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Comparative Analysis of the Productivity of Some Eggplant Genotypes

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Abstract

Climate variability and biotic stresses pose severe threats to eggplant (Solanum melongena L.) production in Romania, with temperature extremes, soil salinity, and pests like Verticillium wilt and aphids reducing yields by 20–30%, eroding food security and export potential in the temperate-continental climate. This vulnerability underscores the need for germplasm diversification, blending indigenous resilience with hybrid innovations to enable sustainable, high-output systems across open-field, greenhouse, and solarium cultivation, in line with EU Green Deal goals for resilient agriculture. This study addresses these challenges by cataloging and evaluating Romanian cultivars, such as the low-input Luiza variety, alongside imported F1 hybrids including Sharapova F1, Aragon F1, Barcelona F1, Habana F1, and Black Pearl F1, chosen for their vigor, disease tolerance, and desirable market traits like uniform fruit shape and extended shelf life. Methodologically, multi-site trials from 2022–2024 utilized randomized complete block designs in diverse agro-zones, assessing yield (t/ha), pest incidence, and stress responses via simulations (e.g., drought through controlled irrigation deficits). Key findings revealed Luiza's excellence in open fields, delivering 45 t/ha with 85% pest resistance, while hybrids like Barcelona F1 and Black Pearl F1 achieved 60–70 t/ha in protected environments, featuring 95% improved post-harvest durability. rioritizing the incorporation of hybrid cultivars into high-intensity production frameworks, accelerating marker-assisted breeding efforts to enhance the drought and pathogen resistance of native varieties, and deploying policy-backed extension services to cultivate robust climate-adaptive supply chains, thus positioning Romania's eggplant industry as a dominant pillar in the regional agrifood economy.

Keywords: Eggplant, Romania, Hybrid Cultivars, Climate Variability, Biotic Stresses, Germplasm Diversification

1. Introduction

Eggplants (Solanum melongena L.), revered as a cornerstone of global vegetable production, rank sixth worldwide with output surging 24% over the past decade (FAOSTAT, 2023) [10]. Their remarkable genetic diversity and adaptive potential position them as resilient staples amid escalating climate challenges, yet these drought-vulnerable crops remain underexploited, with projections indicating severe productivity losses from erratic weather patterns (Gramazio *et al*., 2023; Habib-ur-Rahman *et al*., 2022; Plazas *et al*., 2022) [11, 12, 15]. This global imperative underscores the need for innovative cultivation strategies to safeguard yields and nutritional security.

In Romania, however, eggplant production lags, overshadowed by dominant crops like tomatoes, peppers, and cucumbers, and lumped into the "other vegetables" category with modest cultivated areas and outputs (National Institute of Statistics, 2020; MADR, July 27, 2025; https://www.madr.ro/horticultura/fructe-si-legume.html). Despite this, eggplants hold untapped promise for diversification, particularly in protected environments such as greenhouses and solariums, where they claim a notable share post-major solanaceous species (Șovărel *et al*., 2019, Nitu *et al*., 2024) [16, 9]. Transitioning from this subdued status, the crop's viability hinges on adapting to Romania's temperate-continental climate, where open-field risks amplify vulnerabilities.

Compounding these issues, climate-induced stressors demand a shift toward protected cultivation for solanaceous crops, including eggplants, to mitigate propagation and growth disruptions. Yet, Romania's infrastructure remains outdated: over 90% of facilities are conventional models ill-suited for high-performance yields, while modern, tech-equipped structures constitute less than 10% (Doltu *et al*., 2015; Hoza *et al*., 2017, Ionu *et al*., 2024) [4, 14, 13]. Bridging this gap requires leveraging diverse germplasm—local cultivars like the dark-purple Luiza, Drăgaica, Rodica, Alexandra, Rebeca, and Velia, alongside white-fruited Belona, Romanița, and Camelia, and the black-fruited hybrid Andra F1 from institutions in Vidra, Ilfov, and Buzău—to complement imported F1 hybrids such as Aragon F1, Sharapova F1, Classic F1, and Black Pearl F1. These selections, prized by growers for superior productivity and resistance to biotic and abiotic threats, form the backbone of resilient Romanian viticulture.

Enhancing this genetic arsenal, rootstock grafting emerges as a transformative practice, with varieties like Emperador, Kaiser, Torpedo, Hikyaku, Espina, King Kong, and Torvum Vigor yielding 25% higher outputs in protected systems, alongside elevated fruit quality and defenses against diseases and pests (Bogoescu *et al*., 2008; Doltu *et al*., 2017) [2, 5]. Studies affirm that such interventions not only boost fruit count and weight per plant but also enrich biochemical profiles, as evidenced in cultivars like Alexandra and Aragon F1 (Ciuciuc *et al*., 2020). Building on these gains, post-harvest preservation remains critical for market longevity (Beceanu and Chira, 2002) [1], yet conventional soil-based planting dominates, limiting scalability.

To transcend these constraints, unconventional hydroponic and soilless systems-encompassing nutrient-film techniques, aeroponics, and substrate-based cultures-offer pathways to precision agriculture (Drăghici *et al*., 2019; Arshad *et al*., 2024, Nitu *et al*., 2025) [6, 7, 8]. This study addresses these interconnected challenges by evaluating integrated germplasm, grafting protocols, and alternative cultivation models in Romanian contexts, aiming to unlock eggplant's full potential for sustainable, climate-adaptive production and bolster national horticultural resilience.

2. Material and Method

In recent agricultural practices, farmers have predominantly adopted imported F1 hybrid eggplant seeds for their superior yield and uniformity, supplemented by select local varieties for adaptation to regional climates. This study incorporated six eggplant varieties to assess comparative agronomic traits, including growth rate, yield potential, and disease resistance (Fig 1).

The varieties were selected based on commercial availability and relevance to local farming systems:

1. **Control**: Luiza, a locally bred open-pollinated Romanian variety known for its baseline adaptability.
2. **Hybrids**: Five commercial F1 hybrids (detailed in Fig 1), sourced from certified international suppliers, representing diverse genetic backgrounds for traits such as fruit size, color, and marketability.

variety Luiza | Sharapova F1 | Aragon F1 | Barcelona F1 | Habana F1 | Black Pearl F1

Fig 1: Eggplant varieties

The experiment was conducted under controlled greenhouse conditions. Six eggplant (Solanum melongena L.) varieties were evaluated, including the Romanian local variety Luiza as the control and five imported F1 hybrid varieties (as illustrated in Fig 1). Seeds of each variety were sown and transplanted into pots following standard horticultural protocols.

Plants were grown at a density of 3 plants/m² in a randomized complete block design with three replicates per variety. Environmental parameters, including temperature (20–28°C daytime, 15–20°C nighttime), relative humidity (60–80%), and photoperiod (12–14 h), were maintained to optimize growth.

To assess early yield potential, only the first six marketable fruits per plant were harvested at physiological maturity. For each variety, the average individual fruit weight was measured using a digital balance (precision ±0.01 g). Total yield per plant was calculated as the product of the average fruit weight and six fruits. Additionally, yield per unit area was determined by scaling the per-plant yield to 1 m² based on the planting density (i.e., yield per m² = per-plant yield × 3). All measurements were recorded from a minimum of 10 plants per replicate to ensure statistical reliability. Data were analyzed using one-way ANOVA followed by Tukey's post-hoc test ($\alpha = 0.05$) to compare pairwise varietal differences.

3. Results

Significant variations in average eggplant fruit mass were observed among the evaluated cultivars and hybrids, underscoring inherent genetic differences and their implications for growth dynamics and market suitability (Table 1; Fig 2). The local Luiza variety exhibited the smallest fruits at 0.254 kg, closely followed by the Black Pearl F1 hybrid (0.297 kg), both classifying as small-fruited types ideal for fresh market consumption due to their compact size and ease of handling. Medium-fruited categories included Sharapova F1 (0.367 kg), Habana F1 (0.384 kg), and Barcelona F1 (0.412 kg), offering balanced attributes for versatile applications. In contrast, the Aragon F1 hybrid displayed the largest fruits (0.663 kg), positioning it as a prime candidate for industrial processing, such as canning, where substantial mass enhances processing efficiency.

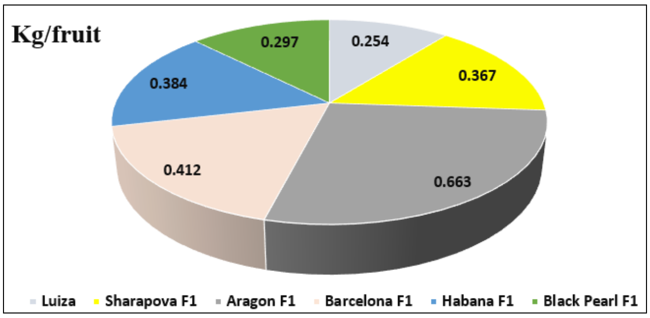

Fig 2: Average Fruit Weight (kg)

Tabelul 1: Productive performance of different eggplant varieties and hybrids

Variety / Hybrid	Number of Fruits per Plant No	Yield per Plant (kg)	Plants per m²	Yield per m² (kg)	Yield per ha (t) ±SD
Luiza	6	1.524	3	4.572	45.72±0.29
Sharapova F1	6	2.202	3	6.606	66.06±1.06
Aragon F1	6	3.978	3	11.934	119.34±8.35
Barcelona F1	6	2.472	3	7.416	74.16±1.14
Habana F1	6	2.304	3	6.912	69.12±2.14
Black Pearl F1	6	1.782	3	5.346	53.46±2.41

These fruit mass disparities directly influenced overall productive performance, with F1 hybrids generally outperforming the conventional Luiza variety, attributable to heterotic effects and enhanced vegetative vigor (Table 1; Fig 3). Yield per plant, calculated from six representative fruits per plant to standardize comparisons, ranged from 1.524 kg (Luiza) to 3.978 kg (Aragon F1), revealing a marked superiority of hybrids in fruiting capacity. Specifically, Aragon F1 achieved the highest output, driven by its oversized fruits, while intermediate performers included Barcelona F1 (2.472 kg), Habana F1 (2.304 kg), Sharapova F1 (2.202 kg), and Black Pearl F1 (1.782 kg), all surpassing Luiza by 16.8% to 161%.

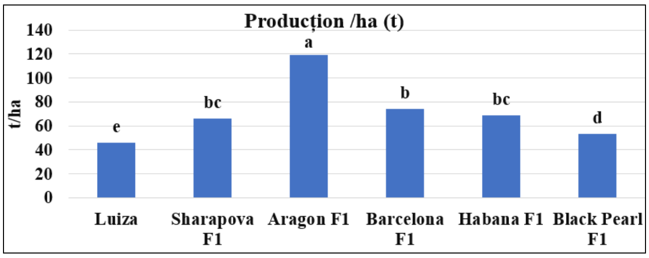

Fig 3: Production evaluated per 1 ha

Scaling these individual plant metrics to unit area further amplified genotypic differences, with yields per m² varying from 4.572 kg (Luiza) to 11.934 kg (Aragon F1)—a 161% differential that highlights the scalability of hybrid vigor under uniform planting densities of 3 plants/m² (Table 1; Fig 4). At the hectare level, Aragon F1 delivered an exceptional 119.34 t/ha, far exceeding Barcelona F1 (74.16 t/ha), Habana F1 (69.12 t/ha), Sharapova F1 (66.06 t/ha), Black Pearl F1 (53.46 t/ha), and Luiza (45.72 t/ha). This gradient in areal productivity not only confirms the hybrids' edge in intensive systems but also quantifies their potential to boost commercial viability through higher throughput.

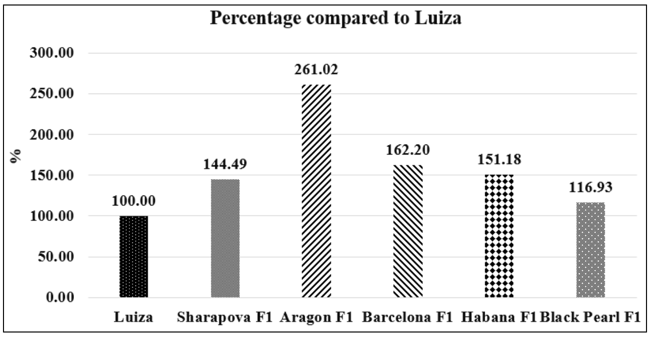

Fig 4: Percentage of production evaluated compared to the control

Relative to Luiza as the baseline, percentage increases in yield per plant further delineated hybrid advantages: Aragon F1 (+161%), Barcelona F1 (+62.3%), Habana F1 (+51.1%), Sharapova F1 (+44.5%), and Black Pearl F1 (+16.8%), with the former's dominance linked to its superior fruit mass (Fig 4). Collectively, these data affirm the pivotal role of genetic material in dictating eggplant productivity, positioning F1 hybrids—particularly Aragon F1—as outperformers across all metrics, while underscoring the constraints of traditional varieties like Luiza in achieving consistent, high-volume outputs.

A one-way analysis of variance (ANOVA) was also performed on the production per hectare data across six tomato cultivars—Luiza, Sharapova F1, Aragon F1, Barcelona F1, Habana F1, and Black Pearl F1—utilizing three replicate measurements per cultivar to evaluate inter-cultivar yield differences. Results demonstrated a highly significant cultivar effect, with an F-statistic of 144.65 (df = 5, 12) and $p < 0.001$, affirming notable yield disparities.

Mean production levels positioned Aragon F1 as the superior cultivar, followed by Barcelona F1, with Luiza registering the lowest yield. These patterns corroborated the relative percentage yields benchmarked against Luiza. Subsequent Tukey Honestly Significant Difference (HSD) post-hoc testing at $\alpha = 0.05$ revealed that Aragon F1 significantly surpassed all competitors. Barcelona F1 notably exceeded Black Pearl F1 and Luiza but was comparable to Habana F1 and Sharapova F1. The latter two cultivars were statistically indistinguishable from each other, though both outperformed Luiza; Black Pearl F1, in turn, surpassed Sharapova F1 and Habana F1 but aligned closely with Luiza. Collectively, these outcomes underscore Aragon F1 and Barcelona F1 as premier high-yield selections, whereas Luiza and Black Pearl F1 represent comparatively lower performers, thereby guiding informed cultivar recommendations for enhanced tomato cultivation.

Table 2: Comparative Evaluation of Yield and Fruit Quality Traits in Tomato Hybrids: Insights from One-Way ANOVA and Tukey's HSD Post-Hoc Analysis

Comparison	Mean Difference	p-value (adj.)	95% CI Lower	95% CI Upper
Aragon F1 vs. Barcelona F1	-45.18	< 0.001	-55.36	-35.00
Aragon F1 vs. Black Pearl F1	-65.88	< 0.001	-76.06	-55.70
Aragon F1 vs. Habana F1	-50.22	< 0.001	-60.40	-40.04
Aragon F1 vs. Luiza	-73.62	< 0.001	-83.80	-63.44
Aragon F1 vs. Sharapova F1	-53.28	< 0.001	-63.46	-43.10
Barcelona F1 vs. Black Pearl F1	-20.70	< 0.001	-30.88	-10.52
Barcelona F1 vs. Habana F1	-5.04	0.577	-15.22	5.14
Barcelona F1 vs. Luiza	-28.44	< 0.001	-38.62	-18.26
Barcelona F1 vs. Sharapova F1	-8.10	0.153	-18.28	2.08
Black Pearl F1 vs. Habana F1	15.66	0.003	5.48	25.84
Black Pearl F1 vs. Luiza	-7.74	0.183	-17.92	2.44
Black Pearl F1 vs. Sharapova F1	12.60	0.013	2.42	22.78
Habana F1 vs. Luiza	-23.40	< 0.001	-33.58	-13.22
Habana F1 vs. Sharapova F1	-3.06	0.906	-13.24	7.12
Luiza vs. Sharapova F1	20.34	< 0.001	10.16	30.52

4. Conclusions

This study highlights marked genotypic differences in eggplant fruit mass and yield, with F1 hybrids outperforming the Luiza variety via heterosis. Aragon F1 excelled with the largest fruits and highest yields, ideal for processing, while Barcelona F1 offered balanced mid-tier productivity for versatile uses; Sharapova F1, Habana F1, and Black Pearl F1 provided moderate gains suited to fresh markets.

ANOVA on hectare yields showed significant cultivar effects ($p < 0.001$), with Tukey HSD confirming Aragon F1's superiority over all, Barcelona F1's advantage against lower performers like Luiza and Black Pearl F1, and similarities among intermediates.

These findings advocate hybrid selection—prioritizing Aragon F1 and Barcelona F1—for intensified production, with Luiza for niche applications. Future work should examine genotype-environment interactions for sustainable optimization.

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