EXPLORING TOMATO CULTIVATION IN RELATION TO LOCAL GROWING CONDITIONS IN A DIVERSIFIED PRIVATE VEGETABLE GARDEN

STUDIU EXPLORATORIU PRIVIND CULTIVAREA TOMATELOR ÎN CONDIȚIILE SPECIFICE UNEI GRĂDINI LEGUMICOLE PRIVATE DIVERSIFICATE

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Abstract.
Private vegetable gardens are heterogeneous agroecosystems in which cultivar identity, associated vegetation and local growing conditions frequently vary simultaneously. This exploratory observational study characterized three pre-existing tomato (Solanum lycopersicum L.) configurations in a diversified private garden: 'Moneymaker' grown predominantly in full sun with Tagetes patula L. and Ocimum basilicum L.; 'Buzău 1600' grown with sweet pepper (Capsicum annuum L.); and naturally shaded 'Moneymaker' with Portulaca oleracea L. ground cover. Plant height, fruit number and field ripening status were recorded for 10 plants per configuration. Because each configuration comprised a single plot, results were summarized descriptively without inferential statistical comparisons. Full-sun 'Moneymaker' plants averaged 172.5 ± 7.9 cm and carried 12.9 ± 2.7 fruits per plant. 'Buzău 1600' plants averaged 39.6 ± 3.3 cm and carried 5.0 ± 1.1 predominantly unripe fruits, whereas shaded 'Moneymaker' plants reached 197.0 ± 7.5 cm but carried only 3.5 ± 1.2 fruits. Because cultivar, light environment and associated vegetation varied concurrently, no causal effect can be assigned to an individual factor. Nevertheless, such standardized observations could support coordinated citizen-science networks or distributed agroecological Living Labs using private gardens as observational nodes.
Key words: tomato, agroecology, companion plants, intercropping, preliminary study

Rezumat.
Grădinile legumicole private sunt agroecosisteme eterogene, în care soiul, vegetația asociată și condițiile locale de cultivare variază frecvent în mod simultan. Acest studiu observațional exploratoriu a caracterizat trei configurații preexistente de cultivare a tomatelor (Solanum

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lycopersicum L.) într-o grădină privată diversificată: soiul 'Moneymaker', cultivat predominant în plin soare împreună cu Tagetes patula L. și Ocimum basilicum L.; soiul 'Buzău 1600', cultivat împreună cu ardei (Capsicum annuum L.); și soiul 'Moneymaker', cultivat în condiții de umbrire naturală, cu Portulaca oleracea L. ca acoperitor de sol. Înălțimea plantelor, numărul de fructe și stadiul de coacere în câmp au fost înregistrate la câte 10 plante din fiecare configurație. Deoarece fiecare configurație a fost reprezentată de o singură parcelă, rezultatele au fost sintetizate descriptiv, fără comparații statistice inferențiale. Plantele 'Moneymaker' cultivate în plin soare au avut o înălțime medie de 172,5 ± 7,9 cm și au prezentat 12,9 ± 2,7 fructe/plantă. Plantele 'Buzău 1600' au avut în medie 39,6 ± 3,3 cm și 5,0 ± 1,1 fructe/plantă, predominant necoapte, în timp ce plantele 'Moneymaker' cultivate la umbră au atins 197,0 ± 7,5 cm, dar au prezentat numai 3,5 ± 1,2 fructe/plantă. Deoarece soiul, mediul luminos și vegetația asociată au variat concomitent, niciun efect cauzal nu poate fi atribuit unui factor individual. Cu toate acestea, asemenea observații standardizate ar putea susține rețele coordonate de știință participativă sau Living Lab-uri agroecologice distribuite, în care grădinile private să funcționeze ca noduri observaționale.

Cuvinte cheie: tomate, agroecologie, plante companion, culturi asociate, studiu preliminar

INTRODUCTION

Small private and household vegetable gardens contribute directly to local food provision, dietary diversity and access to fresh produce. Urban and peri-urban horticulture includes home, family, community and private gardens and can support food security, social resilience and the multifunctional use of cultivated spaces [Altieri et al., 2025; Eigenbrod and Gruda, 2015; Gao et al., 2025]. Nevertheless, locally produced food should not automatically be regarded as resource efficient. The environmental performance of urban tomato production also depends on material inputs, water use, energy requirements, infrastructure and the ability to recycle resources within the production system [Piezer et al., 2019]. Private gardens operate under constraints that differ from those of specialized commercial farms. Available land is limited, solar radiation is spatially heterogeneous because of buildings, trees and perennial vegetation, and vegetable, aromatic, medicinal, ornamental and spontaneous plant species are frequently grown in close proximity. Under these conditions, the management objective is not necessarily to maximize the yield of a single crop, but to use the available space, solar radiation, water, soil and biological diversity efficiently while producing food with limited dependence on synthetic inputs [FiBL, 2010; Maitra et al., 2021].

Although the heterogeneity of private gardens complicates conventional experimental control, it may also provide access to a wide range of cultivars, management practices and local environmental conditions that are rarely represented in centralized field experiments. Citizen-science vegetable variety trials conducted in home and community gardens have generated geographically distributed information on germination, plant health, yield and consumer-relevant traits [Sykes et al., 2021]. Similarly, decentralized on-farm evaluations have demonstrated that standardized observations collected by numerous participants can support the characterization of crop-variety adaptation across contrasting environments [van Etten et al., 2019]. The scientific usefulness of such distributed observations depends on clearly defined protocols, essential metadata, participant training and appropriate data-validation procedures [Kosmala et al., 2016[. When connected through an agroecological Living Lab, private gardens could therefore contribute not only as food-production spaces, but also as observational sites for participatory knowledge production under real-life conditions [Stone et al., 2026].

Agroecological diversification may include intercropping, companion planting, living ground covers and the spatial allocation of cultivars according to their growth habit and environmental requirements. Intercropping can improve land-use efficiency when component species differ in resource acquisition, canopy architecture, rooting depth or temporal development. However, facilitation is not an automatic consequence of plant diversity. Outcomes depend on species identity, planting date, density, root distribution, nutrient availability and competition for light and water [Brooker et al., 2015; Li et al., 2014]. In tomato-based systems, tomato–lettuce intercropping produced land-use advantages under appropriate planting schedules, while delayed establishment of the subordinate crop intensified competition and reduced its performance [Cecílio Filho et al., 2011; Cunha-Chiamolera et al., 2017].

Ecological interactions in diversified tomato systems may occur both above and below ground. Tomato intercropping with potato-onion altered soil physicochemical properties and microbial community structure in replicated greenhouse experiments [Li et al., 2020]. Subsequent studies reported changes in tomato root distribution, rhizosphere bacterial networks, yield and fruit quality [He et al., 2025; Zhou et al., 2025]. These studies demonstrate the biological plausibility of crop-neighbour effects, but also indicate that the effects are species- and context-dependent and cannot be extrapolated automatically to other plant associations. Aromatic and flowering species are frequently included in household gardens because they provide culinary products, floral resources and potential plant-protection functions. French marigold (*Tagetes patula* L.) reduced glasshouse whitefly infestation in tomato through the emission of airborne limonene [Conboy et al., 2019]. Basil (*Ocimum basilicum* L.) volatiles primed wound-related signalling in tomato under controlled conditions [Yoshida et al., 2024]. Nevertheless, these mechanisms do not necessarily result in increased tomato production. In a certified organic field experiment, thyme improved tomato root development and reproductive parameters, whereas basil reduced tomato yield and increased late-blight severity [Szczech et al., 2024]; by contrast, intercropping tomato with aromatic species has elsewhere been associated with higher yield, quality and disease resistance through elevated soil nutrients and enzyme activities [Yu et al., 2026]. Companion plants must therefore be evaluated in relation to species, density, spatial arrangement, environmental conditions and the specific ecosystem service expected from the association.

Light availability is another major constraint in diversified gardens. Reduced radiation may alter tomato canopy architecture, dry-matter accumulation, assimilate partitioning, flowering, fruit set, ripening and fruit biochemical composition. Under a 52% shading screen, Sandri et al. [2003] recorded lower total, vegetative and fruit dry mass, although fruit number per unit area did not differ significantly from the unshaded control. A study using approximately 50% reduction in solar radiation reported lower tomato production, smaller fruits and reduced glucose, fructose, lycopene and β-carotene concentrations, together with changes in organic acids, amino acids, fatty acids, phenylpropanoids and flavonoids [Abreu et al., 2019]. Other experiments demonstrated that the effects of shading on tomato yield and fruit quality depend on shade intensity, temperature, cultivar and grafting combination [Angmo et al., 2021; Milenković et al., 2020].

Portulaca oleracea L. has an ambiguous role in diversified vegetable systems. It is a C4 annual species capable of rapid establishment in cultivated soils and is widely considered an important weed. Seed germination and emergence are strongly influenced by light, seed position at the soil surface, burial depth and crop-residue cover [Chauhan and Johnson, 2009]. At the same time, purslane is an edible and nutritionally valuable species, rich in minerals, vitamins and omega-3 fatty acids, and is increasingly considered an underutilized crop suitable for dietary diversification [Srivastava et al., 2023]. Its tolerance to drought, high temperature and salinity may support its introduction as an alternative or complementary crop in stress-prone production environments [Carrascosa et al., 2023].

Direct evidence regarding tomato–purslane associations is limited. Under saline greenhouse conditions, the presence of *P. oleracea* was associated with increased tomato yield and reduced Na accumulation in tomato leaves. However, at higher companion-plant densities and under non-saline conditions, purslane increased competition and reduced tomato growth and yield [Graifenberg et al., 2003]. Consequently, *P. oleracea* may function as a spontaneous weed, edible secondary crop, living ground cover, competitor or companion plant depending on density, water availability, salinity and management objectives.

The present study evaluated tomato growth and fruiting in three diversified configurations established in a private vegetable garden in Romania. Rather than manipulating cultivar, light environment and neighbouring vegetation as independent treatments, the study treated each configuration as a complete, self-contained case study, since these factors co-occurred as whole crop situations. The objective was to characterize plant height, fruit number and field ripening status within each case study and to discuss the agronomic relevance of cultivar identity, light environment and neighbouring vegetation under the spatially heterogeneous conditions of a household food garden. The study was thus conceived as a preliminary, case-based assessment intended to generate hypotheses for subsequent replicated experiments, rather than as a comparison among treatments.

Although the present assessment was not designed as a citizen-science project, its broader relevance as a potential observational model for coordinated private-garden networks is considered for the future.

MATERIAL AND METHOD

The study was conducted during the 2025 growing season in a privately managed open-field vegetable garden located in Modelu commune, Călărași County, south-eastern Romania. The garden covered approximately 100 m² and was established on chernozem soil, a typical soil type in the area [Moise and Lungu, 2013; Mușat et al., 2022; Rîpa et al., 2024]. Tomato plants were established at approximately 40 cm between plants within the row and 70 cm between rows, and irrigation was applied manually with a hose according to crop requirements and prevailing weather conditions. The site was managed as a diversified household food garden, with tomato, pepper, aromatic, flowering and spontaneous plant species grown within the same cultivated area.

The two tomato cultivars used in the garden were 'Moneymaker', an indeterminate cultivar widely used in horticultural and postharvest studies [Chira et al., 2024; Simionescu et al., 2024], and 'Buzău 1600', a Romanian fresh-consumption cultivar developed at the Buzău Vegetable Research and Development Station and officially described as vigorous, indeterminate and large-fruited [SCDL Buzău, 2015; Vînătoru et al., 2015; Vînătoru et al., 2016; Zamfir et al., 2018].

Three crop configurations were evaluated, and because each combined a particular cultivar, its own neighbouring vegetation and a distinct light environment, they were treated as three complete, self-contained case studies rather than as treatment levels of a single experiment (Table 1). Accordingly, each case study is described and analysed individually.

Table 1

Description of the three pre-existing tomato configurations evaluated in the private garden

Configuration	Tomato material	Neighbouring vegetation	Light context
V1	Moneymaker	*Tagetes patula* and *Ocimum basilicum*	Predominantly full sun
V2	Buzău 1600; compact observed phenotype	*Capsicum annuum*	Open garden area
V3	Moneymaker	*Portulaca oleracea* ground cover	Natural shade

The first case study (V1) comprised 'Moneymaker' grown in a predominantly full-sun area of the garden, in association with *Tagetes patula* L. and *Ocimum basilicum* L. The second case study (V2) comprised 'Buzău 1600' variety, grown in an open garden area in association with sweet pepper (*Capsicum annuum* L.). The third case study (V3) comprised 'Moneymaker' grown in a naturally shaded area, with *Portulaca oleracea* L. forming a low ground cover. Each case study thus represents a specific, realistic combination of cultivar, companion vegetation and light conditions as encountered in a diversified private garden. Ten tomato plants were evaluated in each case study, resulting in 30 observed plants. Plant height, total fruit number per plant and field ripening status were recorded. Plant height was measured from the stem base to the apical growth point. All fruits present on each selected plant were counted, regardless of ripening stage. Fruit ripening was assessed visually according to the predominant external colour at the common field assessment. Because ripening was not monitored through repeated assessments from anthesis to harvest, this parameter was interpreted qualitatively. The ten plants scored per case study are sub-samples of a single plot and do not constitute independent replicates; formal inferential comparison would therefore be pseudo-replication in the sense of Hurlbert [1984], and none was performed.

Statistical analysis. Plant height and fruit number were summarized as means and standard deviations for each case study separately. Because each garden configuration was represented by a single plot, no inferential statistical comparison was performed. Numerical differences among configurations are reported only as descriptive contrasts and are not interpreted as evidence of causal effects of cultivar, light environment or associated vegetation. Each case study is described on its own, and the observations are not interpreted as evidence of causal effects of cultivar, companion species or shading, nor extrapolated beyond the studied garden and season.

RESULTS AND DISCUSSIONS

The three case studies are presented and interpreted individually below; because no companion-free control was available and each plot differed in several respects at once, no case is treated as a treatment level relative to the others. Descriptive values are summarized in Table 2.

Table 2.

Plant height and fruit number in the three garden configurations

Case study	Plant height (cm)	Fruits per plant
V1	172.5 ± 7.9	12.9 ± 2.7
V2	39.6 ± 3.3	5.0 ± 1.1
V3	197.0 ± 7.5	3.5 ± 1.2

(mean ± SD; n = 10 observed plants per configuration)

Case study 1 (V1)

Plants reached 172.5 ± 7.9 cm and carried 12.9 ± 2.7 fruits per plant, and at the common field assessment they showed the most uniform visual progression towards ripe fruit. Vegetative growth and fruit load were thus consistent with a plant developing under adequate radiation and manual irrigation, and the even ripening indicates that a large proportion of the fruit had reached a comparable developmental stage by the assessment date.

Because no full-sun 'Moneymaker' plot without companion plants was available, an independent effect of the accompanying species cannot be established, and their potential functions can only be discussed as biologically plausible. *Tagetes patula* volatiles, particularly limonene, have been shown to reduce glasshouse whitefly infestation in tomato [Conboy et al., 2019], and *Ocimum basilicum* volatiles primed tomato wound-response signalling through jasmonic-acid, MAPK and reactive-oxygen pathways [Yoshida et al., 2024]. Companion effects are also not uniformly positive: in certified organic tomato, thyme improved root and reproductive traits while basil reduced yield and increased late-blight severity [Szczech et al., 2024], whereas aromatic intercropping elsewhere raised tomato yield and disease resistance through changes in soil nutrients and enzyme activities [Yu et al., 2026]. The exact contribution of the companion species to plant health or pest occurrence cannot be determined from the present observations.

Case study 2 (V2)

Plants formed a compact canopy of 39.6 ± 3.3 cm, carried 5.0 ± 1.1 fruits per plant, and bore predominantly green fruit at the field assessment. This stature and the largely pre-ripe fruit describe the state of these plants under the specific conditions of this garden and should be interpreted in that context. Reference yields of about 3 kg per plant for 'Buzău 1600' are mentioned under greenhouse, intensive-culture conditions [Doltu et al., 2019; SCDL Buzău, 2015]. In a low-input open-field garden reduced production are expected. The compact observed phenotype may reflect field growing conditions together with seed provenance, segregation in farmer-maintained seed, or uncertainty in the recorded cultivar identity, factors that are expected to matter, since Romanian studies emphasize that tomato varietal expression depends on genotype, cultivation system, environmental conditions and intended use [Chira et al., 2024; Simionescu et al., 2024; Zamfir et al., 2018]. Because 'Buzău 1600' is a large-fruited type, its fruit number should not be read as a proxy for yield: total and mean fruit mass were not determined, so the productive value of this case cannot be expressed in kg per plant or per unit area.

Case study 3 (V3)

Plants were the tallest of the three case studies, at 197.0 ± 7.5 cm, but carried the fewest fruits, 3.5 ± 1.2 per plant, and combined high stature with slower apparent ripening. Considered on its own, this case shows a decoupling of vegetative height from reproductive output: tall stems were not accompanied by a matching fruit load. This pattern is consistent with a shade-response phenotype in which stem elongation is promoted while fruiting is constrained. Controlled studies report that shading can reduce total and fruit dry matter [Sandri et al., 2003], lower production and fruit size, and modify sugars, carotenoids and antioxidant-related metabolites [Abreu et al., 2019], with yield and quality responses depending on cultivar and environment [Angmo et al., 2021; Milenković et al., 2020]. Notably, Sandri et al. [2003] found no significant difference in fruit number per unit area despite reduced dry mass, which cautions that fruit count alone may understate the productive consequences of low radiation.

The purslane ground cover in this case deserves separate consideration. *Portulaca oleracea* is commonly classified as a weed because it produces numerous seeds, emerges efficiently from the soil surface and can propagate from stem fragments [Chauhan and Johnson, 2009], and its prostrate growth and rapid surface coverage may increase competition for water and nutrients at high density. Conversely, it is edible and nutritionally valuable and can provide an additional vegetable product from the same cultivated area [Carrascosa et al., 2023; Srivastava et al., 2023], while its tolerance to drought, heat and salinity makes it a potential secondary crop for low-input systems, particularly where climatic stress limits conventional vegetables. Graifenberg et al. [2003] evaluated tomato grown with *P. oleracea* under saline and non-saline greenhouse conditions: under salinity the association increased tomato yield and reduced Na accumulation in tomato leaves while improving aspects of P and Ca nutrition, whereas higher companion-plant density reduced tomato growth and yield under non-saline conditions. Purslane should therefore not be classified automatically as either beneficial or detrimental; its effect depends on density, salinity, water availability, tomato growth stage and whether it is managed as an edible intercrop, living ground cover or spontaneous weed. Because natural shade and purslane cover co-occurred here, the low fruit number cannot be attributed independently to *P. oleracea*. A future experiment should compare shaded and unshaded 'Moneymaker', each with and without standardized purslane densities.

Cross-cutting observations for diversified private gardens. Read together as independent cases rather than ranked treatments, the three situations illustrate several general points. Plant height was not a reliable indicator of productive performance, since the tallest plants carried the fewest fruits. Private gardens are heterogeneous agroecosystems in which strict treatment isolation is difficult (Figures 1–3), and their value extends beyond a single crop to household access to fresh food, crop diversity, local knowledge and the adaptive use of small areas [Altieri et al., 2025; Eigenbrod and Gruda, 2015; Gao et al., 2025]. The observations identify four practical priorities for diversified private gardens: allocate fruiting vegetables to areas with adequate solar radiation; select companion plants according to a clearly defined function; distinguish between managed ground cover, edible secondary crop and unmanaged weed; and document cultivar identity, seed provenance and crop management. Replicated experiments confirm that neighbouring plants can alter soil pH, organic carbon, available nutrients, microbial diversity and root distribution [He et al., 2025; Li et al., 2020; Zhou et al., 2025], but such findings cannot be transferred directly to the tomato–basil, tomato–marigold or tomato–pepper associations observed here.

Fig. 1. V1 – ‘Moneymaker’ in the predominantly full-sun garden area with *Tagetes patula* and *Ocimum basilicum*

Fig. 2. V2 – compact plants recorded as ‘Buzău 1600’ in association with sweet pepper

Fig. 3. V3 – ‘Moneymaker’ in the naturally shaded garden area with *Portulaca oleracea* ground cover

Although the present assessment was exploratory, non-randomized and restricted to a single private garden, such gardens can contribute to scientific knowledge when integrated as observational nodes within a coordinated citizen-science network or a distributed agroecological Living Lab. In this framework, repeated observations collected from numerous gardens using standardized protocols and supported by essential metadata could document variation in tomato cultivar performance, associated vegetation, light exposure, crop health, and pest and disease pressure across diverse environmental and management contexts. Citizen-science vegetable variety trials conducted in home and community gardens have already generated geographically distributed information on cultivar germination, plant health, yield and consumer-relevant traits [Sykes et al., 2021], while crowdsourced on-farm trials have demonstrated the potential of decentralized observations to characterize crop-variety adaptation across contrasting environments [van Etten et al., 2019]. Individually limited observations can therefore acquire broader scientific value when aggregated through a predefined design and supported by participant training, consistent reporting and appropriate data-validation procedures [Kosmala et al., 2016]. Integrated within an agroecological Living Lab, such participatory knowledge production could connect private gardeners, researchers and other food-system actors across multiple locations [Stone et al., 2026]. For tomato, this distributed approach could document cultivar behaviour under contrasting local conditions and generate testable hypotheses concerning associated vegetation, microclimate and agroecological management, while the resulting evidence would remain observational and context dependent.

CONCLUSIONS

Three diversified tomato case studies were documented in a private vegetable garden, each analysed individually as a self-contained combination of cultivar, companion vegetation and light environment. In the full-sun case, 'Moneymaker' associated with *Tagetes patula* and *Ocimum basilicum* combined moderate plant height with the highest fruit number and the most uniform visual ripening. In the open-garden case, the plants grown as 'Buzău 1600' with sweet pepper showed a compact phenotype and a low-to-intermediate fruit number that should be read against the specific low-input field conditions rather than against official greenhouse yields. In the shaded case, 'Moneymaker' with a *Portulaca oleracea* ground cover produced the tallest plants but the fewest fruits, together with slower apparent ripening. Considered together, these cases show that plant height alone is not an adequate indicator of productive performance in tomato, since the tallest plants carried the fewest fruits. They also indicate that light availability, cultivar identity, seed provenance and the spatial arrangement and density of neighbouring plants should all be considered when allocating the limited resources of private food gardens. Interpreted as descriptive baselines rather than as a comparison among treatments, the three case studies nevertheless provide biologically and agronomically relevant reference points for designing controlled, replicated experiments on tomato performance, natural shade and multifunctional companion plants in low-input private gardens.

More broadly, this case-based assessment illustrates how private vegetable gardens could become observational nodes in a coordinated citizen-science network or distributed agroecological Living Lab for documenting tomato diversity, crop performance and agroecological management across heterogeneous local environments.

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