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Passiflora incarnata L. - CULTIVATION IN OPEN FIELD

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Abstract

The article presents the synthesis of the results of the investigations conducted over several years, regarding the acclimatization and cultivation of the species Passiflora incarnata L. in open field, under the conditions of the Republic of Moldova, the plant being native to subtropical and tropical areas. P. incarnata is commonly used as an herbal medicine, possessing sedative, spasmolytic, hypertensive, cardiotonic properties etc. The dry raw material productivity from field cultivation reached 3.6 t/ha from 2 cuts. About 2.7 t/ha pharmaceutical raw material and edible, delicious, fragrant fruits can be harvested at a single cut. After several years of testing, a high-performance form of the aforementioned species, with stable characteristics in terms of raw material, fruit and seed productivity, has been selected and after the DUS and VCU testing, we came to the conclusion that it can be proposed as a new cultivar, with high value for medicinal plant growers and pharmaceutical companies.

Key words: *species, sedative, production, raw material.*

INTRODUCTION

The species is native to South America, but can also be found quite often in Asia and Australia (Smruthi et al., 2021). The genus *Passiflora* is very large and includes over 550 species (Fonesca et al., 2020) The study of introduction, multiplication and use of the species *Passiflora incarnata* L. was initiated, in our region and in the neighboring ones
(Krasovsky et al., 2022) due to the high interest in this species for the taste of the fruits, the medicinal and decorative properties (Boboc & Cantor, 2017) possessed by this species (Cerqueira Silva, 2014).
The use of all products derived from *Passiflora incarnata* plants was confirmed by multiple publications (Deepika et al., 2024), from various research centers in different countries.
Thus, extracts from the aerial part of the plant, that is, the leaves, stems, fruits and even the roots are used to treat various conditions such as helminth infestations, gastric tumors, to relieve stress (Costa et al., 2005), (Cerqueira-Silva, 2014), (Amata et al., 2009). Besides, it possesses antibacterial (Tassew & Chou, 2022), antimicrobial properties (Badalova & Atay, 2022), and in China it was discovered that preparations from *Passiflora incarnata* L. have beneficial soothing effects in cases of heart and liver disorders (Hou et al., 2021).
In addition to being delicious and flavored, the fruits of this species also contain vitamins A, C and D (Dhawan, 2004), being an important source of alkaloids, flavonoids and carotenoids (Khan & Nabavi, 2019), providing numerous health benefits (Zeraik et al.2010).
The seeds of *Passiflora incarnata* L. are a source of essential fatty acids such as linoleic (55-60%), oleic (18-20%), palmitic (10%–14%), used in the food industry and in the cosmetic industry as an ingredient in soaps, shampoos and moisturizers (Faleiro et al., 2014).
Extensive studies on the biochemical compounds of the seeds have demonstrated that they contain a large amount of sterol – β-sitosterol, which has anti-hypercholesterolemic and anti-inflammatory effects (Al-Fartosy, 2011). The aerial part of the plant is often used as a sedative remedy (Krenn, 2002).
In addition to all their medicinal properties, the seeds of *Passiflora incarnata* constitute the main propagation material of the genus *Passiflora*
(Angelini & Tavarini, 2021). Extracts from the flowers of *Passiflora incarnata* can be used to improve the duration and the quality of sleep (Ngan et al., 2019).

Butanol extracts from the leaves of *Passiflora incarnata* are effective in the prevention of neurodegenerative and Parkinson's disease (Ingale & Kasture, 2022) as well as neurotic dysfunctions (Gad et al., 2022).
All products obtained over time from *Passiflora incarnata* L. have been validated as beneficial for human health and wellbeing (Singh & Nagpal, 2022). Recent research has confirmed the calming and anti-stress effect of *Passiflora incarnata* L. preparations not only on the nervous system of humans, but also on some animals. Thus, a beneficial tranquilizing effect of *Passiflora incarnata* L. preparations was observed in suckling piglets during the post-weaning period, which was very stressful for the animals, but which proceeded normally, with even a weight gain in the animals being recorded during the respective period (Pastorelli & Luzi, 2022). It was also observed that the addition of a mixture of *Passiflora incarnata* grass to the feed significantly influenced the behavior of minks under stress, which improved animal welfare and optimized production parameters (Wlazło & Żebracka, 2022).
In accordance with current publications (Pacheco, 2021), obtaining high quality pharmaceutical raw material, seeds and planting material requires research on the productivity of the raw material and the quality indices of the species under the growing conditions of the Republic of Moldova, by applying single- and double-harvest cultivation techniques, in different years.

MATERIALS AND METHODS

The study was conducted on a separate sector, in open ground with irrigation possibilities, on the territory of the Institute of Genetics, Physiology and Plant Protection of Moldova State University. The data obtained are results of the harvesting of raw material in the first and second years of life of *Passiflora incarnata* L. plants. The yield of fresh and dried pharmaceutical raw material from the first- and second-year plantations was determined. Simultaneously with determining the production of raw material, phenological phases, morphometric indices such as plant mass, axial shoot length, number of lateral shoots, proportion (yield) of leaves, fruits, stems in the total mass of raw material and seed production were also determined.
The plants were harvested at the full budding stage - beginning of flowering – for plant raw material and then – at full fruit development and ripening.
After the first cut, to obtain the plant raw material, mineral nitrogen fertilizers (NO_3) were applied to the "stubble", then the area was irrigated and the space between the rows, which initially constituted 0.7m, was loosened.
The experiment included the following options: obtaining two harvests per season – the first one – at the flowering stage and the second one – at the initial stage of fruit development, in the first and second year of vegetation, and obtaining production at full fruit maturity in the first and second year of vegetation.
Seedlings obtained from seeds of the selected biotype of *Passiflora incarnata* L, improved and acclimatized to the environmental conditions of R. Moldova, were used to establish the plantations. The seedlings were grown under controlled greenhouse conditions, in boxes, at temperatures above 25 °C and high humidity, obtained by covering the boxes in the early stages with "Agril" film with a density of 19 g/cm, which helped maintaining humidity and temperatures at a constant level, thus favoring faster and more even seed germination. Sowing to obtain seedlings was carried out, depending on the year, at the end of March or the beginning of April. The seedbed was made up of a mixture of forest soil, peat and sand in a ratio of 2:1:1. During the seedling production period, the soil in the nursery was irrigated sufficiently to keep it slightly moist, which facilitated the emergence of the seedlings within the optimal time frame of 48-62 days. After the seedlings emerged, they started growing rapidly and the protective film was removed to provide more light and to lower the temperature, which helped hardening the seedlings.
After reaching 10-15 cm in height, with 5-7 leaves on the stems, the seedlings were transplanted into open ground. At the end of May, the seedlings were transplanted manually in abundantly irrigated soil, incorporating the root system and the lower part up to the first leaf into the soil at a depth of 18-20 cm, at a density of 60.000-70.000 units/ha.

In the 2nd year of life, *Passiflora incarnata* L. plants started growing from the rhizome buds, occupying the space between the rows and the one adjacent to the plantation. During our research, another propagation method was applied to the *Passiflora incarnata* L. species – sowing the seeds directly in open ground, and covering the seedlings with Agril film with a density of 21 g/cm.

RESULTS AND DISCUSSIONS

The seedlings planted in open ground formed 25-30 cm long shoots in 35-40 days (Figure 1), and in the first half of July, developed flower buds, which bloomed in 6-8 days and, by the end of July, produced fruits, which reached the stage of full ripening in late September or early October.

Figure1. *Passiflora incarnata* L. seedlings

The second-year *Passiflora incarnata* L. plants started growing 15-20 days earlier than the seedlings were planted in the first year, that is – in early May.

Figure 2. *Passiflora incarnata* L. plants in full bloom

At the beginning of June, the plants formed 8-9 leaves, and after 15 days – flower buds, which bloomed (Figure 2.) at the beginning of July. In the middle of the July, the early stage of fruit development was recorded and at the end of September – the full ripening stage.

At the first harvest, the plants were in the full flowering - beginning of fruit development stage (Figure 3.), the shoots were leafy (leaf ratio 52.3-59.8%), the presence of fruits was 2.6-5.8%. The regeneration of plants after the first cut lasted 68 days.

Figure 3. *Passiflora incarnata* L. fruits

The plant mass obtained from the second harvest (Table 1), performed at the beginning of fruit development stage, consisted of leafy shoots (leaf ratio 52.9-64.0%).

Table 1. The structure of the *Passiflora incarnata* L. raw material obtained in the first year of vegetation

Variant	Technology	Development stage	The share of organs in raw material, %		
			leaves	stems	fruits
V_1	with 2 cuts: I (86 days)	flowering 50%	59.8	37.4	2.6
	II (62 days)	fruit development	64.0	30.9	5.1
	with 1 cut (150 days)	fruit ripening	47.1	24.4	28.6
V_2	with 2 cuts: I (99 days)	flowering 70%	52.9	41.7	5.4
	II (68 days)	fruit development	52.3	41.9	5.8
	with 1 cut (178 days)	fruit ripening	44.5	28.7	26.8

*V_1 – transplanted seedlings; V_2 – seeds sown in the field, under Agril film

The raw material in the double-cut technology consisted of 65-80 cm long shoots, weighing 85-89 g in V_1, the most vigorous being the plants

from V_2 with a weight of 114-169 g, with 5-7 lateral shoots, 10-14 floral buds and 0.9-2.0 fruits with a diameter of 10-15 mm at the beginning stage of their development (Table 2). The raw material in the double-cut technology was of very high quality, without the presence of any mature fruits, which are not admissible for obtaining high quality pharmaceutical raw material.

Table 2. Morphometric and numerical parameters of the plants

Variant	Technology	Parameters of the axial shoot				
		length cm	shoots, pcs.	leaves, pcs.	buds, pcs.	fruits, pcs.
Vi	with 2 cuts:					
	I	65.1	5.5	24.1	10.4	0.9
	II	50.7	6.8	20.1	1.2	0.3
	with 1 cut	89.0	10.4	30.8	0.5	4.3
V_2	with 2 cuts:					
	I	79.9	6.7	21.0	13.2	2.0
	II	85.7	4.2	24.8	1.6	1.4
	with 1 cut	116.8	11.2	31.6	0.7	6.8

*V_1 – transplanted seedlings; V_2 – seeds sown in the field, under Agril film

When applying the single-cut technology, shoots from both variants harvested during the fruit maturation stage were more vigorous, with a weight of 223.0-285.5 g, and fruits with mature seeds with a weight of 63.8-76.5 g (average from 25 plants, Table 3). The quality of the raw material in the single-cut crop was average, with a high content of stems lignified in the basal part and devoid of leaves, requiring manual work to remove the fully ripe fruits, which were still valuable as a source of seeds.

Table 3. The structure of the production of *Passiflora incarnata* L. plants in the 1st year of vegetation

Variant	Technology	Weight, g			
		plant	leaves	buds	fruits
V_1	with 2 cuts:				
	I	85.9	51.4	32.2	2.3
	III	82.8	53.0	25.2	4.3
	with 1 cut	223.0	105.0	54.2	63.8
V_2	with II cuts:				
	I	169.5	89.6	70.8	9.1
	II	113.9	59.5	47.8	6.6
	with 2 cuts	285.5	127.0	82.0	76.5

*V_1 – transplanted seedlings; V_2 – seeds sown in the field, under Agril film

The harvest obtained by sowing in the field was 15 t/ha of raw material consisting of 12 t/ha of herba and 3 t/ha of fruits. The useful production (fresh mass without fruits) obtained by direct sowing in the field in the single-cut technology was twice as high as in the variant obtained by transplanting seedlings. The raw material production in the single-cut variant, obtained by transplanting seedlings, was 7.76 t/ha, of which 6.24 t/ha was herba and 1.52 mature fruits (Table 4).

The two-cut (harvest) technology proved to be more efficient due to the higher productivity of fresh herba – of 14.75 t/ha and its high quality.

Tabelul 4. The productivity of the species *Passiflora incarnata* L.

Variant	Technology	The productivity of:			
		fresh herba t/ha	pharmaceutical herba, t/ha	fruits t/ha	seeds, kg/ha
V_1	with 2 cuts:				
	I	3.10	0.99	-	
	II	4.66	1.63	-	
	total	7.76	2.62	-	
	with 1 cut	6.16	2.76	1.52	103
V_2	with 2 cuts:				
	I	5.51	1.87	-	
	II	9.24	3.33	-	
	total	14.75	5.20	-	
	with 1 cut	12.38	4.56	2.83	185

*V_1 – transplanted seedlings; V_2 – seeds sown in the field, under Agril film

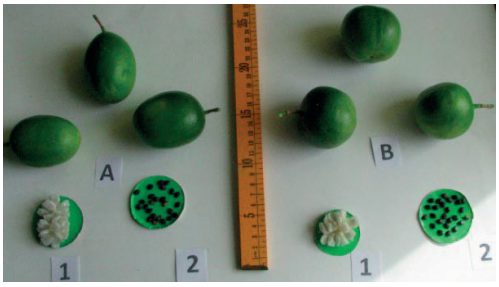

Figure 4. Fruits with seeds of *Passiflora incarnata* L.

When ripe, the fruits of *Passiflora incarnata* L. are yellow-green, buy oblong (Figure 4. A, ori ovoid forms – B), soft to the touch, slightly wrinkled, the lower skin is thinner. Inside the fruit, there is a white protective layer, containing a round, also white sac enclosing the seeds. The seeds (Figure 4. A-2 and B-2) are surrounded by a yellowish gelatinous pulp (Figure 4. A-1and B-1) with a very pleasant aroma and taste, somewhat similar to melon, with a slight flavor. The fruits are on average 58.1 mm long and 50.3 mm wide, with an average weight of 42.2 g (Table 5). The average multiannual germination capacity of the seeds is 66%.

Table 5. Morphometric indices of *Passiflora incarnata* L. fruits

Parameters	Values
Fruit length, mm	58.1
Fruit diameter, mm	50.3
Fruit weight, g	42.2
Number of seeds in a fruit, pcs	106.4
Ratio of fruits with mature seeds	63.4
Weight of 1000 seeds, g	35.2

*average of 25 fruits in 5 repetitions

CONCLUSIONS

The research has shown that *Passiflora incarnata* L. plants adapted to the climatic conditions of the Republic of Moldova can be successfully cultivated and propagated by sowing in open ground, being able to bear fruit and form mature seeds in the first year of vegetation. In early spring, the young seedlings can be successfully protected from low temperatures by covering them with Agril film.

The raw material obtained by two cuts (harvests) per season is characterized by very high quality, leaf content of 52-64% and lack of fully developed fruits and lignified stems, which meets the quality standards for pharmaceutical herba.

According to productivity indices, the variant with plants obtained by sowing directly in open filed had a higher raw material production, in the single-cut option, of 12.38 t/ha, or 201% as compared with the variant obtained by transplanting seedlings – 6.16 t/ha. When applying the technology of sowing directly in the open field followed by two cuts, yields of 14.75 t/ha were obtained, as compared with 7.76 t/ha obtained from the variant with transplanted seedlings, or almost twice as much. The production of pharmaceutical herba was also higher in the variant obtained by direct sowing in the field, with 4.56 in the single-cut option and 5.2 t/ha in the double-cut option, as compared with 2.76 and 2.62 t/ha, the positive difference being 63% and 86%, respectively. For the production of high-quality raw material, it is preferable to use the double-cut technology.

The determined morphological parameters demonstrated that the fruits of *Passiflora incarnata* L. grown in open ground, under the meteorological conditions of our area, correspond to the species description in published sources, with a seed number of 106.4 units per fruit and the weight of 1000 seeds of 35.2 g.

To obtain edible and viable fruits and high-quality seeds, it is necessary to use the technology with a single harvest per season, carried out at the end of October.

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