THE POTENTIAL FOR INCREASE IN THE QUANTITY AND QUALITY OF SEEDS IN SOLANO-FRUITFUL VEGETABLES

POTENȚIALUL CREȘTERII CANTITĂȚII ȘI CALITĂȚII SEMINȚELOR LA LEGUMELE SOLANO-FRUCTOASE

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Abstract.
A quality planting material has a strong influence on the success of vegetable crop. This paper presents a state of arts regarding some possibilities of improving the quantity and quality of seeds in the main solanaceous vegetables, tomatoes, pepper and eggplant. Seed production technology can be optimized by modern approaches. Soil mulching or the use of foliar treatments with calcium nitrate and biostimulants can determine the yield of seed with superior quality characteristics.
Key words:

Rezumat.
Un material săditor de calitate are o influență puternică asupra succesului culturii legumelor. Prezenta lucrare prezintă stadiul actual al cunoașterii privind unele posibilități de îmbunătățire a cantității și calității semințelor la principalele legume solanacee, tomatele, ardeii și pătlăgelele vinete. Tehnologia de producție seminceră poate fi optimizată prin abordări moderne. Mulcirea solului sau utilizarea tratamentelor foliare cu azotat de calciu și biostimulatori pot determina obținerea unei cantități mai mari de sămânță de calitate.
Cuvinte cheie: biostimulants, *Capsicum annuum*, fruit quality, yield

INTRODUCTION

The production of high-quality horticultural seeds for economically important species such as tomato (*Solanum lycopersicum* L.), pepper (*Capsicum annuum* L.) and eggplant (*Solanum melongena* L.) is essential for the productivity, sustainability and competitiveness of modern vegetable production systems. Seed quality plays a decisive role in crop establishment, influencing germination, seedling emergence and early plant development. High-quality seeds ensure rapid and uniform emergence, promote vigorous and healthy seedlings, and enhance the plants' ability to withstand environmental stresses. Consequently, the use of

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reliable, high-quality planting material contributes to more uniform crops, improved production efficiency and higher economic returns, making seed quality a key component of modern horticultural practices and competitive agricultural production [Ciofu et al., 2004; Echim and Scurtu, 2020; Munteanu, 2003].

Soil and climatic conditions have a significant impact on tomato, pepper and eggplant cultivation, especially on flowering and fruit set, fruit development and with consequent effects on seed quantity and quality [Karapanos et al., 2008]. The quantity and quality of fruits of solanaceous vegetable crops are strongly affected by the temperature and humidity of the soil and atmosphere, soil fertility and nutrient availability. These factors can be managed to some extent through various agrotechnical methods [Ciofu et al., 2004; Munteanu, 2003; Stan and Stan, 2010].

Mulching, an agrotechnical practice involving the coverage of soil surfaces with organic or inorganic materials, can modify the soil microclimate, improve water retention, and influence plant growth and fruit development [Barche et al., 2015; Ciofu et al., 2004; Stan and Stan, 2010].

All these effects are reflected in the growth and development of plants, in the early setting of fruits and their physiological maturation, in the increase in fruit quality [Barche et al., 2015], with important effects on seeds as well [Verma et al., 2016a].

Appropriate soil management, together with proper plant nutrition, is essential to optimize seed production [Ciofu et al., 2004; Stan and Stan, 2010].

Nitrogen and calcium are essential nutrients for tomato, pepper and eggplant [Ciofu et al., 2004; Stan and Stan, 2010], while biostimulants are increasingly used to improve yield, fruit quality and seed quality [Muhie, 2023].

Each of these agrotechnical methods has the potential to increase the quantity and quality of seeds in tomatoes, peppers and eggplants. The effect can be improved when mulching, calcium nitrate fertilization and biostimulant application are integrated into a unitary technology. Mulch optimizes the root environment, calcium nitrate provides basic nutrition, and biostimulants can enhance the efficiency of nutrient use, leading to higher seed production and superior seed quality [Ciofu et al., 2004; Munteanu, 2003; Stan and Stan, 2010]. The integrated approach leads to seeds with uniform maturation, higher specific mass, high germination and superior seedling vigour, essential aspects for professional seed production in tomatoes, peppers and eggplants.

Although numerous studies have examined the effects of mulching, fertilization, and biostimulants on growth, yield, and fruit quality in solanaceous vegetable crops, comparatively little attention has been given to their influence on seed production and quality. Moreover, most studies focus on individual factors rather than their combined or synergistic effects.

Therefore, this review aims to synthesize the available scientific information regarding the influence of mulching, calcium fertilization and biostimulant application on the production and quality of seeds in tomato, pepper and eggplant

crops, highlighting the potential benefits of integrating these agrotechnical practices within seed production technologies.

MATERIAL AND METHOD

This study was conducted as a comprehensive literature review aimed at evaluating the effects of mulching systems, calcium nitrate fertilization, and the application of biostimulants on seed yield and seed quality in tomato (*Solanum lycopersicum*), pepper (*Capsicum annuum*), and eggplant (*Solanum melongena*). The review focused on identifying and analysing scientific evidence regarding the influence of these agronomic practices on the physiological, morphological, and biochemical characteristics of seeds intended for commercial production.

An extensive survey of national and international scientific literature was carried out using major academic databases available online, including multidisciplinary and agricultural science platforms. Peer-reviewed journal articles, scientific books, conference proceedings, and technical reports relevant to vegetable seed production were considered. Particular attention was given to studies published under agro-climatic and technological conditions comparable to those currently encountered in Romania, as well as to research conducted in other regions with advanced seed production technologies.

RESULTS AND DISCUSSIONS

1. Effects of mulching on seed yield and quality

Mulching has an important impact on soil moisture, to which solanaceous plants have high requirements. In general, the climatic conditions in our country require irrigation of vegetable crops. Therefore, both Romanian and international scientific literature recommends the use of mulch as a solution to maintain moisture and reduce the amount of water for irrigation [Abdrabbo et al., 2017; Ciofu et al., 2004; Munteanu, 2003; Stan and Stan, 2010].

1.1. Influence of mulching on plant growth and development

Soil water regime

Soil mulching significantly improves the efficiency of water use applied through drip irrigation and increases yield in in solanaceous vegetables [Abdrabbo et al., 2017].

Mulching helps reduce nitrogen leaching by improving soil water regime and increasing the efficiency of nitrogen absorption by pepper plants, the effect being more pronounced in the case of stable mulches during the growing season, such as black polyethylene film [Romic et al., 2003].

Soil temperature

Another important influence is the property of increasing or decreasing soil temperature, depending on the type of mulch used [Amare and Desta, 2021]. This aspect is important for tomato, pepper, and eggplant crops, which prefer higher soil temperatures [Ciofu et al., 2004; Munteanu, 2003].

In general, plastic mulch films have a soil warming effect, with the maximum effect for transparent film, followed by black film [Zhang et al., 2021]. Organic mulches, such as tree bark or straw, lead to a decrease in soil temperature [Sinkevičienė et al., 2009]. A similar effect is caused by white plastic mulch film [Amare and Desta, 2021].

Environmental effects of mulch colour

According to the specialized literature, the colour of mulch is an important agronomic factor, having a significant impact on the vegetative and physiological development of plants from the *Solanaceae* family. For tomato crops, a study conducted in Brazil demonstrated that the use of plastic mulch films of different colours caused significant variations in fruit production, these effects being dependent on the season [Mendonça et al., 2021]. Similar results were reported in the case of pepper, where the response of plants to mulch films with distinct chromatic properties was conditioned by the growing season [Díaz-Pérez, 2010].

Compared to white polyethylene mulch, the use of black polyethylene mulch is associated with a reduction in the number of axillary shoots and increased plant elongation, these effects being similarly reported in several cultivated species of the *Solanaceae* family, such as tomato [Decoteau et al., 1988]. The chlorophyll content of leaves is also affected by the colour of the mulch. The use of silver-grey mulch has been associated with increased chlorophyll content at the leaf level, an effect highlighted in tomato crops [Ozer, 2017]. The colour of the mulching film also has an influence on the quality of the fruit, with a positive influence observed for tomatoes of red film [Ozer, 2017].

The effects of soil mulching are not limited to the soil level. These effects are also reflected in the atmosphere, through the accumulation of gases such as CO_2, CH_4 or N_2O in the surrounding atmosphere [Livesley et al., 2010]. Also, depending on the color and nature of the mulch, it has important effects on the quality of light [Kaul and Kasperbauer, 1992], and it can attract or repel some types of insects [Barche et al., 2015].

Pests, diseases and weed control

Mulching can also reduce the risk of attack by pests and pathogens that affect fruits and seeds [Barche et al., 2015; El-Beltagi, 2022; Moursy et al., 2015], which can lead to healthier seed production. Certain diseases can reduce both the germination capacity of seeds and the vigour and health of the resulting plants, which gives mulching an important role in achieving healthy seed production [Scurtu, 1997]. Some of these soil diseases, such as fusarium or verticillium wilt, can cause significant damage to tomato, pepper and eggplant crops [Sovarel and Costache, 2018].

Another beneficial effect of soil mulching is the significant influence on the dynamics of pest populations, contributing to the modification of their behaviour and density within the agricultural ecosystem [Stoleru and Sellitto, 2016]. This

practice helps reduce the incidence of soil-borne diseases in species such as tomatoes, and the application of organic mulch can stimulate the growth of species diversity of beneficial microorganisms in the soil [Moursy et al., 2015].

Another important effect of mulching is the suppression of weed growth. Both organic and plastic mulch have this effect [Barche et al., 2015], except for the transparent plastic foil [Zhang et al., 2021].

Effects on yield and physiological processes

Regarding fruit production in solanaceous crops, studies have indicated increased yield both in the open field [Adamczewska-Sowińska et al., 2016;], and in protected areas [Liang et al., 2011], in all three species: tomatoes [Tipu et al., 2014], peppers [Constantin and Paraschiv, 2025] and eggplants [Adamczewska-Sowińska et al., 2016; Constantin and Paraschiv, 2025].

In addition, soil mulching substantially influences a series of fundamental physiological processes of plants, such as the rate of photosynthesis and the intensity of transpiration, effects observed in pepper plants [Liang et al., 2011].

The phenological stages of plant development of *Solanaceae* species can be significantly influenced by the application of mulching to the soil, modifying the times and intensity of the various growth stages, with different responses depending on the species. Some studies indicate that earliness in peppers is more strongly influenced than in eggplants [Constantin and Paraschiv, 2025].

Some studies indicate that polyethylene films can be replaced with biodegradable films for both tomatoes [Di Mola et al., 2023], and eggplants [Di Miceli et al., 2024]. It is observed that different types of organic mulch affect tomato production differently [Tegen et al., 2016; Tipu et al., 2014], with different responses depending on the cultivar [Tegen et al., 2016].

1.2 Influence of mulching on seed yield and seed quality

In the scientific literature, there is a significant gap regarding how soil mulching directly influences seed yield in fruit-bearing vegetable species of the *Solanaceae* family. Although the effects of mulching on soil microclimate, vegetative growth and fruit production are well documented in both international literature [Barche et al., 2015], and national literature [Ciofu et al., 2004], the impact of this technology on seed quantity and quality has been less investigated.

The increase in seed production is closely correlated with the increase in the number of fruits per plant and per unit area, as well as with the increase in the amount of seed per fruit [Dascălu Constantin et al., 2023], parameters strongly influenced by environmental conditions and cultivation technology [Demir and Ellis, 1992]. In this context, water availability is a major limiting factor. Water deficit can have pronounced negative effects on seed yield and quality in species of the *Solanaceae* family, effects reported especially in tomato [Pervez et al., 2009] and pepper [Rathnayaka et al., 2021].

Through the influence exerted on the soil water regime and on the efficiency of water use [Abdrabbo et al., 2017; Ciofu et al., 2004], soil mulching contributes to improving the conditions for plant growth and development, with favourable effects on the quantity and quality of seeds produced.

Research shows that the type and color of mulch can positively influence seed production. For example, in the case of peppers, the use of a silver-black plastic mulch increased the amount of seeds obtained, possibly by modifying the microclimate at the soil and plant level [Verma et al., 2016b].

At the same time, soil mulching influences the development of phenophases, with particularly obvious effects in pepper cultivation [Constantin and Paraschiv, 2025]. This leads to faster and more uniform seed maturation, which is particularly advantageous in the climatic conditions of Romania, where early autumn frosts may occur before pepper seeds reach physiological maturity [Munteanu, 2003].

Overall, mulching represents an important agrotechnical practice that modifies the soil microclimate, improves water availability and influences plant growth and physiological processes in solanaceous crops. Through these mechanisms, mulching can indirectly contribute to increased seed yield and improved seed quality. However, direct studies focusing on seed production remain limited, highlighting the need for further research in this area.

2.

3. Effects of calcium nitrate and biostimulants on seed yield and quality

It is well established that the germination energy of seeds largely depends on the nature and level of the embryo's reserves, which are closely related to the nutritional conditions of the seed-producing crop at the time of seed formation, as well as to the maturity conditions and the degree of seed maturation at harvest [Scurtu, 1997].

Mineral and organic nutrition play an essential role in the processes of seed formation and development in plants, including those of the *Solanaceae* family. The availability and balance of nutrients significantly influence floral induction, pollen fertility, embryo development, as well as the accumulation of reserve substances in seeds, thus influencing the quantity and quality of seeds [Copeland and McDonald, 2001].

Plant growth and development are strongly influenced by mineral nutrition and the application of biostimulants, which play an essential role in regulating physiological and biochemical processes. Calcium and nitrogen are fundamental nutrients, involved in cell wall stability, membrane integrity, protein synthesis and photosynthetic activity, directly influencing plant vigour and productivity [Ciofu et al., 2004].

2.1. Influence of nitrogen and calcium on plant growth and development, on seed yield and seed quality

Role of nitrogen

Nitrogen is an essential element that tomatoes, peppers and eggplants generally have high requirements for, and ensures the vegetative growth of plants and fruits. However, excess nitrogen can be harmful, causing a luxuriant growth of the plant mass, to the detriment of fruiting and earliness [Ciofu et al., 2004; Munteanu, 2003].

Tomatoes, peppers and eggplants are plants that love fertile, nutrient-rich soils and are considered plants with moderate to high nitrogen consumption, which they need especially in the vegetative growth phase, for leaf and stem development [Munteanu, 2003]. Nitrogen fertilization is an essential factor in determining yield, quality and organoleptic characteristics of solanaceous vegetables. The different forms of nitrogen, mineral or organic, are essential for seed formation, influencing the induction and development of fertile flowers, the accumulation of compounds important for taste and nutritional value and the synthesis of reserve proteins in seeds [Ciofu et al., 2004].

In addition, nitrogen supply influences physiological processes in the plant, influencing leaf chlorophyll content and net photosynthetic rate [Zhang et al., 2022]. Nitrogen deficiency negatively affects the growth of plants of tomatoes [Zhang et al., 2022], pepper [Magalhães et al., 2023] and eggplant [Aminifard et al., 2011].

In pepper cultivation, nitrogen and calcium deficiencies exerted more severe effects on plant growth and development relative to deficiencies of other essential nutrients [Magalhães et al., 2023].

Role of calcium

Calcium is also an element of major importance in the cultivation of these vegetables [Ciofu et al., 2004; Stan and Stan, 2010]. Calcium deficiency can lead to a physiological disorder called blossom end rot, which manifests itself especially in tomatoes and peppers, but can also occur in eggplants [Taylor and Locascio, 2004].

Calcium plays a crucial role in reproductive processes, contributing to pollen viability and its germination on the stigma, including in Solanaceae species, as well as in many other plant species [Brewbaker and Kwack, 1963]. During the early stages of embryonic development, calcium stabilizes cell membranes and cell walls, thereby maintaining tissue integrity [White and Broadley, 2003]. Through these mechanisms, adequate calcium intake reduces seed abortion and supports the formation of viable, quality seeds [Brewbaker and Kwack, 1963].

Calcium is an essential element for the cultivation of fruit-bearing solanaceous crops [Munteanu, 2003]. Calcium fertilization during flowering and early fruiting periods can prevent or minimize calcium deficiency disorders in pepper plants [Mayorga-Gómez et al., 2020].

In peppers, studies have shown that the use of calcium treatments led to an increase in total and marketable production, regardless of the chemical form of calcium, but with stronger effects when used in the form of calcium nitrate. The

effects were more important in the case of marketable fruit, due to the decrease in the number of fruits affected by blossom end rot [Buczkowska et al., 2016].

In peppers, calcium treatments can lead to a slight decrease in dry matter and total sugar in the fruit, with variable effects on vitamin C and carotenoid content [Buczkowska et al., 2016].

Some studies indicate that calcium deficiency has a negative effect on tomato seed development, causing them to be small, deformed, and black [Paiva et al., 1998].

Calcium nitrate as a source of nitrogen and calcium

Calcium nitrate can be used in seedling fertilization programs. In optimal concentrations, calcium nitrate has beneficial effects on pepper seedlings, but high concentrations have had a negative influence [Gulser et al., 2010].

Fertilization with calcium nitrate has beneficial effects on fruit production in tomatoes [Peyvast et al., 2009] and peppers [Stagnari and Pisante, 2012]. Studies indicate that calcium nitrate fertilizers can be successfully used on peppers by applying foliar treatments, which is easier to apply than soil application [Buczkowska et al., 2016]. The increase in productivity is due to the positive effect that fertilizer treatments have on the number of fruits per plant and the weight of tomato [Sarijan et al., 2025] and pepper [Constantin et al., 2024] fruits.

The application of calcium nitrate can have a positive effect on the nutritional properties of fruits, effects highlighted in peppers. In this species, a significant increase in the content of antioxidant pigments, especially lycopene and β-carotene, was observed [Flores et al., 2004]. However, these effects are dependent on the level of nitrogen applied, as in tomatoes it has been found that excess nitrogen can lead to a decrease in fruit quality, even if it causes an increase in production [Rebouças et al., 2015].

Studies confirm that an optimal intake of calcium nitrate has a significant effect on reducing the number of fruits affected by apical rot, effects observed in tomatoes [Sarijan et al., 2025] and pepper [Constantin et al., 2024; Mayorga-Gómez et al., 2020].

Regarding the influence of calcium nitrate on seed quantity, studies indicate that, in peppers, it can increase seed quantity and quality, and combining it with biostimulants can amplify the positive effects [Gheorghe et al., 2025].

2.2. Influence of biostimulants on plant growth and development, on seed yield and seed quality

Biostimulants are primarily natural, rarely synthetic, substances that cannot be classified as fertilizers or pesticides, and their use in agriculture and horticulture is steadily increasing. It exhibits properties that stimulate plant metabolism, leading to improved yield, increased fruit quality, and enhanced resistance to various biotic and abiotic stress factors [Muhie, 2023].

Biostimulants can influence the physiological processes involved in seed formation and development, through their effects on flowering, pollination and nutrient assimilation. By improving the physiological state of plants and reducing the impact of stress factors, they favour pollen viability and fertilization success, contributing to an increase in the number of seeds formed [Pohl et al., 2019b]. By stimulating photosynthesis and the transport of assimilates, biostimulants can support embryo development and the accumulation of reserve substances in seeds, positively influencing their quality [Ciofu et al., 2004]. Thus, the use of biostimulants can play an important role in optimizing seed production, both quantitatively and qualitatively.

Some studies conducted on tomatoes show that applying biostimulants to plants under water stress can improve plant physiological responses, such as photosynthesis, chlorophyll content, and water use efficiency [Kadoglidou et al., 2025].

The use of seaweed-based biostimulants can significantly decrease fruit ripening time, effects observed in tomatoes [Mannino et al., 2020].

The use of humic and fulvic acids in fertilization programs, in combination with algae extracts, improved the quality of tomato fruits, increasing the content of carotenoids, vitamin E, fatty acids and antioxidant compounds [Liava et al., 2023].

The increase in production and quality of tomato fruits was obtained through treatments with different types of biostimulants [Alfosea-Simón et al., 2020; Distefano et al., 2022], including with extracts obtained from agri-food by-products, such as fennel, lemon residues and beer lees [Abou Chehade et al., 2018]. Similar results were observed in different types of peppers, in which the use of treatments with biostimulants determined an increase in fruit production and quality [Bonini et al., 2020; Constantin et al., 2024; Mezeyová et al., 2024]

Biostimulants also have the ability to increase the production and quality of eggplant fruits [Bashir et al., 2025; Pohl et al, 2019a]

Another positive effect of biostimulants treatments is the reduction in the incidence of apical rot in pepper fruits [Buczkowska et al., 2016].

In peppers, it was found that biostimulants can increase the efficiency of calcium nitrate in terms of its effects on fruit [Constantin et al., 2024] and seed production [Gheorghe et al., 2025].

Foliar treatments with seaweed-based biostimulants significantly improved seed quantity and quality in peppers [Gheorghe et al., 2025] and eggplants [Dascălu et al., 2025].

Studies indicate that seed treatments with biostimulators have positive effects on the germination process in tomatoes [Supraja et al., 2020] and eggplants [Shchetyna et al., 2024].

Overall, the analysed studies highlight that mulching, calcium nitrate fertilization, and the application of biostimulants play synergistic and interdependent roles in influencing plant growth, fruit development, and, indirectly, seed yield and quality in tomato, pepper, and eggplant crops. While mulching

primarily acts by improving the soil microclimate and water availability, calcium nitrate ensures essential mineral nutrition, and biostimulants enhance physiological efficiency and stress tolerance.

The available evidence suggests that the integration of these agronomic practices can lead to improved seed production through enhanced fruit set, uniform maturation, and better accumulation of reserve substances in seeds. However, despite these promising results, the direct effects on seed yield and quality remain insufficiently documented, as most studies focus predominantly on vegetative growth and fruit production.

Therefore, further experimental research is required to better quantify the individual and synergistic effects of these technologies on seed production parameters, particularly under specific agro-climatic conditions. Such investigations would contribute to the development of optimized and sustainable seed production systems for solanaceous vegetable crops.

CONCLUSIONS

The present review highlights the significant role of mulching, calcium nitrate fertilization, and biostimulant application in improving plant growth, fruit development, and indirectly, seed yield and quality in tomato, pepper, and eggplant crops. Each of these practices contributes through distinct mechanisms, including the optimization of soil microclimate, essential nutrients, and the stimulation of physiological and biochemical processes involved in plant development and seed formation.

The available scientific evidence suggests that their integrated use can generate synergistic effects, leading to improved fruit set, more uniform maturation, and enhanced accumulation of reserve substances in seeds, all of which are essential for obtaining high-quality seeds with superior germination and vigour. At the same time, these practices can contribute to increased resilience of plants to abiotic and biotic stress factors, supporting more stable seed production under variable environmental conditions.

However, despite the growing interest in these agronomic approaches, there is still a limited number of studies that directly address their impact on seed yield and quality, as most research has focused predominantly on vegetative growth and fruit production. Therefore, further experimental studies are needed to better quantify their individual and combined effects on seed-related parameters, particularly under different agro-climatic conditions. Such research would support the development of efficient, sustainable, and scientifically grounded technologies for seed production in solanaceous vegetable crops.

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