

ABSTRACT

The thesis looks at, in a sort of integrated way, how three main technological factors in eggplant cultivation, the hybrid, grafting, and fertilization, can shape both productivity and the biochemical profile of the fruits, especially their antioxidant capacity. The work tries to bring together theory with practical research, with the aim of linking results from horticultural fields to the newer trends in sustainable farming and functional food.

Part I shows the importance of eggplants from several sides, food, therapeutic, economic and agrotechnical, and also the ecological needs of the crop and some details about technologies in protected areas. In this section I also talk about the principles of grafting and give a critical overview of what the literature says about how different technologies affect biochemical indicators (like dry matter, macro- and microelements, pigments, antioxidant potential).

Part II goes into the experimental study carried out between 2019–2021 at the “V. Adamachi” SCPS (USV Iași). The research was set up using a factorial design with two hybrids (Mirval F1, Black Pearl F1), two rootstocks (Rezistar, *S. sisymbriifolium*), a control, and four fertilization treatments (control, biological – Micoseed, organic – Orgevit, chemical – Nutrispore). This layout made it possible to look not only at individual effects, but also how the factors interact and influence crop performance.

The protocol included biometric and agro productive measurements (vegetative growth, fruit architecture, yield), biochemical tests (polyphenols, tannins, chlorophylls, lycopene), also the evaluation of antioxidant capacity (DPPH, ABTS), titratable acidity and photosynthetic parameters with the LCpro+ system (A, gs, E, Ci, Tl, Qleaf).

The main goal was to define a technological model that could bring together productivity with functional quality and resource efficiency, all in the idea of sustainable agriculture. The specific objectives were something like: i) to see how hybrid, grafting and fertilization affected production and fruiting, ii) to identify biochemical and antioxidant signatures, iii) to connect the photosynthetic profile with productive performance, and iv) to prepare an optimized model, based on experimental evidence, that would actually respond to what producers and consumers are asking for.

Materials and methodology

In the experimental program we tested two eggplant hybrids that had quite different practical value. Mirval F1 was very early maturing and had a high productive potential, while Black Pearl F1 was semi early, being appreciated mainly for the uniformity and the commercial quality of the fruits. For grafting we used two known rootstocks, Rezistar (*Solanum torvum*), which is recognized for its tolerance to pathogens and its vigor, and *Solanum sisymbriifolium*, which was included mainly for research purpose, together with an ungrafted control.

The nutrition scheme included four contrasting regimes. Micoseed was a biological treatment, based on microbial consortia, Orgevit was organic, made from granulated poultry manure, Nutrispore was a chemical NPK with fast effect, and finally we had a control variant without fertilization.

The experiment was carried out between 2019 and 2021 at the “Vasile Adamachi” teaching farm of USV Iași. It followed a split plot design with three replications and randomized placement, in order to evaluate the effects and interactions between hybrid, grafting and fertilization. The measurements looked at agro productive, biometric, biochemical and physiological aspects. We analyzed polyphenols and tannins (by spectrophotometry), photosynthetic pigments (chlorophylls and lycopene), antioxidant

activity (DPPH and ABTS tests), titratable acidity and also photosynthetic parameters such as net assimilation, stomatal conductance, transpiration, intercellular CO₂, leaf temperature and photosynthetic active radiation, using the LCpro+ system.

Experimental results

1. Productive parameters - the comparative analysis of the two hybrids showed a clear advantage for Mirval F1, which surpassed Black Pearl F1 both in average yield (81,459 compared to 54,267 kg/ha) and in the number of fruits per plant (3.9 vs 3.2). The differences came mainly from the heavier fruit load, not really from the individual mass. Grafting confirmed its decisive role, increasing yield a lot: Rezistar reached 81,349 kg/ha, *S. sisymbriifolium* 74,523 kg/ha, while the control only had 47,955 kg/ha, with similar increases also in fruit number. Biological fertilization with Micoseed gave the best outcome (73,793 kg/ha and 4.3 fruits per plant). On the other hand, the control had bigger fruits (0.73 kg), but a lower fruit load, which finally limited the total yield. These results point out the trade off between individual fruit weight and fruit number, and also underline the importance of keeping a technological balance if we want superior performance.

2. Biochemical profile and antioxidants - the total polyphenol content (TPC) was in general higher in Mirval F1 than in Black Pearl F1, but the clearest differences showed up when interactions were considered. The combinations Mirval F1 × ungrafted × organic and Mirval F1 × *S. sisymbriifolium* × Micoseed reached the highest TPC peaks, suggesting that a moderate nutrient supply together with rhizospheric stimulation may favor phenolic accumulation. For pigments, chlorophylls and lycopene were maximized under treatments with strong mineral nutrition. For example Mirval F1 grafted on *S. sisymbriifolium* with chemical fertilization had the top values, but also the ungrafted with organic fertilization gave competitive lycopene levels, probably because of a potassium–water balance.

The tannin content varied only within narrow limits, no risk of astringency, with a sharp peak in Mirval F1 × ungrafted × organic, showing a synergy between secondary metabolism and resource availability. Antioxidant evaluation (ABTS, DPPH) confirmed the dependence on combinations. *S. sisymbriifolium* favored mostly DPPH, while Rezistar stimulated ABTS when biological fertilization was applied. The best scores appeared in Mirval F1 × Rezistar × Micoseed (DPPH) and Mirval F1 × *S. sisymbriifolium* × chemical (ABTS). Still, the high chlorophyll or TPC values from ungrafted variants did not always mean higher antioxidant scores, which suggests antioxidant efficiency depends more on phenolic integration and the overall physiological status than on a single biochemical.

3. Titratable acidity - the titratable acidity values showed a relatively narrow variability among the variants, no deviations that would indicate major imbalances in the organoleptic profile. Yet, there was a general trend of lower acidity in biological and organic regimes, both for Black Pearl F1 and Mirval F1, compared with chemical treatments. From a taste perspective the differences are subtle, they may only refine the pleasure of consumption without compromising the fruit quality.

4. Gas exchange and photosynthesis (LCpro+) - the physiological analysis showed some subtle but still important differences between hybrids and treatments. In Mirval F1, the control kept rather stable values of net assimilation ($A \approx 6.0 \mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$), with stomatal conductance around 0.30 to 0.32 and transpiration near 3.1 to 3.3, while the intercellular CO₂ concentration was between 335 and 345 ppm. Under biological fertilization there were short phases of decrease, followed by quick recoveries back in the 5.8–7.0 range, linked with a better internal efficiency. On the other hand chemical fertilization gave lower assimilation values, even though Qleaf and transpiration increased, which seems to point to a reduced photochemical efficiency at some hours of the day.

For Black Pearl F1, the control variant showed medium to high A values and solid stomatal conductance. Biological fertilization kept similar levels, with leaf temperature a bit higher, but without clear signs of heat stress. Chemical fertilization pushed assimilation to higher peaks in some intervals, but this came together with higher transpiration and conductance, meaning more water consumption for basically the same photosynthetic gain. As for the rootstocks, *S. sisymbriifolium* boosted net assimilation a lot under chemical fertilization and also gave stability in biological regime, while Rezistar stood out when paired with Mirval F1, where it raised ABTS scores and ensured a fast physiological recovery after temporary drops. These findings suggest that the choice of rootstock may affect not only yield and biochemical quality, but also the physiological resilience of the plants under changing nutrition and microclimate conditions.

The photosynthesis analysis showed both photochemical and stomatal limitations, and also underlined the role of the root microbiome in more efficient carbon use. Overall, what comes out is the need of a balanced model that combines economic yield, functional quality and resource efficiency, in line with the principles of sustainable agriculture.

Proposed technological model (based on the operational synthesis). From the results, three main technological scenarios can be outlined, each one pointing toward a different agronomic objective. The first is maximizing production. For this, the best combination seems to be Mirval F1 × Rezistar × Micoseed, with rational irrigation and careful management of fruit load. This gives high yields, stable assimilation and a moderate water cost, so it fits well for farms more focused on volume and profitability.

The second scenario is aiming for higher functional quality. The best option here is Mirval F1 × *S. sisymbriifolium*, fertilized organic (which helps TPC and lycopene) or chemical but well dosed (for chlorophylls and ABTS). Irrigation has to be carefully adjusted so it supports biosynthesis of bioactive compounds. This scenario makes more sense for niche markets where buyers are looking for functional food value. The third is about keeping a balance between quality and sustainability. For that, the recommended solution is Black Pearl F1 × *S. sisymbriifolium* with biological or organic fertilization. It provides better water use efficiency, a strong antioxidant profile and physiological stability, so it is more suitable for farms interested in reducing mineral inputs.

Personal contributions, added value and limitations. One of the main merits of this research is the mapping of interactions between hybrid, rootstock and fertilization regime on antioxidant biomarkers (DPPH, ABTS), correlated with the pigment profile (chlorophylls, lycopene) and with the level of total polyphenols (TPC). This integrated approach allowed to identify the best combinations for functional quality and also showed the role of physiological mechanisms in shaping the differences in performance. An original contribution is the link between leaf photosynthesis (A, gs, E, Ci), measured with the LCpro+ system, and both yield and biochemical composition of the fruits. It highlighted that productivity and quality are determined by a balance between photosynthesis and water.

Based on these findings, the thesis proposes a technological model grounded on evidence, able to optimize productivity and functional value at the same time, being adapted to greenhouse conditions and compatible with the principles of sustainable agriculture. Still, the study has some limits. There is the natural variability of physiological measurements, the restricted selection of genotypes (two hybrids and two rootstocks), and also the different behavior of antioxidant markers, which underlines the need of a multi-marker approach. These aspects do not reduce the value of the conclusions, rather they open clear directions for future research, with wider panels of biomarkers and validation on a broader genetic spectrum.

General conclusions of the thesis. The results obtained in this research demonstrate, through a coherent set of experimental data, that the agronomic and functional value of eggplants cannot be assigned to just one isolated technological factor, but comes from the smart and balanced harmonization of three essential components, the hybrid, the rootstock and the fertilization regime. The choice of hybrid sets the genetic platform of performance, while the rootstock and fertilization shape, through physiological and biochemical mechanisms, the final expression of yield and quality. Mirval F1 hybrid confirmed itself as a solid base for high commercial yields, and when combined with the Rezistar rootstock and with biological fertilization Micoseed it can be pushed towards top performance, integrating vegetative vigor, photosynthetic stability and a strong supply of antioxidants. On the other hand, *S. sisymbriifolium* rootstock stood out by providing photosynthetic robustness and higher pigment levels, especially in mineral nutrition scenarios, where lycopene and ABTS scores reached reference values. These differences underline that each combination has its own profile of advantages, and the choice must be made depending on the main objective, volume, functional quality or sustainable balance.

The research shows that the future of technologies in eggplant cultivation is not a fixed recipe, but an integrated and flexible strategy, able to use the complementarity between genetics, technology and environment, for the benefit of farmers, consumers and agricultural sustainability.