Technical paper

Variation in growth, production and quality attributes of *Physalis* species under temperate ecosystem

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Variation in growth, production and quality attributes of *Physalis* species under temperate ecosystem.

Abstract – Introduction. Diverse fruit crops with a high value reduce the risk of crop failure and offer alternatives to farmers and the market. The scope of profitable production with such quality crops along with environmental concerns make the evaluation of new species desirable. The aim of our study was to determine the most appropriate species of *Physalis* for small-scale commercial production in the temperate climate of western Himalayan regions. **Materials and methods**. Four *Physalis* species, *viz*., *P. peruviana, P. ixocarpa, P. pruinosa* and *P. nicandroides*, were field-grown during 2010–2011 in the experimental field of the Central Institute of Temperate Horticulture, Srinagar, India, to determine the most appropriate species of *Physalis* suitable for a temperate climate. **Results and discussion**. All the species tested produced vegetative growth, flowered and fruited; however, they differed significantly. The number of basal shoots was found to be maximum for *P. pruinosa* (6.37), whereas the maximum number of prickles per shoot was recorded as maximum for *P. nicandroides* (6.48). The number of points of attachment varied significantly with species, and the maximum was recorded for *P. pruinosa* and *P. ixocarpa* (7.16 for each); the maximum size of fully developed leaves (146.8 mm) and overall plant height (168.27 cm) were recorded for *P. pruinosa*. *Physalis pruinosa* and *P. ixocarpa* were found to exhibit vigorous growth under a temperate climate. Significant differences were recorded for fruiting, flowering and yield potential among the *Physalis* species. The minimum days taken for bud burst were reported for *P. nicandroides* (23.55) and *P. ixocarpa* (24.41). Similarly, the minimum days taken to reach maturity were reported for *P. peruviana* (64.96). The maximum number of fruits per plant (260.23), length of fruit (33.83 mm), average fruit weight (37.19 g), husk weight (0.32 g), fruit husk ratio (121.27), maximum fruit firmness (43.96 Relative Index) and yield (9.96 Relative Index) were recorded for *P. pruinosa*. Significant variation was recorded in quality attributes. The highest total soluble solids were found for *P. nicandroides* (8.46 °Brix), whereas the minimum total titrable acidity (0.35%) and maximum ascorbic content (38.41 mg·100 g^{-1}) were recorded for *P. peruviana*. The '*L*' value of fruits, showing brightness, was recorded as the highest for *P. peruviana* (58.97), whereas fruits of all the species showed a negative '*a*' value, indicating that none of them produced redness; however, the '*b*' value, indicating yellowness, was maximum for *P. pruinosa* (18.72).

***Physalis* / India / Himalayan region / fruits / morphology / flowering / fruiting / quality / choice of species**

Variation des caractéristiques de croissance, production et qualité d'espèces de *Physalis* sous écosystème tempéré.

Résumé – Introduction. Diverses cultures fruitières de grande valeur pourraient réduire les risques de maigres récoltes et offrir des solutions aux agriculteurs et au marché. L'intérêt de productions rentables produisant des récoltes de qualité soucieuses des préoccupations environnementales rend souhaitable l'évaluation de nouvelles espèces. Le but de notre étude a été de déterminer les espèces de *Physalis* les plus appropriées à la production à petite échelle en climat tempéré des régions de l'Himalaya occidental. **Matériel et méthodes**. Quatre espèces de *Physalis*, à savoir *P. peruviana*, *P. ixocarpa*, *P. pruinosa* et *P. nicandroides*, ont été cultivées en champ en 2010 et 2011 dans une parcelle expérimentale à Srinagar (Inde) afin de déterminer les espèces de *Physalis* les plus appropriées au climat tempéré. **Résultats et discussion**. Toutes les espèces testées ont eu une croissance végétative et ont fleuri et fructifié, mais elles ont différé sensiblement. Le plus grand nombre de pousses basales a été trouvé pour *P. pruinosa* (6,37), alors que le nombre maximum de piquants par pousse a été enregistré par *P. nicandroides* (6,48). Le nombre de points d'attache a beaucoup varié selon les espèces ; il a été maximal pour *P. pruinosa* et *P. ixocarpa* ; la taille maximale de la feuille complètement développée (146,8 mm) et surtout de la hauteur du plant (168,27 cm) a été enregistrée pour *P. pruinosa*. *Physalis pruinosa* et *P. ixocarpa* ont montré une croissance vigoureuse sous climat tempéré. Au sein des espèces de *Physalis* étudiées, des différences significatives ont été enregistrées pour la fructification, la floraison et le rendement potentiel. *Physalis nicandroides* et *P. ixocarpa* ont débourré le plus rapidement [(23.55 et 24.41) jours, respectivement]. De même, *P. peruviana* est parvenu à maturité le plus rapidement (64.96 jours). Le plus grand nombre de fruits par plante (260,23), la longueur de fruit (33,83 mm), le poids moyen des fruits (37,19 g), le poids de l'enveloppe (0,32 g), le ratio fruit/enveloppe (121,27), la fermeté maximale des fruits (43,96 index relatif) et le rendement maximal (9,96 index relatif) ont été enregistrés pour *P. pruinosa*. Les sucres totaux les plus élevés ont été trouvés pour *P. nicandroides* (8,46 °Brix), tandis que l'acidité totale titrable minimale (0,35 %) et la teneur maximale d'acide ascorbique (38,41 mg·100 g^{-1}) ont été mesurées pour *P. peruviana*. La plus forte valeur '*L*' du paramètre de coloration des fruits traduisant la luminosité a été enregistrée pour *P. peruviana* (58,97), tandis que toutes les espèces ont eu une valeur '*a*' négative indiquant qu'aucun d'entre eux n'a présenté une coloration rouge ; la valeur de '*b*' indiquant le jaunissement a été maximale pour *P. pruinosa* (18,72).

***Physalis* / Inde / région himalayenne / fruits / morphologie / floraison / fructification / qualité / choix des espèces**

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1. Introduction

Introduction and adaptation of new crops contribute to an increase in diversity of agricultural systems and offer new alternatives to farmers and markets, with crops that may have a high value and for which generally there is no over-production [1]. Therefore, new crops can increase the income of farmers, contribute to a more environmentally-friendly agriculture, reduce the risk of crop failure and also increase botanical knowledge. Growing consumer demand for new crops and unique fruits and vegetables is spurring a need for increased information on the growth habits, production and quality of different species. The scope of profitable production with quality crops together with environmental concerns make the evaluation of new species desirable [2, 3]. There are many new crops for tropical and subtropical regions that can present desirable attributes for introduction as new crops in temperate regions. Cape gooseberry (*Physalis peruviana*), also called Poha or golden berry, originating from Peru, husk tomato (*P. ixocarpa*), also known as tomatillo, originating from Mexico, *P. pruinosa*, also called ground cherry, originating from Eastern North America, and *P. nicandroides*, originating from North America [4, 5], are gaining popularity in the speciality market [6–8]. These species are herbaceous crops grown for edible fruit eaten raw, as a dessert, jams, dehydrated fruits, sauces, appetizers or used as dish decorations, and usually cultivated as short-cycle (3–4 months) annual crops but, in the absence of frost, they can be perennial [9–13]. There is much interest in consumption of fruits of *Physalis* species due to their nutritional value, especially their content of provitamin A, vitamin C (ascorbic acid), minerals such as phosphorus and iron, and fibre [14–16] and polyphenols [17, 18]. Among these, *P. peruviana* is widely used as folk medicine as a diuretic and for treating diseases such as malaria, asthma, hepatitis, dermatitis and rheumatism [19–21], and bowel and worm complaints [22]; it also shows antibiotic activity [23]. The high β-carotene content of cape gooseberry has the potential of an anticarcinogenic effect [24] and antioxidant properties [25–28]. In their region of origin they are adapted to wide altitude ranges (from sea level to 3200 m), ranging from erolytic and warm areas with intense solar radiation to humid and cloudy environments [29]; they can successfully set fruit without problems if the minimum temperature is above 50 °C [30, 31]. These fruits are small, 1–3.5 cm diameter; the yellow-orange round berry at maturity contains many seeds and is covered by a large papery calyx [32–34], which is toxic and should not be eaten. The fruits can be stored for up to one year if picked before they are fully ripe and left inside their calyx. The leaf blades of *P. nicandroides* are curved, coarse, toothed to slightly angled-lobed ovoid. They are sharp or pointed forward; the base is acute heart-shaped and leaf surfaces are covered by glandular hairs. The flowers of *P. ixocarpa* are hermaphrodite (have both male and female organs) and are pollinated by bees. *Physalis pruinosa* has small orange fruit similar in size and shape to a cherry tomato. The plants are usually small, only 30 cm to 90 cm in height. The purpose of our study was to determine the most appropriate species of *Physalis* for small-scale commercial production in the temperate climate of western Himalayan regions.

2. Materials and methods

2.1. Selection of planting material and experimental design

Four species of *Physalis, i.e.*, *P. ixocarpa, P. nicandroides*, *P. pruinosa* and *P. peruviana*, chosen for their commercial importance, were used for the study (*table I*). The present research study was carried out at the research farm of the Cent. Inst. Temp. Hortic. (CITH), Srinagar, Jammu & Kashmir, India, for two years (2011 and 2012). The experimental farm is situated at lat. 34°05' N, long. 74°50' E, and alt. 1640 m above sea level. Seeds were sown in a greenhouse in April 2011 and 2012 in 5-cm-diameter transplant flats, 100-mL cells containing a mixture of leaf mould and soil (1:1 ratio). The transplant flats were covered

Table I.
Species and source of the seeds of *Physalis* studied (Jammu and Kashmir, India).

Species	Seed Source
Physalis ixocarpa *Physalis nicandroides* *Physalis pruinosa*	Ntl. Bureau Plant Genet. Resour., Reg. Stn., Shimla, India
Physalis peruviana	Sher-e-Kashmir Univ. Agric. Sci. Technol. (Kashmir), Srinagar, Jammu and Kashmir, India Sher-e Kashmir Univ.Agric. Sci. Technol. (Kashmir), Reg. Agric. Stn., Leh, Jammu and Kashmir, India

Table II.
Monthly average weather data of experimental field for studying *Physalis* species during 2011–2012 (May to October) (Jammu and Kashmir, India).

Month	Precipitation (mm)	Temperature (°C)		Humidity (%)
		Max.	Min.	
May	20.0	21.92	9.82	59.32
June	34.9	25.17	10.78	61.10
July	31.4	28.56	16.42	59.10
August	57.0	28.52	17.63	62.29
September	53.2	27.20	12.15	56.78
October	27.9	23.77	5.50	61.97

Table III.
Initial soil properties of the experimental field (Jammu and Kashmir, India).

pH[1]	Electrical conductivity[1] ($ds \cdot m^{-1}$)	Organic carbon (%)	Available nitrogen	Available phosphorus	Available potassium	Zinc	Iron	Copper	Manganese
			($kg \cdot ha^{-1}$)						
7.1	0.48	0.71	420	28.2	346	1.2	5.7	0.8	6.8

[1] Sample composition: 1 part soil and 2.5 parts distilled water.

with clean plastic film wrap to aid moisture retention during germination. During the first weeks of May 2011 and May 2012 (two-year experimental study), all the seedlings were transplanted into the field on 0.2-m raised beds with spacing of 60 cm between rows and 30 cm between plants. All the plants were staked after 3 weeks of planting using locally available forest sticks.

During the six-month study (May to October) average maximum and minimum temperatures were recorded as 25.8 °C and 11.2 °C, respectively; average relative humidity was recorded as 60.1% and average precipitation was recorded as 37.4 mm (*table II*). The initial soil properties of the experimental field were measured (*table III*). After planting, the raised beds were mulched with black poly film to reduce weed competition and the crop was drip-irrigated. All cultural practices including fertiliser were applied uniformly as per the recommended schedule. Mature fruits were harvested twice a week when their calyx began to turn yellow [35] and the total fresh marketable and culled yields (fresh weight plus husk) were recorded. Harvesting of fruits lasted for 54 days for *P. peruviana*, 60 days for *P. nicandroides*, 68 days for *P. pruinosa* and 56 days for *P. ixocarpa*. Unfilled damaged or dropped immature

Table IV.
Morphological characters of *Physalis* species grown under temperate ecosystem (Jammu and Kashmir, India) (means of 2011 and 2012 results).

Species	No. of basal shoots	No. of prickles per shoot	No. of points of attachment of prickles	No. of bristles on upper third of shoots	Size of fully developed leaf (mm^2)	Plant height (cm)
Physalis ixocarpa	4.17	6.12	7.16	7.14	95.24	104.84
Physalis nicandroides	5.27	6.48	5.35	5.63	66.55	92.12
Physalis peruviana	3.52	4.59	3.40	2.62	89.85	68.25
Physalis pruinosa	6.37	4.30	7.54	6.62	146.86	168.07
Least significant difference at 5%	0.27	0.33	0.35	0.26	1.22	0.92

fruits were classified as culls. A completely randomised design was used with four replications.

2.2. Morphological, flowering and fruiting characters

The morphological characters of plants and their flowering/fruiting characteristics were recorded periodically. Fruit firmness was recorded using a HP Qualitest digital firmness tester; model no. 63776 (Qualitest International, Inc., Canada). Colour values of fruit for '*L*' (brightness), '*a*' (redness) and '*b*' (yellowness) were assessed using a Hunter lab refractometer; model no. 45/0, serial no.CEE 20285 (Hunter Associates Laboratory, Inc., Reston, VA, USA).

2.3. Total titrable acidity, total soluble solids and ascorbic acid

Juice from a random sample of 15 fruits per plant was extracted using a pestle and sieve for its quality.

Determination of total total soluble solids was recorded using a digital refractometer measuring Brix grades. Total titrable acidity (%) and ascorbic acid were measured as $mg \cdot 100\ g^{-1}$ using methods described by Rangana [36].

2.4. Statistical analysis

The experiment was laid out in a completely randomised design. The treatment means were compared using the least significant difference values of ≤ 0.5%. All the analyses were conducted using the procedure of the Statistical Analysis System (SAS, Institute Inc., Cary, NC, USA) and described by Panse and Sukhatme [37].

3. Results and discussion

3.1. Morphological characters

The vegetative growth of all eight crops (crops of the four species for the two years of the study, therefore 4 species × 2 years = 8 crops) was vigorous; however, it significantly varied among the different species (*table IV*). The number of basal shoots was found to be maximum for *P. pruinosa* (6.37), followed by *P. nicandroides* (5.27), whereas *P. peruviana* produced the minimum number of basal shoots (3.52). The maximum number of prickles per shoot (6.48) was found for *P. nicandroides*, which was closely followed by *P. ixocarpa* (6.12), whereas *P. pruinosa* produced the minimum number (4.30). The number of points of attachment of prickles varied significantly with species; the maximum (close to 7) was recorded for *P. pruinosa* and *P. ixocarpa,* while the minimum was recorded for *P. peruviana* (3.40). The number of bristles recorded on the upper third of the shoot was maximum for *P. ixocarpa* (7.14) and minimum for *P. peruviana* (2.62). The size of fully developed leaves was maximum for *P. pruinosa* (146.86 mm), followed by

Table V.
Flowering and fruiting characteristics of *Physalis* species grown under temperate ecosystem (Jammu and Kashmir, India).

Species	Time taken from planting to bud burst	Time taken to reach maturity	Fruit length	Fruit breadth	No. of fruits per plant	Average fruit fresh weight	Husk fresh weight	Fruit husk ratio	Fruit firmness (RI)	Yield per plant (kg)
	(days)		(mm)			(g)				
Physalis ixocarpa	24.41	69.58	27.40	31.34	206.35	26.54	0.27	93.40	31.40	5.41
Physalis nicandroides	23.55	64.96	27.59	33.64	201.27	22.74	0.26	87.81	25.47	4.64
Physalis peruviana	29.35	77.48	29.53	29.37	93.29	22.21	0.27	93.67	34.30	3.58
Physalis pruinosa	29.32	75.45	33.83	38.21	260.23	37.19	0.32	121.27	43.96	9.41
Least significant difference at 5%	0.98	1.44	0.82	0.74	2.17	0.76	0.02	1.16	1.10	0.60

P. ixocarpa (95.24 mm), whereas the smallest leaf size was recorded for *P. nicandroides* (66.55). Plant height was maximum (168.27 cm) for *P. pruinosa*, followed by *P. ixocarpa* (104.84 cm), and *P. peruviana* had the smallest height (68.25 cm). *Physalis pruinosa* and *P. ixocarpa* were found to exhibit vigorous growth under a temperate climate. Variation in the vegetative growth of *Physalis* species has already been recorded by other authors [8, 10, 38].

3.2. Flowering and fruiting characteristics

Significant differences were recorded for flowering, fruiting and yield potential among the *Physalis* species. The minimum days taken for bud burst from the day of planting were reported for *P. nicandroides* (23.55) and *P. ixocarpa* (24.41), whereas they were maximum for *P. pruinosa* and *P. peruviana* (29.32 and 29.53, respectively) (*table V*). Similarly, the least days taken from planting to maturity were reported for *P. nicandroides* (64.96), followed by *P. ixocarpa* (69.58), and the maximum were found in *P. peruviana* (77.48). Similar results showing about 64 days taken for fruit harvest were reported by Wolff [38], whereas Dremann reported that 80 days were necessary [32] and Chai *et al.* found that (90 to 150) days were taken from planting to maturity for *P. peruviana* [39], which contrasts with the results obtained in our study. In the Cundinamarca State of Columbia, cape gooseberry flower bud development lasts between (18 and 20) days [40], whereas Gupta and Roy reported that, in India, flowering initiated 70–80 days after transplanting and 19.23 days passed between the flowering initiation and anthesis [41]. In the Boyacas State of Columbia (lat. 4° N, 2690 m a.s.l., 12.5 °C mean temperature) cape gooseberry fruits required 75 days to be harvested, whereas, at a lower altitude of 2300 m (17.0 °C mean temperature) development was faster, requiring only 66 days [42, 43].

The number of fruits per plant varied significantly among the *Physalis* species. The maximum number of fruits per plant was recorded for *P. pruinosa* (260.23), followed by *P. ixocarpa* (206.35), whereas the lowest number was found for *P. peruviana* (99.23) (*table V*). Fruit length was recorded as maximum for *P. pruinosa* (33.83 mm), whereas fruit breadth was maximum for *P. nicandroides* (33.64 mm). Average fruit weight was recorded as maximum for *P. pruinosa* (37.19 g) and minimum for *P. peruviana* (22.21 g). Maximum husk weight was observed for *P. pruinosa* (0.32 g), for which the fruit husk ratio was also maximum (121.27). Fruits of *P. pruinosa* were found to be firm, with the maximum value (43.96 RI), followed by *P. peruviana* (34.30 RI). Similarly, significant variation was also recorded in yield among the *Physalis* species and the maximum was recorded for *P. pruinosa*

Table VI.
Physico-chemical characteristics of fruits *Physalis* species grown under temperate ecosystem (Jammu and Kashmir, India).

Species	Total soluble solids °Brix	Total titratable acidity (%)	Ascorbic acid (mg·100 g^{-1})
Physalis ixocarpa	8.24	0.54	18.21
Physalis nicandroides	8.46	0.36	15.24
Physalis peruviana	6.43	0.35	38.41
Physalis pruinosa	9.30	0.67	24.28
Least significant difference at 5%	0.55	0.08	0.52

(9.41 kg per plant), followed by *P. ixocarpa* (5.41 kg per plant), while *P. peruviana* produced the minimum yield (3.58 kg per plant). Because the number and size of fruits vary among different species, this leads to differences in yield per plant. Our study reveals that *P. pruinosa* and *P. ixocarpa* exhibited the best yields. Other findings also confirmed the variability of different genotypes of *Physalis* species in terms of yield per plant and fruit weight [33, 44–46].

Similarly, Hernando Bermejo and Leon [47] and Singh *et al.* [10] also reported great variation in fruit weight, colour and size of *P. ixocarpa* and *P. peruviana* cultivars, respectively, under different agroclimatic conditions.

3.3. Chemical composition

Significant variation was noted in total soluble solids, total titratable acidity and ascorbic acid content in the *Physalis* species (*table VI*). The maximum mean total soluble solids were recorded in *P. pruinosa* (9.30 °Brix) and *P. nicandroides* (8.46 °Brix), while they were minimum (6.43 °Brix) in *P. peruviana*. Similarly, fruit total titratable acidity was minimum in *P. peruviana* (0.35%), whereas the maximum was recorded in *P. pruinosa* (0.67%). Ascorbic acid content was recorded as maximum in *P. peruviana* (38.41 mg·100 g^{-1}), followed by *P. pruinosa* (24.28 mg·100 g^{-1}), whereas the minimum of 15.24 mg·100 g^{-1} was recorded in *P. nicandroides*. In comparison, Tunja fruit of Columbia ecotypes of cape gooseberry has 17.3 °Brix for total soluble solids and 2.0% of total titrable acidity [48]. Curiously, fruits of Columbia which were introduced from African ecotypes of Kenya and South Africa did not develop intense yellow colour, ripened 10–15 days later than Columbia ecotypes and had lower total soluble solids and total titratable acidity contents [48]. Differences in total soluble solids, total titratable acidity and ascorbic acid have already been reported [10, 38, 45, 49]. According to Xolff, the variation in total soluble solids and total titrable acidity in *Physalis* species may be due to environmental conditions, particularly during the period of the growth and development of fruits, and differences in species [38]. As reported by Fisher *et al.*, the ecotype and altitude did not have a significant effect on ascorbic acid content of the cape gooseberry, which was found to be in the range of 30.0–36.5 mg·100 g^{-1} [15].

3.4. Colour characteristics of fruits

The colour values at maturity of the *Physalis* species for the *L* (brightness), *a* (redness) and *b* (yellowness) when the calyx turned yellow varied significantly with different species (*table VII*). The maximum '*L*' value was recorded for *P. pruinosa* (58.97), followed by *P. ixocarpa* (57.81), whereas fruits of all the species showed a negative '*a*' value, indicating none of them produced redness; however, the '*b*' value was maximum for *P. ixocarpa* (27.29). Variation in colour among husk tomato genotypes has already been reported by other

Table VII.
Colour value of fruits of *Physalis* species grown under temperate ecosystem (Jammu and Kashmir, India).

Species	*L*	*a*	*b*
Physalis ixocarpa	57.81	– 6.59	27.29
Physalis nicandroides	55.33	– 7.56	23.31
Physalis peruviana	53.77	– 3.58	18.72
Physalis pruinosa	58.97	– 6.76	26.27
Least significant difference at 5%	0.95	0.39	1.06

authors [32, 47, 50] and for *P. peruviana* cultivars under temperate ecosystems by Singh *et al.* [10].

4. Conclusion

All the *Physalis* species evaluated, *i.e.*, *P. ixocarpa, P. nicandroides, P. pruinosa* and *P. peruviana,* produced vegetative growth, flowering and fruiting under temperate conditions. *Physalis pruinosa* and *P. ixocarpa* were found to exhibit vigorous growth; however, the minimum days taken to reach maturity were reported for *P. peruviana*. The maximum average fruit weight, number of fruits per plant, size of fruit, fruit husk ratio and fruit firmness were recorded for *P. pruinosa*. Comparatively, better quality fruits (total soluble solids, total titratable acidity and ascorbic acid content) were recorded for fruits of *P. peruviana*. In the end, under temperate climatic conditions, *Physalis ixocarpa, P. pruinosa* and *P. peruviana* were found to perform well for fruiting, flowering, yield and quality of fruits.

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Variación de las características de crecimiento, producción y calidad de especies de Physalis bajo ecosistema templado.

Resumen – Introducción. Existen diversos cultivos fruteros de gran valor que podrían reducir los riesgos de rendir cosechas pobres y ofrecer soluciones a los agricultores y al mercado. El interés por producciones rentables que produzcan cosechas de calidad, veladoras de las preocupaciones medioambientales, anima a que se evalúen nuevas especies. El objetivo de nuestro estudio fue de determinar las especies de *Physalis* más apropiadas para la producción a pequeña escala en clima templado de las regiones del Himalaya occidental. **Material y métodos**. Se cosecharon cuatro especies de *Physalis*, concretamente *P. peruviana*, *P. ixocarpa*, *P. pruinosa* y *P. nicandroides*, en campo, en 2010 y 2011, en una parcela experimental en Srinagar (India) con el fin de determinar las especies de *Physalis* más apropiadas para el clima templado. **Resultados y discusión**. Todas las especies sometidas a prueba tuvieron un crecimiento vegetativo y florecieron y fructificaron, pero difirieron notablemente. El mayor número de brotes basales se encontró en *P. pruinosa* (6,37), mientras que el número más alto de pinchos por brote se registró en *P. nicandroides* (6,48). El número de puntos de inserción varió mucho según las especies: el más alto se alcanzó en *P. pruinosa* y *P. ixocarpa*; el tamaño más grande de la hoja completamente desarrollada (146,8 mm) y, sobre todo, la altura de la planta (168.27 cm) se registró en *P. pruinosa*. *P. pruinosa* y *P. ixocarpa* mostraron un crecimiento vigoroso bajo clima templado. Entre las especies estudiadas de Physalis, se registraron diferencias significativas en cuanto a la fructificación, la floración y el rendimiento potencial. *Physalis nicandroides* y *P. ixocarpa* fueron los más rápidos en brotar [(23,55 y 24,41) días, respectivamente]. Asimismo, *P. peruviana* fue el primero en alcanzar la madurez (64.96 días). *Physalis pruinosa* registró el mayor número de frutos por planta (260,23), longitud del fruto (33,83 mm), peso medio de los frutos (37,19 g), peso del envoltorio (0,32 g), ratio fruto/envoltorio (121,27), la máxima firmeza de los frutos (43,96 Relativo Index) y el rendimiento máximo (9,96 Relativo Index). Los azúcares totales más altos se hallaron en *P. nicandroides* (8,46 °Brix), mientras que la acidez valorable total mínima (0,35 %) y el contenido máximo de ácido ascórbico (38,41 mg·100 g^{-1}) se midieron en *P. peruviana*. El valor 'L' más alto del parámetro de coloración de los frutos, que representa la luminosidad, se registró en *P. peruviana* (58.97), mientras que todas las especies tuvieron un valor 'a' negativo, lo que indica que ninguna de ellas produce una coloración roja, el valor 'b' indica que el amarilleo fue máximo en *P. pruinosa* (18,72).

Physalis **/ India / región Himalaya / frutas / morfología / floración / fructificación / calidad / elección de especies**