environment. Following the determinations of the annual increases, the following can be concluded.

The varieties that presented no. the highest number of branches with fruit buds, from the total number of branches, are: Marinada 99.62%, Vairo 97.36% and Mirela 94.04% in the first growing season. The varieties that differentiated the weakest in the first growing season are Supernova 85.12%, April 84.57% and Nico 76.94%. In the 2nd year of vegetation, the varieties that presented no. the highest number of branches with fruit buds, of the total number of branches, are: Marinada 99.71%, Vairo 96.79% and Lauranne 96.73%. The varieties that differentiated the weakest, in year 2, are: Mirela 89.20%, April 82.10% and Nico 77.47%.

Due to the fact that the first year was for acclimatization and accommodation to the new living environment, the trees being young, the growth of year 1 was not taken into account for the following characterization. Following the assessment of tree growth trends in year 2, the varieties April, Supernova and Nico tend to fruit on long (mixed) branches. Varieties Marinada and Vairo tend to fruit on bunches of may and white branches, and varieties Lauranne, Mirela and Ana, predominantly on bunches of may.

Conclusions regarding the physico-chemical characteristics of fruits

Regarding the amount of harvested fruit, since the second year of vegetation, all studied varieties have come into fruit. Even if the first harvest is not an economic one, it amortizes expenses. Thus, a quantity of 116.49kg core/ha in the case of the Marinada variety, 95.77kg core/ha in the case of the Mirela variety, or 79.51kg core/ha in the case of the Ana variety can amortize a good part of the cost of the work performed.

In the third year of vegetation, significant harvests were obtained, which confirm the hypotheses of other studies, that the high density almond cultivation system reaches a maximum harvest much faster than the intensive system, thus the investment is recovered much faster, and the profit it is generated much earlier than in the intensive system. As a result, harvests as in the case of the varieties Marinada of 670.13 kg core/ha, Supernova 480.24 kg core/ha and Lauranne 474.81 kg core/ha from the second year of fruiting, point out that this new culture system is a desirable one, to be studied on long term and desirable in commercial plantations.

About the average weight of an almond in shell and shell it can be said that in the first year of fruiting, the tree had few fruit branches and had a small harvest, making larger fruits. In the first year, the varieties with the largest mass of a fruit in the shell were April, Marinada and Mirela, and the fruits with the smallest mass were presented by the Vairo, Lauranne and Nico varieties. In the second year of fruiting, when some varieties set abundantly, the April, Mirela and Vairo varieties presented the largest mass of one fruit in the shell, and Lauranne, Supernova and Nico varieties presented the smallest mass of fruits .

In the first year, the varieties with the largest mass of a core were April, Marinada, Ana and Mirela, and the fruits with the smallest mass were presented by the Lauranne,

Supernova and Vairo varieties. In the second year of fruiting, the April, Mirela and Ana varieties showed the largest mass of a core, and the fruits with the smallest mass were presented by the Marinada, Lauranne and Nico varieties.

A more abundant harvest, as in the second year, causes the tree to produce fruits of a smaller caliber, with a smaller mass, because of this the differences in the size of the fruits from one harvest to another are significant, in the girl's situation.

The length, width and thickness of the fruits in the shell and the cores, the largest fruits in the shell are presented by the varieties, Lauranne, Ana and Vairo, and the smallest Mirela, April and Nico. The varieties with the largest kernels are Lauranne, Supernova and Vairo, and the varieties with the smallest kernels are Marinada, Ana and April.

The percentage of core, in the first year of fruiting a high percentage of core was presented by the varieties Nico, Ana and Mirela, and a small percentage of core was presented by the varieties Supernova, Vairo and April. In the second year, a large percentage of core was presented by the varieties Nico, Supernova, and Ana, and a small percentage of core was presented by the varieties Marinada, Vairo, and April.

The percentage of double kernels, in the first year of fruiting, a high percentage of double kernels was presented by the varieties April, Ana and Supernova, and a small percentage of double kernels was presented by the varieties Mirela, Nico and Vairo. In the second year, a high percentage of double kernels was presented by the varieties April, Ana and Supernova, and a small percentage of double kernels was presented by the varieties Lauranne, Marinada and Vairo.

The varieties with the highest oil content are Nico, Mirela and Vairo, and the varieties with the lowest oil content are Ana, Supernova and Lauranne.

The most important fatty acids contained in almonds are linoleic acid (Omega 6) and oleic acid (Omega 9). The varieties with the highest percentage of linoleic acid are Lauranne, Marinada and Supernova, and the varieties with the lowest percentage of linoleic acid are Nico, April and Mirela. The varieties with the highest percentage of oleic acid are Mirela, April and Nico, and the varieties with the lowest percentage of oleic acid are Ana, Marinada and Lauranne.

Varieties that had an increased content of linoleic acid showed a lower content of oleic acid. The 2022 vegetation year being very dry, in the analysis of the fatty acid profile, a change in the percentage ratio between linoleic acid and oleic acid was noted, with the fruits having a much higher percentage of linoleic acid and a lower percentage of oleic acid, compared to the year previously when the trees were not subjected to significant water stress.

The April, Ana and Supernova varieties have the highest protein concentration, and the Vairo, Mirela and Nico varieties have the lowest concentration.

Almonds are recognized for the high amount of mineral elements beneficial to humans that they contain. The varieties with a rich content in Mg, K and Ca are

Marinada, Lauranne and Supernova, and the varieties with the lowest content in Mg, K and Ca are Mirela, April and Ana.

The varieties with a rich content of Mn, Fe and Cu are Supernova and Nico, and the varieties with the lowest content are Ana and April. The varieties with the highest Zn content are April, Ana and Vairo, and the varieties with the lowest content are Marinada, Mirela and Nico.

Conclusions regarding the varieties studied

The foreign varieties, Lauranne, Marinada, Supernova and Vairo acclimatized without problems in the pedoclimatic conditions of the present experiment. No differences were observed between local and imported varieties in sensitivities or damage due to local climate or soil conditions.

The trees developed fruit buds and branches from the first year, flowered and set fruit from the second year of growth and from the third year a considerable harvest was obtained.

Ana is a tree of great vigor, the branches tend to become vertical, with medium-late flowering and a medium flowering duration, fruiting on mixed branches and May bouquets. The fruit in the shell is large, medium mass, with a medium-hard cracking shell and a small percentage of peel, the core is medium to large, medium mass, with a considerable percentage of double kernels. Compared to the other varieties, it is poorly productive, sensitive to alternation of fruiting. Compared to the other varieties studied, the fruits contain mineral elements in small amounts, except for zinc. The fruits contain a small amount of oil, and the fatty acid profile shows that this variety has a medium amount of linoleic acid and a small amount of oleic acid. The protein percentage is high compared to the other varieties studied.

April is a tree of low vigor, the branches tend to grow horizontally, with a pendulous tip, it has a medium flowering with a medium flowering duration, fruiting mainly on mixed branches. The pod is small in length, wide and thick, with a large mass, with a hard cracking shell and a high percentage of shell, the core is small in length, wide and convex, with a large mass, having a very high percentage of double kernels . Compared to the other varieties, it is poorly productive, sensitive to alternation of fruiting. Compared to the other varieties studied, the fruits contain mineral elements in small amounts, except for zinc. The fruits contain a medium amount of oil and the fatty acid profile shows that this variety produces a small amount of linoleic acid and a high amount of oleic acid. The protein percentage is very high compared to the other varieties studied.

Lauranne is a tree of great vigor, the branches tend to verticalize and open wide, a very late flowering with a long flowering period, fruiting mainly on May bouquets. The fruit in the shell is long, narrow and thin, of low mass, with a medium-soft-to-crack peel and a medium percentage of shell, the core is long and narrow, of low mass, with a very low percentage of double kernels. Compared to the other varieties, it is very productive, a little sensitive to alternation of fruiting. Compared to the other varieties studied, the fruits are rich in mineral elements, especially K and Ca. The fruits contain a

small amount of oil and the fatty acid profile shows that this variety produces a large amount of linoleic acid and a small amount of oleic acid. The protein percentage is average compared to the other varieties studied.

Marinada is a tree of medium vigor, the branches tend to become vertical and open wide, it has a very late flowering with a long flowering period, fruiting mainly on salves and May bouquets. The fruit in the shell is medium long, wide, with a large mass, with a medium-hard shell when cracked and a high percentage of shell, the core is medium long and wide, with a large mass, having a very small percentage of double kernels. Compared to the other varieties, it is very productive, it is not sensitive to alternation of fruiting. Compared to the other varieties studied, the fruits are very rich in mineral elements. Compared to the other studied varieties, the fruits contain a large amount of oil and from the fatty acid profile it appears that this variety produces a large amount of linoleic acid and a small amount of oleic acid. The protein percentage is average compared to the other varieties studied.

Mirela is a tree of little vigor, the branches tend to grow horizontally, it has a medium-late flowering with a long flowering period, fruiting mainly on May bouquets. The fruit in the shell is medium to small and thick, with a large mass, with a medium-hard shell when cracked and a medium percentage of shell, the core is medium in length but wide, with a large mass, having a very small percentage of double kernels. Compared to the other varieties, it is medium productive, sensitive to alternation of fruiting. Compared to the other varieties studied, the fruits contain mineral elements in small amounts. The fruits contain a large amount of oil and the fatty acid profile shows that this variety produces a small amount of linoleic acid and a large amount of oleic acid. The protein percentage is very high compared to the other varieties studied.

Nico is a tree of medium vigor, the branches tend to verticalize and open wide, it has a medium flowering with a medium flowering duration, fruiting mainly on mixed branches. The fruit in the shell is small, of low mass, with a soft cracking shell and low percentage of shell, the core is medium long and narrow with medium mass, having a very low percentage of double kernels. Compared to the other varieties, it is medium productive, very sensitive to alternation of fruiting. Compared to the other varieties studied, the fruits contain mineral elements in medium amounts, except for Mn, Fe and Cu which showed high values. The fruits contain a very large amount of oil and the fatty acid profile shows that this variety produces a small amount of linoleic acid and a large amount of oleic acid. The protein percentage is low compared to the other varieties studied.

Supernova is a tree of great vigor, the branches tend to become vertical, it has a late flowering with a short flowering period, fruiting mainly on mixed and pale branches. The fruit in the shell is medium-long, small-mass, with a hard-to-crack shell and a small percentage of shell, the core is large, small-mass, with a high percentage of double kernels. Compared to the other varieties, it is productive, a little sensitive to alternation of fruiting. Compared to the other varieties studied, the fruits are rich in

mineral elements. Compared to the other varieties studied, the fruits contain a small amount of oil and the fatty acid profile shows a large amount of linoleic acid and a medium amount of oleic acid. The protein percentage is high compared to the other varieties studied.

Vairo is a tree of great vigor, the branches tend to become vertical, it has a very late flowering with a long flowering period, fruiting mainly on sage and mixed branches. The fruit in the shell is large, narrow and thin, of medium mass, with a hard-to-crack shell and a high percentage of shell, the core is large, of small mass, without double pits. Compared to the other varieties, it is very productive, sensitive to alternation of fruiting. Compared to the other varieties studied, the fruits are rich in mineral elements. Compared to the other varieties studied, the fruits contain a large amount of oil and from the fatty acid profile it appears that this variety has an average amount of linoleic acid and an average amount of oleic acid. The protein percentage is low compared to the other varieties studied.

Conclusions regarding the high density culture system

Positive aspects of the high density culture system.

The high density cropping system proves to be an easier way to manage almond orchards. Less labor is required for tree cutting, an operation that can be done entirely mechanized, creating the row of trees as a fruit fence by mechanized cutting. Lower costs for plantation maintenance, considering the reduced staffing required when most plantation maintenance work is mechanized.

Almond shakers and fruit harvesters used in intensive system require at least two workers. In the high density system, the combine that crosses the row of olives or vines can be adjusted to shake almonds and harvest almonds. Using these machines, the fruits no longer touch the ground, thus reducing the chances of contamination with salmonella or aflatoxins. Similar combines can be easily retrofitted and controlled via the Internet and GPS, these methods being tested and currently implemented in large crops.

The complete mechanization of the works thus reduces costs, which translate into profit, greater safety for workers, but also in saving time, a very precious resource.

The labor force deficit registered by the horticultural field, of qualified personnel as well as unqualified personnel, is no longer a problem in the management of these types of orchards, being necessary a no. minimum staff.

High yields from the third year after planting, and the almond plantation reaches maximum production much faster, usually in 4-5 years after planting, thus recovering the initial investment much faster. In intensive system this maximum production is reached after 10-12 years.

The vertical axis crown is much easier to form and maintain than the bowl crown types used in the high density system. With the vertical axis crown, the trees are not susceptible to breaking the frames from strong winds or fruit shakers, and in the situation where a tree dies, the gap left does not have a big impact on the production of

the plantation, compared to the intensive system where such gaps have a big impact on production.

Recommendations.

Further study of these varieties is recommended for a better long-term understanding of their behavior, but also newer varieties released by the most successful breeding programs in Europe, where very very late flowering varieties such as “ Makako", "Penta" or "Vialfas".

Long-term study of this cropping system, to understand the behavior of varieties and their response to fruiting alternation, yield evolution, disease and pest behavior and the evolution of this system in the context of climate change.

Creation of comparative crops to study and present the benefits and effects of the high density versus intensive system in almond cultivation, both in terms of cost, benefit and yield but also the differences in crop quality.

Promotion of this almond culture system to horticultural researchers, farmers, nurseries and the general public. Promotion of almond culture in general.

The varieties Marinada, Lauranne, Vairo and Mirela are the most recommended for the establishment of new high density plantations in Tulcea county.

The varieties Supernova, Ana, Lauranne or Vairo are recommended for the establishment of new intensive plantations due to their high vigor.

The Nico variety is recommended for planting in family gardens due to its thin skin and easy to open with the hands.

The variety April and Mirela are recommended in breeding new varieties due to the habitus and vigor of these varieties, where if the quantity and quality of the harvest is improved they can become top varieties.