

Cultivation Potential of *Physalis peruviana* L. in Contrasting Agro-Ecological Zones of Georgia

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Abstract. This study presents the first comprehensive evaluation of *Physalis peruviana* L. adaptation in the specific agro-climatic transition zones of Georgia. While the crop is globally known, its interaction with the unique alluvial-carbonate soils of the Liakhvi River basin and the humid subtropical gradients of Imereti has not been previously documented. The research aimed to identify the technological limits and production potential of Cape gooseberry in these contrasting environments. A three-year experimental cycle (2023-2025) was conducted. Soil monitoring included agrochemical and geophysical parameters (pH, humus, mobile phosphorus, and exchangeable potassium) in accredited laboratories following ISO/IEC 17025 standards. Cultivation was organized using a randomized block design with organic fertilization and specific irrigation regimes. In Vani (Shida Kartli), alluvial-carbonate soils (Fluvisols) exhibited extremely high water permeability (594.0 mm/min), ensuring excellent aeration but necessitating precise drip irrigation. Conversely, soils in the Kharagauli zone revealed significant humus and phosphorus deficiencies. The high relative humidity (>75%) in Imereti increased the risk of fungal diseases, such as powdery mildew. Yield analysis showed a clear advantage for Shida Kartli, with an average of 0.800 kg per plant, compared to 0.400 kg per plant in Imereti. The study justifies the superiority of Shida Kartli for *P. peruviana* cultivation, driven by optimal light intensity and soil physical properties. The integration of organic fertilizers (20-50 t/ha) and balanced NPK application (specifically P_2O_5 at 90-120 kg/ha) is recommended to mitigate soil deficiencies and ensure high-quality fruit production in both regions. © 2026 Bull. Georg. Natl. Acad. Sci.

Keywords: *Physalis peruviana* L., soil fertility, organic fertilizers, Shida Kartli, Imereti, sustainable agriculture

Introduction

Physalis peruviana L., commonly known as Cape gooseberry or Goldenberry, is a perennial herbaceous plant originating from the Andean region of South America. As a member of the Solanaceae family, it has gained significant global attention in recent years, not only as an exotic fruit but as a

high-value functional food. The fruit's chemical profile is remarkably dense, containing high concentrations of vitamins A, C, and the B-complex, alongside essential minerals and polyunsaturated fatty acids (Puente et al., 2011).

Beyond its basic nutritional value, *P. peruviana* is a primary source of withanolides – a group of

naturally occurring steroidal lactones. These bioactive compounds have demonstrated significant pharmacological potential, including anti-inflammatory, antimicrobial, and specifically, cytotoxic properties against various cancer cell lines (Ramadan, 2011). The presence of phenolic compounds, such as quercetin and kaempferol, further enhances the plant's antioxidant capacity, making it a “superfood” with substantial market potential in the health-oriented consumer segment (Perada, M. S. B. et al., 2019).

From an agricultural perspective, *P. peruviana* exhibits a high degree of plasticity, allowing it to adapt to various environmental conditions. However, its productivity and the concentration of secondary metabolites are strictly governed by specific agro-climatic and pedological factors. Studies have shown that while it prefers well-drained fertile soils with a pH between 5.5 and 7.0 (Fischer et al., 2014), extreme variations in soil hydrology and nutrient availability can lead to significant yield fluctuations.

In the context of Georgia, the diversification of the agricultural sector through the introduction of unconventional, high-profit crops is a strategic priority. The country's diverse microclimates provide a unique laboratory for testing the adaptability of *P. peruviana*. However, there is a lack of comprehensive research regarding the technological aspects of its production in contrasting Georgian landscapes, such as the dry steppe-like conditions of Shida Kartli and the humid subtropical zones of Imereti.

The physical properties of the soil, particularly water permeability and nutrient dynamics, remain the most critical challenges for local farmers. For instance, the alluvial soils of the Liakhvi River basin (Variani) present specific hydrological behaviors that differ fundamentally from the loam soils of Western Georgia (Kharagauli).

The objective of this study was to perform a comparative analysis of the technological aspects of *Physalis peruviana* L. production in these two contrasting agro-climatic zones of Georgia. By eval-

uating soil-plant interactions, nutrient requirements, and adaptive capacities, this research aims to establish a scientific foundation for the commercial cultivation of this crop, ensuring both economic profitability and environmental sustainability for Georgian viticulture and fruit-growing regions.

Materials and Methods

Experimental sites and environmental characterization. The research was conducted over a three-year vegetation period (2023-2025) at two ecologically contrasting locations in Georgia:

- **Location A (Shida Kartli, Variani):** Situated in the semi-arid steppe zone (750-800 m a.s.l.), characterized by high solar radiation and moderate annual precipitation.
- **Location B (Imereti, Kharagauli, Bori village):** Located in a humid subtropical microclimate (450-500 m a.s.l.), characterized by high relative humidity and significant annual rainfall.

Soil sampling and physicochemical analysis. Soil samples were collected from the 0-20 cm and 20-40 cm horizons prior to the commencement of the vegetation cycle. Agrochemical diagnostics was performed at the Adam Beridze “Anaseuli” Diagnostic Centre for Soil, Food, and Integrated Plant Protection, and Agrochemistry and Soil Science Laboratory at Akaki Tsereteli State University, in compliance with ISO/IEC 17025:2010 standards.

The following analytical methods were employed:

- **Soil Reaction (pH):** determined potentiometrically in a 1:2.5 soil-to-water suspension.
- **Humus Content:** analyzed using the Tyurin method, involving the oxidation of organic carbon with $K_2Cr_2O_7$ in a sulfuric acid medium.
- **Mobile Phosphorus (P_2O_5):** evaluated via the Deniges method (the stannous chloride reduction of phosphomolybdic acid).
- **Exchangeable Potassium (K_2O):** determined using the Maslova method in an ammonium acetate extract.

- **Water permeability:** measured using the Kachinsky method to determine the infiltration rate (mm/min).

Experimental design and agronomic management. The field experiments followed a Randomized Complete Block Design (RCBD) with four replications. *Physalis peruviana* L. seedlings were propagated in a controlled greenhouse environment using a substrate of peat and perlite (3:1 ratio).

- **Planting Density:** Seedlings were transplanted with a spacing of 1.0 m × 1.0 m, achieving a density of 10,000 plants per hectare.
- **Nutrient Management:** In both locations, organic fertilizer (well-rotted manure) was applied at a rate of 40 t/ha to enhance soil structure and fertility.
- **Irrigation:** A precision drip irrigation system was utilized in Shida Kartli to mitigate moisture deficits, while in Imereti, natural precipitation was supplemented by manual irrigation during critical growth phases.

Data collection and statistical processing. Yield parameters were recorded weekly throughout the fruit ripening stage (June to October). Key metrics included the number of fruits per plant, individual fruit mass, and total biomass productivity. Statistical analysis of the obtained data was performed

using Analysis of Variance (ANOVA) and regression analysis to determine significance levels ($p < 0.05$).

Results and Discussion

Pedological dynamics and soil physical properties. The analysis of soil physical properties revealed significant variations between the two study sites. In Variani (Shida Kartli), the alluvial-carbonate soils exhibited an exceptionally high water permeability of 594.0 mm/min (Table 1). According to the classification by Kachinsky, this rate is considered extremely rapid, which can be attributed to the coarse-textured alluvial deposits of the Liakhvi River basin. While Bautista et al. (2019) emphasize the necessity of well-drained soils for *P. peruviana* to prevent root rot, such extreme permeability poses a risk of rapid nutrient leaching.

In contrast, the soils in Kharagauli (Imereti) exhibited a more moderate infiltration rate (42.5 mm/min), but laboratory diagnostics indicated a critical deficiency in both humus (1.9%) and mobile phosphorus (1.6 mg/100 g), as shown in the comparative data in Table 1. These results suggest that while Imereti provides better water retention, it requires more intensive organic and mineral fertilization to reach the productivity levels observed in Shida Kartli.

Table 1. Chemical and physical properties of soil at experimental sites (0-20 cm layer)

Parameters	Unit	Location A (Variani, Shida Kartli)	Location B (Kharagauli, Imereti)	Method
Soil type	-	Alluvial-carbonate (Fluvisols)	Medium loam	-
pH (H ₂ O)	-	7.8 (Slightly alkaline)	6.2 (Slightly acidic)	Potentiometric
Humus content	%	3.2	1.9	Tyurin
Mobile P ₂ O ₅	mg/100g	1.8	1.6	Deniges
Exchangeable K ₂ O	mg/100g	12.5	14.2	Maslova
Water permeability	mm/min	594.0	42.5	Kachinsky

Table 2. Agro-climatic conditions during the growing Season (Average 2023-2025)

Climatic indicator	Unit	Shida Kartli (semi-arid)	Imereti (humid subtropical)
Sum of active temperatures (>10°C)	°C	3350	3950
Annual precipitation	mm	540	1320
Average relative humidity	%	62	78
Average solar radiation	kWh/m ²	1650	1420

Response to agro-climatic gradients. The growth and development of *P. peruviana* were closely linked to the thermal sum and relative humidity of the respective regions (Table 2). Shida Kartli's semi-arid climate, with a sum of active temperatures of 3350°C, favored high solar radiation exposure, which is essential for sugar accumulation in the fruit. These findings align with Fischer et al. (2014), who noted that high light intensity enhances the metabolic activity of Cape gooseberry.

However, the humid subtropical conditions of Kharagauli, characterized by > 78% average relative humidity (Table 2), stimulated excessive vegetative biomass at the expense of reproductive output. Furthermore, the high humidity levels led to a higher incidence of fungal pathogens, particularly powdery mildew, during the late summer months. This corroborates the research by Silva et al. (2021), who identified high humidity as a primary risk factor for *Physalis* cultivation in subtropical zones.

Yield performance and productivity analysis.

The comparative yield analysis demonstrated a clear advantage for the Shida Kartli region. The average yield per plant in Variani was 0.800 kg, which is double the yield recorded in Kharagauli (0.400 kg), as summarized in Table 3.

Table 3. Yield components and total productivity of *Physalis peruviana* L.

Yield components	Unit	Variani (Shida Kartli)	Kharagauli (Imereti)
Average fruit weight	g	6.5	5.2
Number of fruits per plant	units	123	77
Total yield per plant	kg	0.800	0.400
Estimated yield per hectare	t/ha	8.0	4.0

The lower yield in Imereti can be attributed to the synergistic effect of phosphorus deficiency and environmental stress caused by excessive rainfall during the fruit-setting period. As suggested by Hernández et al. (2021), phosphorus is vital for root development and flowering in *P. peruviana*; thus,

the low P₂O₅ levels in Kharagauli (Table 1) acted as a limiting factor for total productivity. The success in Variani, despite its high soil permeability, was supported by the precision drip irrigation system which maintained consistent moisture levels without allowing for significant nutrient run-off, resulting in superior yield components (Table 3).

Conclusion

The results of this three-year comparative study provide a comprehensive understanding of the technological aspects and environmental adaptability of *Physalis peruviana* L. in the diverse agro-climatic conditions of Georgia. Based on the experimental data, several key conclusions can be drawn:

Regional Suitability: The Shida Kartli region (Variani) proved to be more favorable for the commercial cultivation of Cape gooseberry compared to the humid subtropical zone of Imereti. Higher solar radiation and specific soil physical properties in Variani contributed to a significantly greater yield (0.800 kg/plant), which is double the productivity observed in Kharagauli.

Soil and Hydrology: The study identified a unique hydrological characteristic in the alluvial soils of the Liakhvi River basin, with extremely high water permeability (594.0mm/min). While this prevents waterlogging, it necessitates the implementation of precision drip irrigation and fractionated fertilization to prevent nutrient leaching and ensure plant stability.

Nutrient Management: Soil diagnostics revealed that phosphorus and humus deficiencies are primary limiting factors in both regions. To achieve optimal yields, it is essential to incorporate organic matter (20–50 t/ha) and balanced mineral fertilization, particularly focusing on phosphorus (P₂O₅) applications to support reproductive development.

Phytosanitary Risks: In humid zones such as Imereti, the cultivation of *P. peruviana* is challenged by higher disease pressure. Future agricultural strategies in these regions must prioritize enhanced drainage systems and proactive fungal disease management.

In summary, *Physalis peruviana* L. represents a highly promising high-profit crop for the Georgian agricultural sector. The successful introduction and large-scale cultivation of this species should be

prioritized in Shida Kartli, utilizing modern irrigation and soil management technologies to maximize its economic and nutritional potential.

აგროტექნოლოგია

ფიზალისის (*Physalis peruviana* L.) კულტივირების პოტენციალის შედარებითი შეფასება საქართველოს კონტრასტულ აგროეკოლოგიურ ზონებში

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(წარმოდგენილია აკადემიის წევრის ავთანდილ კორახაშვილის მიერ)

წინამდებარე ნაშრომი წარმოადგენს საქართველოში ფიზალისის (*Physalis peruviana* L.) ადაპტაციური შესაძლებლობების პირველ კომპლექსურ შეფასებას სპეციფიკურ აგროკლიმატურ გარდამავალ ზონებში. მიუხედავად იმისა, რომ ეს კულტურა გლობალურად ცნობილია, მისი ურთიერთქმედება ლიახვის აუზის უნიკალურ ალუვიურ-კარბონატულ ნიადაგებთან და იმერეთის ნოტიო სუბტროპიკულ გრადიენტებთან აქამდე სამეცნიერო ლიტერატურაში აღწერილი არ ყოფილა. კვლევის მიზანი იყო ამ კონტრასტულ გარემოში „ინკების კენკრის“ წარმოების ტექნოლოგიური ლიმიტებისა და პროდუქტიული პოტენციალის დადგენა. ჩატარდა სამწლიანი ექსპერიმენტული ციკლი (2023–2025 წწ.). ნიადაგის მონიტორინგი მოიცავდა აგროქიმიურ და გეოფიზიკურ პარამეტრებს (pH, ჰუმუსი, მოძრავი ფოსფორი და გაცვლითი კალიუმი) აკრედიტებულ ლაბორატორიებში ISO/IEC 17025 სტანდარტების შესაბამისად. კულტივირება მოეწყო რანდომიზებული ბლოკების მეთოდით, ორგანული განოყიერებისა და სპეციფიკური საირიგაციო რეჟიმების გამოყენებით. ვარიანტში (შიდა ქართლი) ალუვიურ-კარბონატულმა ნიადაგებმა (Fluvisols) აჩვენა ექსტრემალურად მაღალი წყალგამტარობა (594.0 მმ/წთ), რაც უზრუნველყოფს საუკეთესო აერაციას, თუმცა მოითხოვს ზუსტ წვეთოვან ირიგაციას. ამის საპირისპიროდ, ხარაგაულის ზონაში გამოვლინდა ჰუმუსისა და ფოსფორის მნიშვნელოვანი დეფიციტი. იმერეთში მაღალმა ფარდობითმა ტენიანობამ (>75%) გაზარდა სოკოვანი დაავადებების, კერძოდ, ნაცრის (powdery mildew) რისკი. მოსავლიანობის ანალიზმა აჩვენა შიდა ქართლის აშკარა უპირატესობა – საშუალოდ 0.800 კგ მცენარეზე, იმერეთში დაფიქსირებულ 0.400 კგ-თან შედარებით. კვლევის შედეგად შეიძლება დავასკვნათ, რომ შიდა ქართლის უპირატესობა *P. peruviana*-ს კულტივირებისთვის განპირობებულია ოპტიმალური სინათლის

ინტენსივობითა და წიადაგის ფიზიკური თვისებებით. წიადაგის დეფიციტის აღმოსაფხვრელად და მაღალხარისხიანი მოსავლის მისაღებად ორივე რეგიონში რეკომენდებულია ორგანული სასუქების (20-50 ტ/ჰა) და ბალანსირებული NPK-ს (კერძოდ, P₂O₅ 90-120 კგ/ჰა) ინტეგრირებული გამოყენება.

REFERENCES

- Fischer, G., Almanza-Merchán, P. J., & Miranda, D. (2014). *Importancia y cultivo de la uchuva (Physalis peruviana L.)* [Analysis of Colombian physalis (*Physalis peruviana* L.) production]. *Revista Brasileira de Fruticultura*, 36(1), 01-14. <https://doi.org/10.1590/0100-2945-441/13>
- Perada, M. S. B., Nazareno, M. A., & Viturro, C. I. (2019). Nutritional and antioxidant properties of *Physalis peruviana* L. fruits from the Argentinean Northern Andean region. *Plant Foods for Human Nutrition*, 74(1), 68-75. <https://doi.org/10.1007/s11130-018-0702-1>
- Puente, L. A., Pinto-Muñoz, C. A., Castro, E. S., & Cortés, M. (2011). *Physalis peruviana* Linnaeus, the multiple properties of a highly functional fruit: A review. *Food Research International*, 44(7), 1733-1740. <https://doi.org/10.1016/j.foodres.2010.09.034>
- Ramadan, M. F. (2011). Bioactive phytochemicals, nutritional value, and functional properties of Cape gooseberry (*Physalis peruviana*): An overview. *Food Research International*, 44(7), 1830-1836. <https://doi.org/10.1016/j.foodres.2010.12.042>

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