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COMPARATIVE ANALYSIS OF ORCHARD PLATFORMS IN THE CONTEXT OF MODERN TREE MAINTENANCE TECHNOLOGIES

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Abstract: In recent decades, the fruit-growing industry has evolved rapidly, and farmers face significant challenges such as climate change, increasing consumer demands, and the need to optimize resources. In this context, the use of cutting-edge technologies becomes essential to ensure efficient and sustainable production. Given the growing demand for high-quality fruit products, this comparative analysis will assess the efficiency and sustainability of different maintenance methods or technologies for monitoring the health of orchards. The article aims to explore various orchard platforms used in the horticultural industry, emphasizing the impact of modern technologies on tree maintenance. By examining constructive solutions and the challenges faced by farmers, the article will provide a foundation for understanding how technological innovations can optimize production and reduce environmental impact. Additionally, it will discuss future trends in the field and the need to adapt orchard platforms to global sustainability and efficiency requirements. Furthermore, the analysis will cover emerging trends in the fruit-growing sector, such as precision agriculture and the use of land monitoring systems. Ultimately, this study will not only provide an overview of the current state of orchard platforms but also offer possible recommendations for implementing best practices in tree maintenance, aiming to increase productivity and crop quality.

Keywords: mechanized planting, sustainable forestry, reforestation

1. INTRODUCTION

Fruit plantations are multi-annual and intensive crops, which involve significant investments both in the establishment phase and during the maintenance period until fruiting. In order to ensure optimal growth and fruiting conditions, a series of specialized works are carried out in orchards, such as soil maintenance, fertilization, irrigation, formation and fruiting pruning, as well as the application of phytosanitary treatments, both in young orchards and in those in production. The plantation maintenance stage is essential in the process of obtaining quality fruit production, having a determining role in the efficiency and sustainability of fruit crops.

In recent decades, fruit growing has undergone a significant transformation, fuelled by technological progress and the growing need for efficiency and sustainability in agricultural production. From traditional forms of cultivation, based on native varieties and manual interventions, to digitally manage super-intensive platforms, the evolution of technologies used in tree maintenance has led to major changes in the organization and productivity of plantations.

The directions of development and profitability of agri-food production, of increasing the volume and quality of fruit production by reducing losses in the fruit-growing sector can be achieved only by improving, modernizing the machines and technical equipment used to perform basic operations within these technologies and by increasing the degree of mechanization of works within the technologies of maintenance of fruit plantations, [1, 2].

In the traditional period, until the mid-20th century, fruit growing was practiced extensively, with minimal interventions and simple tools. Techniques were passed down from generation to generation, based on empirical experience, and work such as pruning, treatments or harvesting was done manually, depending on climatic conditions and direct observations of farmers.

With the development of mechanization, in the second half of the 20th century, the first agricultural machinery for fruit growing was introduced, and maintenance work began to be standardized. This stage allowed for the increase in cultivated areas, but also a better organization of seasonal work,

through the use of tractors, sprayers and other specialized equipment. Fruit growing entered an intensive phase, marked by the reduction of planting distances, the introduction of drip irrigation systems and the transition to modern, high-yielding varieties. Fruit growing platforms began to be thought of as integrated systems, in which each element – from the type of soil to the rootstock – was chosen to maximize production efficiency, [3, 4].

Technologies have become an essential factor in optimizing agricultural processes, including in fruit growing. The efficient maintenance of fruit plantations requires new, even innovative solutions that reduce manual effort, increase productivity and contribute to environmental sustainability. Among these solutions, the use of fruit platforms plays a leading role in facilitating maintenance work, such as pruning, thinning, applying phytosanitary treatments and harvesting. The evolution of agricultural equipment has led to the development of increasingly high-performance platforms, from manual and semi-automatic models to self-propelled platforms equipped with intelligent systems. Choosing the most suitable platform depends on several factors, such as the type of plantation, the size of the exploited area, the desired level of automation and the specific requirements of each farm.

We are currently in the era of digitalization and precision agriculture. Technologies such as soil and air sensors, drones, automated fertigation systems, but also software applications for monitoring plantations, allow unprecedented control over the health of trees and the resources used. These innovations are the basis of new modern fruit growing platforms, which promise not only increased productivity, but also a reduced impact on the environment.

An essential aspect of the use of modern fruit platforms is their impact on the operational and economic efficiency of a plantation. In addition to reducing labour costs, they contribute to improving the quality of agricultural work, ensuring more precise and faster intervention on the trees. In addition, the integration of advanced technologies, such as GPS systems, automation of movements and the use of sensors for crop monitoring, transform fruit platforms into indispensable tools for precision agriculture.

In this context, the article aims to comparatively analyse the main types of fruit growing platforms currently used, highlighting the characteristics, advantages and limitations of each.

In today's agriculture, marked by climate change, the pressure of economic competitiveness and increasingly stringent requirements regarding product quality, fruit growing must adapt quickly by adopting modern technologies and efficient cropping systems. Fruit growing platforms, presented as technical and organizational assemblies for fruit production, thus become essential elements for ensuring profitable, sustainable production adapted to market standards, [1–5].

The purpose of the comparative analysis is to highlight the functional, technological and economic differences between the main types of fruit-growing platforms, such as traditional, intensive and super-intensive, in relation to current tree maintenance requirements. Through this approach, the aim is to identify the most efficient models of orchard organization and technology, adapted both to local pedoclimatic conditions and to modern quality and traceability requirements.

The article aims to comparatively analyse the main types of fruit-growing platforms used in the context of modern tree maintenance technologies. We will explore their characteristics, the advantages and disadvantages of each type of platform, as well as the impact of their use on the efficiency of agricultural work. We will also discuss current trends and the future of mechanization in fruit growing, highlighting the role of new technologies in increasing the sustainability and profitability of orchards.

2. MATERIALS AND METHODS

Fruit-growing platforms are an essential technological component in modern orchard maintenance systems, contributing to increasing efficiency, safety and precision in performing specific works. These equipments ensure access to the tree crown, allow the execution of operations in ergonomic

and safe conditions, but also considerably reduce the physical effort of the operators. The use of platforms optimizes working times and minimizes technological losses, especially in intensive and super-intensive plantations. The action of establishing a fruit-growing plantation/orchard is of major importance, because it involves the initial capital invested and the works that are performed in a shorter or longer period. It ends with the planting of the trees in the final place.

■ Types of fruit plantations and cropping systems

Certain types of fruit plantations are distinguished according to production characteristics, the destination or volume of the fruit, and the area cultivated with trees, which must be taken into account when designing a plantation or orchard:

- commercial/industrial plantations on farms with economically viable areas that ensure large fruit production for fresh consumption and for industrialization; the plantations are specialized by species and varieties, being located in hilly and lowland areas; they are equipped with machine systems, warehouses for storing fruit and a location for sorting fruit.
- family plantations, established in all ecological zones in small and medium-sized farms that produce fruit for sale in a wide range of species and varieties; they have limited technical equipment, and the fruit is stored in simple, temporarily arranged premises;
- plantations in the family garden, in association with other horticultural crops, with small areas, with different species and varieties to achieve staggered consumption of fruit throughout the year or for leisure;
- experimental plantations intended for scientific research and include collections of species and varieties of fruit trees and shrubs, germplasm banks, particularly valuable material for breeding and genetics; they are organized in research stations;
- existing didactic plantations in high schools and horticulture faculties intended for the study and practice of pupils and students.

Plantation systems and types have been improved and can be framed within precise evaluation criteria. They are developed and improved according to a series of criteria: species, variety, rootstock, tree vigour, fruiting, nutrition surface, degree of mechanization of work, crown type, as well as the timing of harvests in the biological cycle, [7].

FRUIT GROWING TECHNOLOGICAL SYSTEMS can be grouped into two major categories: pure crops and associated crops, Figure 1. In general, as in other areas, in hilly and hilly-mountainous regions, all fruit growing technological systems can be practiced, [8]. Moreover, the content of the notion of intensification does not only reflect the degree of land use, expressed by the number of trees per hectare, but also other elements such as: the level of production and their costs, the volume and duration of investment recovery, etc.

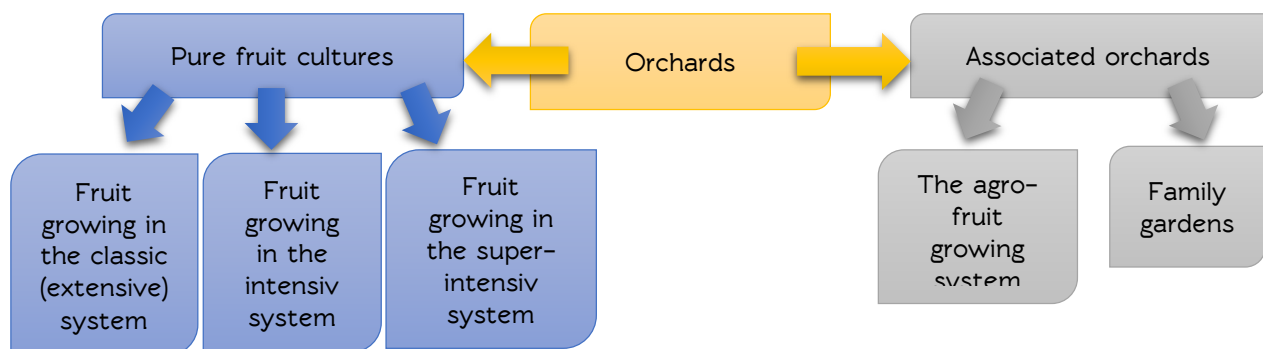


Figure 1 – Fruit growing technological systems

THE CLASSICAL (EXTENSIVE) SYSTEM held the majority of the world's fruit growing until around the 1960s. In this system, the trees have great vigor (8–10 m height), globular crowns (4–8 m diameter) or pyramidal, they are planted at large distances (7–8 to 10–12 m), resulting in a density of about 150–300 trees/ha. Due to these considerations, the land between the rows and even within the

row has a low degree of use both when the plantation is young and after it starts to bear fruit. The economic fruiting of these plantations is 8–10 years, sometimes even 12–15 years after planting. Production is relatively low (10–15 t/ha), and the amortization of the investment is achieved very late. Agrotechnical works (pruning, phytosanitary protection, harvesting) are carried out with difficulty and at high costs. System with a long lifespan of 40–50 years and is applicable to most fruit species. However, due to its characteristics, there is a tendency to be replaced by modern systems.

THE INTENSIVE SYSTEM currently has a high share in tree cultivation worldwide and in our country. The system is also extremely extensive in the high hill area, being predominantly apple at present but with prospects for plum, cherry and sour cherry. Within this system, characterized by densities of 500–1250 trees/ha, planting distances of 4–5 m between rows and 2–4 m between trees in a row are used, depending on the vigour of the variety and the rootstock, as well as the crown shape. The trees are 3–3.5 m high and are managed in the form of flattened crowns–palmettes (pomaceae) or flattened vessel, improved vessel, modified leader, tiered palmette and free palmette (drupaceae). Trees grown in this system produce the first fruits in the third year after planting, the harvests become economical in the 4th–5th year, the full production period lasts 20–30 years, when productions of 20–30 tons/ha can be obtained, with fairly low costs. The degree of land use is much higher than in the classical system, and the densities and crown shapes allow for the correct and timely performance of agro technical works. The variety of relief forms, the generally lower soil fertility, the lower cost of investments and the long duration of exploitation are elements that advocate the priority expansion of this system in all areas suitable for tree cultivation, as well as in highlands.

THE SUPERINTENSIVE SYSTEM is characterized by trees of low vigour (1.5–2 m height), managed in the form of flattened or globular crowns with small volume (spindle, vertical cordon), small planting distances (2.5–4 m between rows and 1–1.5 m per row) resulting in densities of 1250–3333 trees/ha and even more. Recommended system for apple and pear, using rootstocks of sub-medium or low vigour. Trees planted in this system give economic harvests starting with the third year after planting. During the full fruiting period, which lasts 10–15 years, productions of 30–45 t/ha are obtained. The high degree of land use, mechanization, contributes to increasing labour productivity, by reducing labour consumption and material costs, leading to reduced costs per unit of product. In addition to the aforementioned advantages, the system also has a series of disadvantages that must be taken into account when fairly assessing the possibilities of promoting it in certain areas and especially in highlands, as follows: it requires soils with high fertility and good permeability, which are quite rare; the high density of trees makes light scarce, with consequences on production and especially its quality, while at the same time creating favourable conditions for the development of diseases and pests.

THE AGRO-POMICOL SYSTEM, widely practiced at all times and especially in hilly/mountainous areas, is a variant of the classical system. This system is characterized by trees of great vigor, with globular or pyramidal crowns, planted at 8...12 m between rows and 4...5 m per row. The intervals are cultivated with food and fodder plants, throughout the entire duration of the plantation's exploitation, from which a complementary production is obtained that compensates for the lower fruit production (8...10 t/ha). The system has prospects only in high areas where agro tourism is developed.

FAMILY GARDENS occupy relatively small areas, up to 0.5 ha, near households and are cultivated with a large number of species and varieties in order to satisfy their own consumption needs with fruit throughout the year, and in favourable years, additional income can be achieved by capitalizing on the market of the surplus fruit. These gardens have a special agro tourism role, because they beautify the respective areas and offer the owners pleasant pursuits and the visitor's pleasant

images, [9]. Among all the cultivation methods, the modern trend is that the best production results are given by intensive and super intensive orchards mainly due to the rapid entry into fruiting, the short duration of investment recovery and the high profitability.

The article aimed to conduct a comparative analysis focused on the main types of platforms used in fruit growing, with the aim of highlighting their degree of adaptation to modern technological requirements regarding the maintenance of fruit plantations. The choice of platforms was based on criteria of relevance in practical exploitation, popularity among users, but also on the degree of technological innovation present in their construction and operation.

3. SELF-PROPELLED PLATFORMS FOR ORCHARD MAINTENANCE WORK

The development of self-moving platform-type equipment for working in fruit crops is becoming an extremely useful tool, being used in all phases of tree development by facilitating the performance of works such as: tree cleaning and fruiting cuts, fruit thinning as an operation to complete or finalize the thinning of inflorescences, stretching/tightening anti-hail protection nets, monitoring fruit production and harvesting them.



Figure 2 – Platform semi-hydraulic , PL-6 [10]

The semi-hydraulic platform, PL-6 , Figure 1 is designed to provide safe and stable support for workers performing activities at height, such as tree felling or fruit harvesting. Its use significantly contributes to increasing the productivity of work in the orchard.

Thanks to a specialized construction, the active part of the platform can move vertically, together with the operators and the necessary equipment, up to a height of approximately 2.5 meters above ground level. Lifting and lowering are carried out using an integrated hydraulic system.



Figure 3 – Semi-hydraulic platform for orchards, PLR-2.5 [16]

The hydraulic platform for orchards, PLR-2.5 , Figure 3, is intended for carrying out orchard work at height, especially maintenance pruning and fruit harvesting. Built to ensure increased mobility and safety in orchards, this platform allows the efficient lifting of operators, together with auxiliary equipment, up to a working height of 2.5 meters above ground level. Lifting and lowering are controlled by a robust hydraulic system, which allows rapid adaptation to the needs of the work in the field. The structure of the platform is designed to provide stability during operations and to allow easy movement within the rows of trees. By integrating this technology into seasonal work, a significant reduction in execution time and an increase in work efficiency are achieved.

Main features:

- ≡ transport dimensions: 5.1×1.45×1.45 m;
- ≡ working dimensions: 5.1×2.5×1.45 m;
- ≡ platform lifting height: 2.5 m;
- ≡ number of jobs: 6 people;
- ≡ lifting system type: hydraulic.

Main features:

- ≡ drive: class 0.6.T;
- ≡ hydraulic pressure: 120/160 bar;
- ≡ transport dimensions (L x W x H): 485x134x240 cm;
- ≡ working dimensions (L x W x H): 485x250x360 cm;
- ≡ platform dimensions with folded thresholds: 130x400 cm;
- ≡ platform dimensions with open thresholds: 260x400 cm;
- ≡ number of full containers: 3 pcs;
- ≡ number of empty containers: 7 pcs;
- ≡ number of people working: 6 people;
- ≡ number of axles: 4 pcs.

Big 2000 platform, Figure 4, is manufactured in Italy by Billo SRL Big 2000, being a multifunctional platform used in agriculture for various tasks, such as cutting, harvesting and spraying.



Figure 4 – Big 2000 platform [11]

- Main features :
- ≡ 3 or 4 cylinder water-cooled diesel engine;
 - ≡ hydrostatic transmission;
 - ≡ speed from 0 to 15 km/h;
 - ≡ 2-speed shift;
 - ≡ 2 or 4 wheel drive/steering;
 - ≡ Rechargeable battery, working autonomy of over 8 hours.

The Argilés AF5 platform, Figure 5, is designed for maintenance and harvesting work in super-intensive orchards, fully electric and modern. The platform stands out for its increased manoeuvrability, zero emissions and low noise level, characteristics that make it ideal for farms oriented towards sustainable agriculture. The platform is equipped with a stable and precise vertical lifting system, with a maximum working height of approximately 3 m, and the controls allow efficient operation by a single user. Thanks to its modular design and compact dimensions, the AF5 is suitable for orchards with short row distances. By integrating this platform into seasonal work, physical effort is considerably reduced, while increasing the quality and precision of operations on the trees.



Figure 5 – AF-5 multifunctional platform [12]



Figure 6 – Multifunctional platform HBK3 [13]

HOLMAC HBK3 multifunctional platform, Figure 6, is another type of platform used in agriculture for fruit harvesting, dry or green cutting, tying, inflorescence thinning, installation of support systems or manual fruit harvesting. The HOLMAC HBK3 platform represents an advanced technological solution, designed to optimize fruit-growing works carried out at height in fruit plantations. Its robust, yet adaptable construction allows for uniform and safe lifting of the working platform to heights of approximately 2.5–3.2 meters. The lifting system is fully hydraulic, which ensures efficient manoeuvrability and stability during use. The platform is equipped with protective railings, extendable working platforms and tool holders, ensuring comfort and safety for operators. The significant advantages of the HBK3 model are its self-propelled system, powered by a diesel engine that provides autonomy and traction in plantations with uneven terrain. The control panel is located on the platform and allows operators to control the movement and lifting without leaving the work area. The platform can be operated by 2–4 workers simultaneously, which makes it recommended for medium and large-sized fruit plantations, where efficiency and speed of execution are essential. Through its multifunctional nature, the HBK3 contributes to reducing operational costs by reducing the number of passes and execution times.

The HBK3 platform is an example of technological integration in the fruit-growing sector, significantly contributing to reducing work execution time and improving the working conditions of

operators, intended for medium and large farms that want to implement modern technologies in plantation maintenance.

The Haulotte Compact 12 AE electric scissor lift, Figure 7, is a versatile and efficient piece of equipment designed for work at height in various fields, including fruit growing. The platform can work at a maximum height of 12 m, with a lifting capacity of 320 kg, allowing for safe operations such as cutting, tying or harvesting fruit in orchards or plantations.

The equipment is electrically powered, offering silent and emission-free operation. The compact appearance, with a width of 1.17 m and a length of 2.49 m, allows easy maneuvering in confined spaces, characteristic of fruit plantations. The platform is equipped with non-marking wheels, thus protecting the work surfaces. A significant advantage of the Haulotte Compact 12 AE



Figure 7 – Haulotte Compact 12 AE electric scissor lift [15]

model, compared to other models in the same range, is the possibility of traveling at maximum height, which contributes to increasing operational efficiency. The platform has a protection system against potholes (Pot Hole protection), increasing the safety of operators during use.

In recent years, both globally and in Romania, several new technologies have been developed in the maintenance of fruit plantations, which have improved efficiency and productivity, namely: the use of drones for monitoring fruit trees, the use of blockchain technology for tracking agricultural products including fruit, the use of sensors for monitoring soil and climate conditions, the use of geographic information systems (GIS), and even the use of robots for harvesting [14].

Technical systems used in fruit tree maintenance technologies can help improve production, reduce diseases and pests, and save time and resources. Some of the most commonly used technical systems in fruit growing are:

- IRRIGATION SYSTEMS – a well-designed and installed irrigation system can help deliver water in precise amounts to the roots of fruit trees, thereby reducing water loss through evaporation and runoff and conserving water resources. There are various irrigation systems, such as drippers, sprinklers or microjets. Smart irrigation and fertigation managed with the help of systems with moisture sensors and automated control has a substantial impact on productivity and water consumption.
- FERTILIZATION SYSTEMS – Fertilization systems can help provide essential nutrients to the soil in which fruit trees grow. These can be in the form of chemical or organic fertilizers and can be applied through irrigation systems, by spraying or by direct burial into the soil. State-of-the-art technologies, such as drones equipped with targeted spraying systems, allow for localized application of protective substances, significantly reducing the consumption of chemicals and the impact on the environment, [16].
- SOIL MONITORING SYSTEMS – these systems allow monitoring of soil conditions, such as pH, moisture level or the amount of available nutrients. Retrieving this data can provide information that helps adjust the amount and type of fertilization, as well as the amount of water used.
- PRUNING AND HARVESTING SYSTEMS – there are a variety of tools used for pruning and harvesting fruit from fruit trees, such as pruning shears, chainsaws, harvesting machines, fruit platforms, etc. They can save time and be more efficient than manual pruning or manual harvesting. Pruning for the formation, maintenance and regeneration of the crown of fruit trees is an essential work to ensure constant and quality production. In the context of the digitalization

of agriculture, the emergence of semi-automatic and robotic equipment has radically changed the approach to pruning work, so the equipment is equipped with mobile hydraulic arms and guidance systems that can automatically adjust the position of the cutting blades depending on the density of branches and the height of the trees, thus increasing precision and reducing intervention time [17].

- PEST AND DISEASE CONTROL SYSTEMS – these systems include the use of pesticides, fungicides or other substances to control pests and diseases affecting fruit trees. There are also pest and disease monitoring systems, which allow for early detection and prevention of their spread.
- WEATHER PROTECTION SYSTEMS – these include the use of covering systems to protect fruit trees from wind, hail or other extreme weather conditions.
- PLANT SURVEILLANCE SYSTEMS – these systems use sensors to monitor the health of fruit trees, including leaves and fruit. This information can help in early detection of health problems and intervention accordingly.

The integration of modern technical systems into fruit tree maintenance technologies contributes significantly to increasing the efficiency of agricultural work. Through automation, digitalization and the use of specialized equipment, major benefits are achieved such as optimizing production, reducing the incidence of diseases and pests, and saving human and material resources. Thus, these technological solutions not only support the sustainability of fruit farms, but also ensure their adaptation to the increasingly high requirements of the modern and continuously developing agri-food market [18–19].

4. RESULTS

Following the comparative analysis carried out on the main types of platforms used in the maintenance of fruit plantations, a series of functional, constructive and operational characteristics were highlighted that differentiate these equipment according to technical performance and adaptability to various types of orchards.

- Technical and functional performances of the types of platforms subjected to the comparative study show that the tests carried out under laboratory conditions and/or controlled operation followed a series of relevant parameters, such as: maximum working height (2.5...10 m), lifting capacity (number of operators, useful weight), travel speed, stability in work, turning radius and manoeuvrability in narrow spaces. These values were compared between semi-hydraulic, electric scissor, multifunctional or self-propelled platforms, each presenting specific advantages depending on the purpose of use (cutting, harvesting, phytosanitary treatments).
- The efficiency of maintenance work appears when it is observed that platforms with electric or hydraulic drive have managed to reduce working time by up to 30–40% compared to working with ladders or traditional equipment, plus increasing operator safety with a reduction in physical effort. At the same time, the integration of automatic or semi-automatic controls for platform positioning contributes to the fluidity of cutting or harvesting activities.
- Adaptability to terrain and crop is evident from results that indicated that platforms with articulated chassis, adjustable track or all-wheel drive have superior adaptability in modern intensive or super-intensive plantations, where access between rows is limited and the terrain can be uneven.
- Ergonomics and operability: The ergonomics assessment highlighted that modern models are designed to enhance user comfort: platforms with non-slip floors, side guards, intuitive controls and silent lifting systems. These factors contribute to maintaining constant productivity throughout the entire work season.

The relevance of systems analysis is important on the one hand, it provides a useful tool for farmers and investors interested in developing high-performance fruit farms; on the other hand, it supports the decision-making process of authorities and agricultural research institutions in formulating

support and innovation policies in the fruit sector. In addition, in the context of the transition to a digital and green agriculture, the comparative evaluation of fruit platforms contributes to the foundation of smarter, more efficient and more environmentally friendly agricultural practices.

The analysis targeted some of the following platforms: *PL-6* – semi-hydraulic platform for orchards; *BIG 2000* – multifunctional self-propelled platform, used in super-intensive plantations; *Argilés AF5* – platform with electric system, designed for precision work; *Holmac 36043* – professional platform with increased stability and integrated equipment.

The methodology involved detailed documentation of the technical specifications of established models on the market, belonging to recognized manufacturers in the field. These platforms are used in various stages of fruit-growing work, from training and maintenance pruning, to the application of phytosanitary treatments and harvesting. Thus, models with mechanical, hydraulic or electric propulsion, towed or self-propelled, were selected and analyzed, providing a comprehensive picture of the existing options, table 1.

Table 1

Exemplary	Type	Working height	Capacity	Advantages	limitation
PL-6	semi-hydraulic	2.6m	6 people	Low cost, simple maintenance	Requires tractor, reduced mobility
BIG 2000	propelled	–	MULTIPURPOSE	Automation, high efficiency	High cost, specialized maintenance
Clay AF5	propelled	–	MULTIPURPOSE	Versatility, operator comfort	High price, limited availability
Holmac	MACHINE	–	modulation	Energy efficient, compact design	Requires qualified personnel
PLR-2.5	hydraulics	2.5m	6 people	Stability, compact size	Requires tractor
SGT 28 ALS	propelled	28 m	–	Suitable for difficult terrain	High cost, operating complexity
Haulotte Compact 12 AE	propelled	12 m	–	Ideal for narrow spaces	Suitable for indoor use

In this dynamic context, the comparative analysis of different types of fruit platforms – from traditional to super-intensive – becomes essential for identifying the most efficient tree maintenance models, adapted to current market requirements and increasingly unpredictable climatic conditions. Data were collected from technical data sheets, product brochures, scientific publications, as well as official online sources of manufacturers. The comparative evaluation was based on criteria such as working height, operating capacity, type of propulsion, maneuverability, ergonomics, as well as acquisition and maintenance costs, table 2.

Fruit growing methods and systems have evolved with new aspects of modernization and economic efficiency (e.g. dwarf tree plantation), [2]. Based on the above classification criteria of the methods and systems of cultivation, the following characteristics have been established:

- Extensive in all tree species , main agro-economic characteristics: production 10 t/ha; extra fruit 50%, first quality 35%, second quality 15%; number of trees per ha up to 350; generative rootstocks of high vigor; vigorous trees with globular crown; height 5...12 m; large planting distances 7x7.8x8 m; average mechanization; fruiting at 8...10 years; economic fruiting up to 30...35 years; manual labor consumption 810 h/man; labour productivity 88 h/t.
- Intensive for all tree species (fruit or fruit hedges), with a series of agro-economic characteristics: production 20 t/ha; extra fruit 70%, quality I 25%; quality II 5%; number of trees per ha 7,001,650; vegetative rootstocks of medium vigour; trees with flattened or globular crown; average height 34 m; average planting distance 4x5 m; good mechanization; fruiting at 4...6 years; economic fruiting up to 15...20 years; manual labor consumption 916 h/man; labor productivity 37 h/t.
- Superintensive for apple, pear, peach, cherry species (with dwarf trees), where the agro-economic characteristics are the following: production 30t/ha; extra fruit 80%, quality Ia 15%; quality II 5%; number of trees per ha 19,008,000; vegetative rootstocks, weak vigor; trees weak vigour, globular and flattened crowns; good mechanization; fruiting at 23 years; economic

fruiting 12–15 years; small planting distances; labor productivity 24 h/t; labour force consumption 900 h/man/ha.

Table 2

Characteristic	PLR-2.5	PL-6	Clay AF5	BIG 2000
Platform type	hydraulics	semi-hydraulic	electric	propelled
Max. working height	2.5m	2.5m	approx. 3 m	up to 4 m
Propulsion type	towable/tractor	tractor (PTO)	electric battery	diesel engine
Operator capacity	2–3	2–4	1–2	4–6
Field of use	cutting, picking	maintenance, harvesting	precise maintenance	complex works
Terrain adaptability	average	average	great	great
Estimated cost	environment	reduced	high	very high

Comparison of platform models analysed based on technical-functional characteristics and observations during use, table 3, the analysed platforms were compared according to:

- adaptability to the terrain and orchard density;
- productivity during maintenance work (cutting, picking, treatments);
- operator safety;
- the level of automation and ease of operation.

Table 3

Platform model	Drive type	Max. working height (m)	Estimated productivity	Recommended use
PLR-2.5	hydraulics	2.5	average	cutting/picking work
BIG 2000	semi-hydraulic	3.2	high	super intensive orchard maintenance
HOLMAC HBK3	MULTIPURPOSE	vary (with arm)	very high	various works, high adaptability
Haulotte Compact 12 AE	electric (scissors)	12	very high	tall orchards, phytosanitary treatments
SGT 28 ALS	articulated telescopic	up to 28	high (limited to space)	applicable in spacious orchards

Electric and multifunctional models offer the advantage of reducing energy consumption and emissions, table 3, being recommended for working in sensitive environments or on farms that aim for sustainability, and hydraulically operated platforms are robust and offer an efficient alternative for classic plantations, with moderate dimensions, but telescopic platforms offer accessibility to operate at high working heights, but are more difficult to manoeuvre in plantations/orchards with narrow rows or uneven terrain Figure 8.

5. DISCUSSIONS

Following the comparative analysis of the platform models, significant differences were identified in terms of working height, propulsion mode and degree of adaptability to different types of plantations. Hydraulic and semi-hydraulic platforms (PLR-2.5 and PL-6) offer a good cost-benefit ratio for small and medium-sized farms, while electric and self-propelled models (Argilés AF5 and BIG 2000) are more suitable for intensive farms, where efficiency, autonomy and operator comfort are priorities.

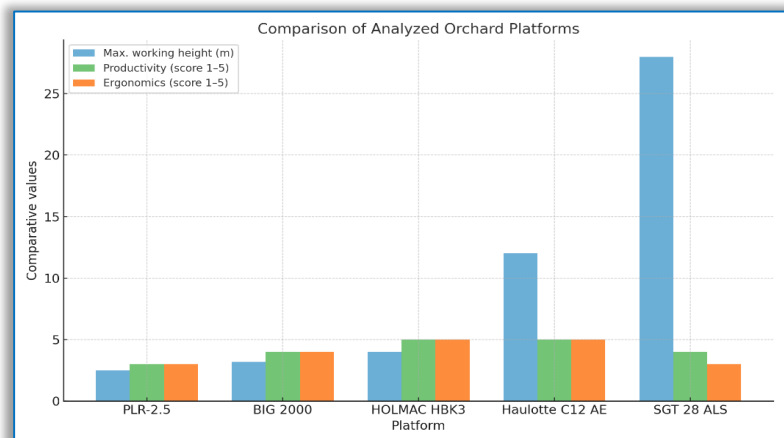


Figure 8. Comparative analysis between fruit platforms

The comparative analysis of the four fruit platforms – PLR-2.5, PL-6, Argilés AF5 and BIG 2000 – was carried out based on the main functional and constructive characteristics, as well as the degree of adaptability to different types of plantations. The results highlight the differences between classic and modern solutions, as well as the impact that the choice of equipment has on the productivity, ergonomics and sustainability of the farm.

Working height and lifting capacity

The PLR-2.5 and PL-6 models offer a maximum working height of 2.5 m, suitable for classic and semi-intensive orchards. The Argilés AF5 allows interventions at heights of approximately 3 m, being suitable for super-intensive plantations with small trees. On the other hand, the BIG 2000 offers a higher working height, up to 4 m, which makes it versatile in medium-sized palmette or vertical axis cultivation systems.

Drive mode and power source

The PLR-2.5 and PL-6 platforms are hydraulically driven, by attachment to the tractor or PTO source, which partially limits their autonomy and flexibility. In contrast, the Argilés AF5 operates electrically, with zero emissions and low noise, being an ecological and economical option for farms oriented towards sustainable agriculture. The BIG 2000 is a self-propelled model with a diesel engine, with the advantage of mobility and autonomy in open fields.

Operator capacity and work ergonomics

While the PLR-2.5 and PL-6 models allow 2–4 operators to work simultaneously, the Argilés AF5 and BIG 2000 platforms have a higher capacity, 1–2 and up to 6 operators respectively. This allows for efficient team organization and the execution of multiple tasks in parallel. The BIG 2000 also offers extendable side tables and ergonomic controls, helping to reduce physical fatigue for workers.

Adaptability and costs

From an economic point of view, the PL-6 remains an affordable solution for small and medium-sized farms, while the BIG 2000 involves a high investment cost, justified by the advanced level of automation. The Argilés AF5, although more expensive than classic models, stands out for its low operating costs and long-term benefits in terms of maintenance and energy consumption.

Contribution to the efficiency of fruit growing work

The analyzed data shows that the use of mechanized platforms leads to a significant increase in the productivity of seasonal works, especially in terms of green/dry cutting and harvesting. The choice of the right platform must be correlated with the type of plantation, tree density, management model and technological calendar of the works.

6. CONCLUSIONS

In conclusion, the comparative analysis of different types of fruit platforms highlights the significant progress recorded in terms of mechanization and automation of maintenance work in orchards. Modern platforms, equipped with hydraulic systems, ergonomic controls and the ability to work at variable heights, directly contribute to increasing efficiency, reducing execution time and improving working conditions for operators. There is a shift from simple platforms, designed exclusively for lifting workers, to multifunctional solutions, capable of serving several operations (cutting, harvesting, phytosanitary treatments) in a safe and sustainable way. At the same time, the integration of sensors, digital controls and even electrical controls ensures added precision and control in maintenance activities.

The research results suggest that the choice of the right platform must be based on the analysis of the specific conditions of each plantation: the type of trees, planting distances, terrain relief and the intensity of seasonal work. The use of high-performance platforms makes a major contribution to increasing productivity, reducing operating costs and obtaining more uniform and healthier crops.

Therefore, the adoption of technological platforms in fruit growing is not only justified, but also necessary in the context of modern agriculture, characterized by increasingly high requirements regarding quality, yield and sustainability of production.

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