UDC 634.662:581.4 +631.527+ 58:069.029 (477.5)
DOI https://doi.org/10.32782/2522-9680-2026-1-234

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To cite this article: Krasovskyi V., Mezhenskyj V., Mezhenska L., Cherniak T., Diachenko-Bohun M., Shkura T., Pototska S. (2026). Biological features of *Ziziphus jujuba* Mill. hybrids. *Fitoterapiia. Chasopys – Phytotherapy. Journal*, 1, 234–243, doi: https://doi.org/10.32782/2522-9680-2026-1-234

BIOLOGICAL FEATURES OF *ZIZIPHUS JUJUBA* MILL. HYBRIDS

Actuality*. The jujube (Ziziphus jujuba Mill.) is an ancient and valuable fruit and medicinal crop, now cultivated in at least 48 countries. Its popularity is driven by its high nutritional content and wide range of medicinal applications. In Ukraine, the crop requires specific breeding efforts for successful expansion beyond its traditional southern area. The main goals are to increase winter hardiness,*

select varieties requiring less heat for ripening (before the end of the growing season in the Forest-Steppe region), and develop forms with large, tasty fruits that are also spineless.

Purpose of the study *is to investigate the biological characteristics of jujube that is crucial for its successful cultivation in the Left-Bank Forest-Steppe region of Ukraine.*

Materials and methods*. The study was conducted on a hybrid seedling population of Z. jujuba in the Khorol Botanical Garden, located in the Left-Bank Forest-Steppe region of Ukraine. The initial material comprised 48 ten-year-old trees derived from free cross-pollination of the winter-hardy mother plant 'Kyshynivska' with pollen from large-fruited, non-hardy Chinese and Tajik cultivars. Morphometric analysis focused on fruit characteristics (weight, linear dimensions) and spininess. The length of both erect and recurved spines was measured, and the spinescence index (number of spines per 10 cm of stem length) was calculated. Data were analysed using descriptive statistics, ANOVA, and Pearson correlation coefficients ($p \leq 0.05$).*

Research results. *The hybrid population showed high winter hardiness, confirming the success of the breeding process. A large potential for breeding was found, with a high coefficient of variation for fruit weight (57.5%). Analysis revealed a strong positive correlation between fruit weight and both fruit length ($r = 0.87$) and diameter ($r = 0.86$). Two exceptionally valuable hybrid genotypes were selected: 'Khorolska Krupnoploda' (5–3–11) and 'Osoblyva' (5–3–17). The study established that fruit weight has no significant linear relationship with the length of erect spines ($r = -0.01$) or the spinescence index ($r = -0.22$). This confirms that combining large fruit size with spinelessness is fully achievable. Furthermore, 77% of the fruits reached commercial ripeness (fully browned skin) by mid-October, confirming their suitability for cultivation in the northern part of the species' current range.*

Conclusions*. The hybrid Z. jujuba population demonstrates high adaptation and vitality in the Ukrainian Forest-Steppe. The identified high variability of traits is ideal for further breeding. The selection of the thornless, large-fruited Osoblyva' (5–3–17) proves that combining highly desirable traits like spinelessness and large fruit size is possible, significantly advancing the prospects for the commercial cultivation and further breeding of jujube in non-traditional areas.*

Key words: *jujube, biological features, genotype, shoot, spine, fruit.*

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Бібліографічний опис статті: Красовський В., Меженський В., Меженська Л., Черняк Т., Дяченко-Богун М., Шкура Т., Потоцька С. (2026). Біологічні особливості гібридів *Ziziphus jujuba* Mill. *Фітотерапія. Часопис*, 1, 234–243, doi: https://doi.org/10.32782/2522-9680-2026-1-234

БІОЛОГІЧНІ ОСОБЛИВОСТІ ГІБРИДІВ *ZIZIPHUS JUJUBA* MILL.

Актуальність. *Зизифа (Ziziphus jujuba Mill.) – це давня цінна плодова та лікарська культура, яку зараз вирощують щонайменше у 48 країнах. Її популярність зумовлена високою харчовою цінністю та широким спектром медичного застосування. В Україні ця культура потребує цілеспрямованої селекції для успішного поширення за межі традиційних південних районів. Основні завдання полягають у підвищенні зимостійкості, доборі сортів, що вимагають менше тепла для достигання (до кінця вегетаційного періоду в умовах Лісостепу), а також створення великоплідних безколючкових форм із високими смаковими якостями.*

Мета дослідження *– вивчення біологічних особливостей зизифи, які мають вирішальне значення для її успішного вирощування в Лівобережному Лісостепу України.*

Матеріал і методи. *Дослідження проводили на гібридній популяції сіянців Z. jujuba у Хорольському ботанічному саду, розташованому в Лівобережному Лісостепу України. Вихідний матеріал включав 48 десятирічних дерев, отриманих унаслідок вільного запилення зимостійкої материнської рослини 'Kyshynivska' пилком великоплідних, але незимостійких китайських і таджицьких сортів. Морфометричний аналіз зосереджувався на характеристиках плодів (маса, лінійні розміри) та колючості. Вимірювали довжину як прямих, так і зігнутих колючок, а також обчислювали індекс колючості (кількість колючок на 10 см довжини пагону). Дані аналізували за допомогою описової статистики, дисперсійного аналізу та коефіцієнтів кореляції Пірсона ($p \leq 0.05$).*

Результати дослідження. *Гібридна популяція продемонструвала високу зимостійкість, що підтверджує успішність процесу відбору. Виявлено значний селекційний потенціал із високим коефіцієнтом варіації для маси плода (57.5%). Аналіз виявив сильну позитивну кореляцію між масою плода, його довжиною ($r = 0.87$) та діаметром ($r = 0.86$). Виділено два винятково цінні гібридні генотипи: 'Khorolska Krupnoploda' (5–3–11) і 'Osoblyva' (5–3–17). Дослідження встановило, що маса плода не має суттєвого лінійного зв'язку з довжиною прямих колючок ($r = -0.01$) або індексом колючості ($r = -0.22$). Отже, поєднання великого розміру плоду з відсутністю колючок є цілком досяжним. Окрім того, 77% плодів досягли товарної стиглості (повністю побуріла шкірка) до середини жовтня, що підтверджує їх придатність для вирощування у північній частині поточного ареалу культури.*

Висновок. *Гібридна популяція Z. jujuba демонструє високу адаптацію та життєздатність в умовах Українського Лісостепу. Виявлена висока варіабельність ознак є ідеальною для подальшої селекції. Відбір неколючого генотипу 'Osoblyva' (5–3–17) з великими плодами доводить можливість поєднання таких високоцінних ознак, як безколючковість та великий розмір плода, що значно покращує перспективи комерційного вирощування та подальшої селекції зизифи в нетрадиційних для неї регіонах.*

Ключові слова: *зизифа, біологічні особливості, генотип, пагін, колючка, плід.*

Introduction. Relevance. The jujube (*Ziziphus jujuba* Mill., family *Rhamnaceae* originated in southwest Asia. Today, it is cultivated in gardens and for agricultural production of fruit in climates ranging from tropical to temperate. Different varieties of jujube are now cultivated in at least 48 countries on all continents except Antarctica (Wu et al., 2025). This unusual plant has been used medicinally and as a fruit since ancient times. Over one billion people in Asia use jujube in traditional medicine, and 20 million farmers cultivate it for its fruit (Yang et al., 2021).

All parts of the jujube tree, including the leaves, fruit, seeds, bark and roots, are used in the development of drugs. There is an increasing commercial demand for *Z. jujuba* due to its wide range of applications in the field of human health. The fruit has many applications for human health, including antioxidant, anti-cancer, refrigerant, pectoral, styptic, sedative, stomachache, tonic, appetite stimulant, and treatment of chronic fatigue, diarrhoea, anaemia, hysteria, irritability, pulmonary ailments, fevers, and ulcers (Sharma et al., 2014; Asad et al., 2023). According to Azami Movahed et al. (2025) the jujube fruit is used as a food source thanks to its high nutritional content, including carbohydrate, fibers, and complex of vitamins. Jujube fruit can be consumed as fresh pulp or used in processing. Dried pulp can also be used as an ingredient in tea, snacks, bread, cakes, etc (Rashwan et al., 2020).

The jujube plants were first introduced to the Nikitsky Botanical Garden in 1914. Its spread was facilitated by the import of large-fruited Chinese varieties in 1953. The first foreign jujube cultivars, 'Kytaiskyi 60' and 'Yuzhanin',

were registered in Ukraine in 1994. Between 2008 and 2012, the cultivars 'Plodivskyi', 'Sinit', 'Tsukerkovyi', and 'Koktebel' developed in Ukraine were entered into Ukraine's State Register of Plant Varieties (Krasovskyi, 2003; Mezhenskyj et al., 2012).

To further spread this promising fruit crop, it is necessary to select new varieties adapted to regional conditions that bear fruit regularly and have large fruits of different ripening times suitable for table and universal use. To extend the cultivation area northwards, it is necessary to increase the winter hardiness of the plants and select varieties that require less heat and ripen before the end of the growing season. It is also important that the plants have few or no thorns. The fruits should be tasty and rich in sugars and vitamins. Ideally, self-fertile, parthenocarpic varieties should be created (Mezhenskyj et al., 2012).

The purpose of the study is to investigate the biological characteristics of jujube that are crucial for its successful cultivation in the Left-Bank Forest-Steppe region of Ukraine.

Materials and methods of the study. *Z. jujuba* 'Kyshynivska' seedlings were planted in the orchard of the Khorol Botanical Garden, which is located in the Forest-Steppe region of Ukraine. The area has a humid continental climate with warm summers (Dfb). The soil is ordinary chernozem. The coordinates for the site are approximately 49.7772° N, 33.2596° E, and the investigation focused on 48 ten-year-old trees that were planted at a distance of 4 × 2 m. Standard cultural practices were applied, except for irrigation.

The length of ten erect and ten recurved spines were measured for each genotype with an accuracy of 1 mm. The length of the erect spines was measured using a ruler. A flexible wire template was used to match the shape of the recurved thorns. The end of each spine was fixed to the wire with a clip, after which the wire was straightened and the length measured with a ruler. The spinescence index was calculated by averaging the number of spines per 10 cm of stem length across three shoots. The length and diameter of the fruit and stone, as well as the length, width and thickness of the seed, were measured in millimetres using an electronic digital calliper (300-I-0.01, Shahe; China, 2021). The weight of the fruit, stones and seeds was measured in grams using electronic scales (FEH-300, Ukraine, 2022). Fruitfulness was assessed visually using the appropriate scales (Tkachyk, 2016). The ripeness of the fruit was checked every ten days by looking at the percentage of fruits whose surface had turned completely brown.

Descriptive statistics were used to analyse the data obtained and calculate the average values (Mean), standard deviation (SD), and coefficient of variation (CV%). Statistical analysis of the study data was performed using Microsoft Excel Office 2019 with an analysis of variance (ANOVA) and Pearson correlation coefficients. Fisher's least significant difference (LSD) test was used to determine significant differences between means at a 95% confidence level ($p \leq 0.05$).

Research results and their discussion.

Creation of a hybrid fund. In 2000, jujube seeds were introduced from the Moldovan Scientific Research Institute of Fruit Growing (the Scientific and Production Association «Codru»), comprising a mixture of different varieties and forms. From this population of seedlings, one variety was selected and named 'Kyshynivska' (see fig. 1).

Fig. 1. Shoot and fruit of *Z. jujuba* 'Kyshynivska'

Its fruits are ellipsoidal in shape, measuring 28 mm in length and 22 mm in diameter. They weigh 5.9 g and, unlike other varieties, they do not crack during heavy autumn rainfall. 'Kyshynivska' is distinguished by its abundant fruiting, good seed germination, and high winter hardiness.

Worldwide, jujube varieties were selected as a southern crop without taking winter hardiness into account. However, for its successful introduction as a fruit plant, this trait is one of the most important because winter hardiness determines whether it can be grown outdoors in Ukraine's forest-steppe conditions. The neighbouring seedlings were grafted with varieties developed in China and Tajikistan: Tajikistan: 'Tayangzao' and 'Vakhshskij 30/60'. These varieties produce large, seedless fruit. During the harsh winter of 2011/12, when the air temperature dropped to -28.6 °C, these varieties were lost from our collection. However, the hybrid seedlings showed high winter hardiness throughout the years of research.

Following free cross-pollination in 2011 involving «Kyshynivska» and pollen from «Tayangzao» and «Vakhshskij 30/60», fruits with developed seeds were produced. These seeds were removed from the drupes in spring and germinated in Petri dishes. The germinated seeds were then sown in open ground. Three-year-old seedlings were then planted in an experimental plot in the breeding site of the Khorol Botanical Garden. Currently, these trees have an average height of 3 metres. The shape, size and weight of the fruits of hybrids varies (see fig. 2).

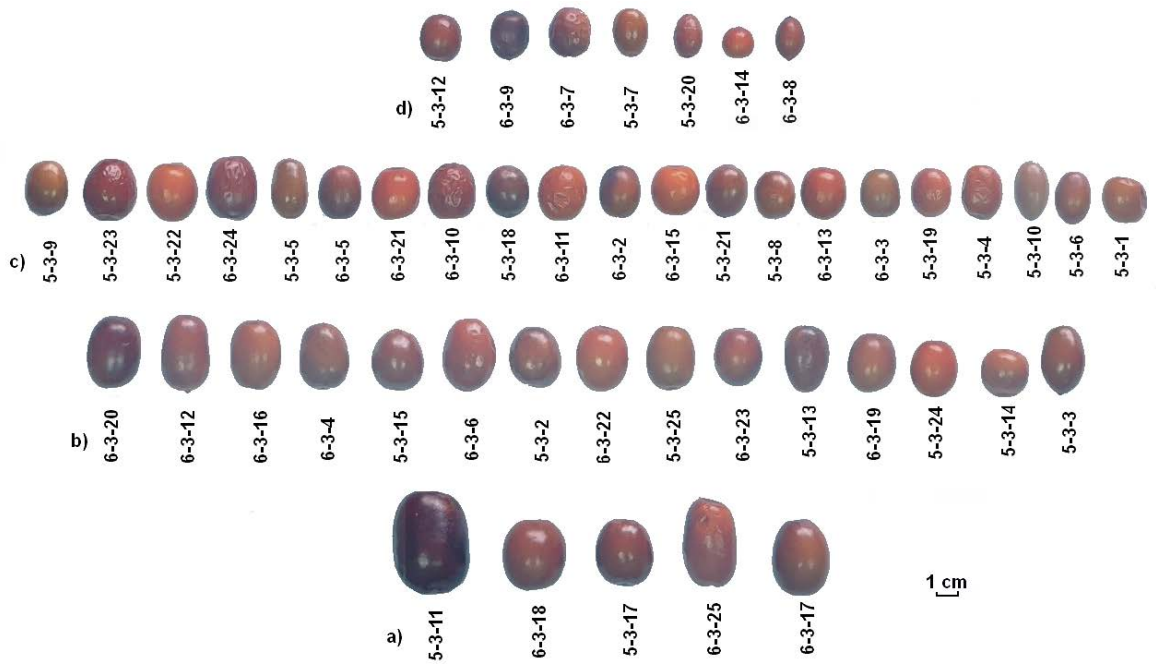

Fig. 2. Fruits of *Z. jujuba* hybrids
Note: **a) large fruits, weighing above 10 g; b) medium fruits, 5–10 g; c) small, 3–5 g; d) very small, less than 3 g. In each row, the fruits are arranged by decreasing weight from left to right**

Krasovskyi et al. (2025) conducted a detailed study of the linear parameters of fruits, pits, and seeds, as well as the weight of trees, within a hybrid jujube population at the Khorol Botanical Garden. The variability of all the linear parameters of the fruits, stones and seeds, including stone weight, falls within the normal range, with a coefficient of variation of 11.2–28.2%. However, fruit and seed weight are characterised by a high coefficient of variation, at 57.5% and 50.0% respectively. A study of a genetic collection of 150 jujube accessions, conducted by Bai et al. (2025), showed less variability. The variation in fruit weight was 12.9%, and the variation in linear fruit dimensions was 5.1–5.3%.

The linear relationships between the measured morphological parameters of the fruit are shown in table 1.

Strong positive correlations are observed between fruit weight and length (r = 0.87), as well as between fruit weight and diameter (r = 0.86).

Therefore, there is a direct relationship: the greater the length and diameter of the foetus, the greater its weight. Additionally, the length of the stone is a key factor in determining the total length of the fruit (r = 0.81). A significant number of indicators show a moderate but significant direct relationship, suggesting a shared influence on growth processes. The weight of the stone moderately correlates with its diameter (r = 0.76) and length (r = 0.67). This emphasises that the weight of the stone is determined by both its length and its thickness. Fruit indicators also moderately correlate with seed weight; for example, fruit weight correlates with seed weight (r = 0.65) and fruit length correlates with seed weight (r = 0.61). Fruit weight also moderately correlates with seed weight (r = 0.64). Stone length also moderately correlates with seed length (r = 0.52) and seed weight (r = 0.53). The weakest correlations were found between seed indicators and fruit/stone indicators, especially for seed thickness, where r ranged from 0.05 to 0.17. This suggests that seed thickness development is relatively independent of the overall size of the fruit.

All large-fruited hybrid genotypes with a fruit weight exceeding 10 g are recommended for fresh and canned consumption (Krasovskyi et al., 2025). Hybrid 5-3-11 has the largest fruit in terms of its linear dimensions and weight (length 42 mm, diameter 27 mm, weight 18 g). It is named ‘Khorolska Krupnoploda’, meaning «large-fruited of Khorol» (fig. 3a). Hybrid 5–3–17 has fruit with the following parameters: length 29 mm, diameter 25 mm and weight 11 g. It is named «Osoblyva», which means «unique, peculiar». It tastes excellent, better than other large-fruited hybrid genotypes, and has no thorns on its branches (fig. 3b).

According to Chen & Schirarend (2007), morphologically *Z. jujuba* has branchlets (new branches) with two stipular spines, either present or absent. The long spines

Table 1

Pearson correlation coefficients between indicators (r)

Indicator	Fruit length	Fruit diameter	Fruit weight	Stone length	Stone diameter	Stone weight	Seed length	Seed width	Seed thickness	Seed weight
Fruit length	1.00									
Fruit diameter	**0.75**	1.00								
Fruit weight	**0.87**	**0.86**	1.00							
Stone length	**0.81**	**0.44**	**0.65**	1.00						
Stone diameter	0.31	0.47	0.45	**0.33**	1.00					
Stone weight	**0.61**	**0.55**	**0.65**	**0.67**	**0.76**	1.00				
Seed length	**0.49**	**0.29**	**0.29**	**0.52**	-0.15	0.18	1.00			
Seed width	**0.32**	**0.40**	**0.35**	**0.32**	**0.29**	**0.30**	**0.43**	1.00		
Seed thickness	0.13	0.12	0.05	0.14	0.17	0.11	0.15	0.16	1.00	
Seed weight	**0.57**	**0.55**	**0.64**	**0.53**	**0.48**	**0.59**	0.11	**0.40**	0.07	1.00

Note: Significant coefficients ($p \leq 0.05$) are shown in bold (n =48).

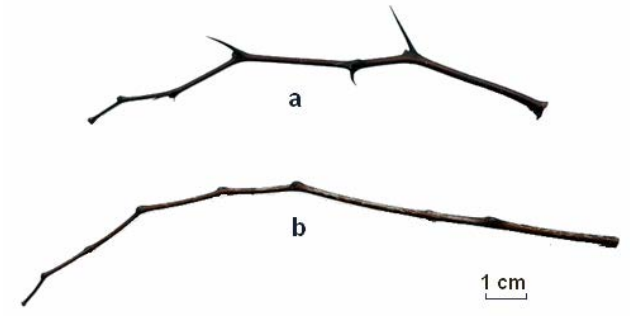

Fig. 3. Shoots of *Z. jujuba* hybrids
***Note:* a) 'Khorolska Krupnoploda' (5–3–11);**
b) 'Osoblyva' (5–3–17)

are erect, reaching up to 3 cm in length and are stout, while the short spines are recurved and develop from old branches (fig. 4).

Fig. 4. Two types of stipular spines on *Z. jujuba*

Plants with spiny branches belong to var. *jujuba* and those without belong to var. *inermis*. The hypothesis that spinescence has evolved primarily as a defense against herbivores is supported by research (Hu et al., 2020). As with many agricultural crops, the absence of spines or a reduction in their number is a sign of a cultivated plant. Huang et al. (2016) note that jujube was domesticated through artificial selection based on important agronomic characteristics. This led to a transition from spiny bushes to thornless trees with larger fruits.

Bai et al. (2025) analysed 150 jujube germplasm resources and determined that the mean length of erect spines was 10.6 mm, ranging from 3.0 to 28.0 mm, and the mean length of recurved spines was 3.3 mm, ranging from 1.7 to 7.0 mm. By contrast, the length of erect spines on plants in the Khorol Botanical Garden ranged from 1.0 to 25.0 mm (mean length: 12.9 mm), while the length of recurved spines ranged from 1.0 to 11.0 mm (mean length: 2.4 mm). The spine characteristics of individual genotypes are presented in table 2.

Only two genotypes, 5–3–8 and 5–3–17 ('Osoblyva'), are characterised by a complete absence of spines. The combination of fairly large, high-quality fruits and the absence of spines makes the latter genotype particularly valuable for both cultivation and further breeding work. Genotype 6–3–10 has very short straight spines, which reliably distinguishes it from all other genotypes in terms of the length of its erect spines. In certain genotypes, recurved spines may be absent at some nodes if erect spines are present at every node.

The spinescence index correlates with the length of erect spines (r = 0.66) and recurved spines (r = 0.69). There is also a high direct correlation between the lengths of erect and recurved spines on the trees of the genotypes under study (r = 0.72). A significant linear relationship exists between these pairs of data.

A striking example of the wild type is genotype 6–3–14, which has the longest, erect spines, a high spinescence index thorns and the smallest fruits. The genotypes with the largest fruits in the studied population

Table 2

Morphometric indicators of the spines of *Z. jujuba* genotypes

Genotype	Length of erect spines, mm			Length of recurved spines, mm			Spinescence index
	Min-Max	Mean ± SD	CV	Min-Max	Mean ± SD	CV	Mean ± SD
5-3-8	0	0	0	0	0	0	0
5-3-17	0	0	0	0	0	0	0
6-3-10	1–8	3.9 ± 2.23	57.3	1–2	1.7 ± 0.58	34.6	1.0 ± 0.4
5-3-18	3–6	4.6 ± 1.26	27.5	1–3	1.9 ± 0.74	38.8	1.7 ± 0.9
6-3-9	2–10	5.8 ± 3.77	64.9	1–2	1.5 ± 0.58	38.5	1.9 ± 0.8
6-3-6	2–10	6.2 ± 2.94	47.4	2	2.0 ± 0.00	0	0.9 ± 0.2
5-3-12	4–9	6.9 ± 1.66	24.1	1–3	2.1 ± 0.70	33.5	1.2 ± 0.4
6-3-15	5–11	7.6 ± 2.59	34.1	1–3	1.8 ± 0.87	48.1	3.7 ± 0.5
6-3-18	5–10	7.9 ± 2.33	29.5	1–2	1.3 ± 0.49	38.0	0.2 ± 0.3
6-3-7	5–10	8.0 ± 1.83	22.8	1–2	1.5 ± 0.52	35.9	3.5 ± 0.3
6-3-22	3–13	8.3 ± 3.33	40.2	1–2	1.7 ± 0.49	28.5	1.7 ± 0.6
5-3-14	5–15	9.0 ± 3.77	41.9	2–2	2.0 ± 0.00	0	1.4 ± 0.9
5-3-25	6–15	9.2 ± 2.74	29.8	1–3	1.9 ± 0.60	31.8	2.5 ± 0.5
6-3-25	3–15	9.2 ± 4.64	50.4	2	2.0 ± 0.00	0	2.1 ± 1.1
5-3-5	8–11	9.9 ± 1.20	12.1	1–3	2.0 ± 0.63	31.6	2.2 ± 0.3
6-3-16	4–15	10.2 ± 3.52	34.5	1–3	2.3 ± 0.71	31.4	2.9 ± 0.7
5-3-23	6–18	10.6 ± 3.95	37.3	1–3	1.6 ± 0.79	50.1	2.2 ± 0.4
6-3-2	7–15	10.8 ± 2.53	23.4	1–2	1.4 ± 0.50	37.0	2.8 ± 0.6
5-3-20	9–15	11.4 ± 1.58	13.8	1–3	2.3 ± 0.65	28.5	4.9 ± 0.8
5-3-9	9–16	11.5 ± 2.72	23.6	2–3	2.4 ± 0.50	21.3	2.1 ± 0.3
6-3-21	7–20	11.8 ± 4.05	34.3	1–3	1.8 ± 0.71	40.4	3.0 ± 1.1
5-3-10	8–20	12.1 ± 5.99	49.5	2–4	2.8 ± 0.87	31.0	1.9 ± 0.7
6-3-12	9–25	12.5 ± 2.27	18.2	2–3	2.2 ± 0.44	19.8	1.5 ± 0.6
5-3-21	7–16	12.5 ± 3.24	25.9	1–4	2.2 ± 0.87	40.1	4.7 ± 0.6
6-3-24	7–18	12.7 ± 4.16	32.8	2–5	3.9 ± 0.94	24.1	3.3 ± 2.1
6-3-19	5–20	13.0 ± 4.59	35.3	1–4	2.2 ± 1.14	51.6	2.6 ± 0.3
5-3-22	8–22	13.2 ± 5.75	43.6	2–5	2.8 ± 1.25	44.4	2.9 ± 0.7
6-3-23	1–22	13.4 ± 7.07	52.8	1–3	2.3 ± 0.76	33.1	2.8 ± 0.6
5-3-15	11–20	13.5 ± 3.17	23.5	2–3	2.4 ± 0.50	21.3	2.6 ± 0.2
6-3-20	6–22	13.8 ± 4.64	33.6	1–4	2.2 ± 0.92	41.8	2.7 ± 0.1
5-3-7	12–15	14.1 ± 0.99	7.1	2–4	2.8 ± 0.75	26.6	2.1 ± 0.3
6-3-13	12–20	14.1 ± 2.96	21.0	1–3	1.8 ± 0.98	54.0	1.7 ± 0.5
6-3-5	8–20	14.1 ± 3.28	23.3	1–2	1.4 ± 0.53	37.4	2.0 ± 0.6
6-3-3	5–21	14.1 ± 6.35	45.0	1–3	2.0 ± 0.76	37.8	2.1 ± 0.4
5-3-24	12–20	14.5 ± 2.64	18.2	1–2	1.7 ± 0.49	28.5	2.6 ± 0.4
6-3-4	13–19	14.8 ± 2.57	17.4	1–3	1.9 ± 0.88	46.1	3.4 ± 1.4
5-3-4	13–17	15.2 ± 1.32	8.7	2–4	2.7 ± 0.79	28.8	2.9 ± 0.3
6-3-8	4–25	17.9 ± 7.43	41.5	2–7	4.9 ± 1.64	33.4	5.1 ± 0.4
5-3-11	12–25	18.2 ± 5.25	28.8	2–11	4.8 ± 2.79	57.8	3.6 ± 0.5
5-3-19	12–25	18.3 ± 3.53	19.3	2–5	3.0 ± 1.00	33.3	3.6 ± 0.4
5-3-2	15–22	18.8 ± 2.15	11.4	2–5	3.5 ± 0.93	27.0	4.1 ± 0.3
6-3-11	15–25	19.5 ± 3.50	18.0	1–4	2.2 ± 0.98	45.0	4.5 ± 1.0
6-3-17	7–23	19.6 ± 5.02	25.6	1–6	2.8 ± 1.60	56.8	2.6 ± 0.3
5-3-6	15–25	19.9 ± 3.96	19.9	1–3	2.4 ± 0.81	34.2	1.8 ± 0.1
5-3-1	16–23	20.0 ± 2.54	12.7	2–9	4.8 ± 1.83	38.1	5.2 ± 1.3
5-3-3	16–25	20.6 ± 3.03	14.7	3–6	3.5 ± 1.13	31.8	5.0 ± 0.6
5-3-13	16–25	20.7 ± 3.06	14.8	1–3	2.1 ± 0.99	46.6	1.8 ± 0.1
6-3-14	15–25	20.8 ± 3.77	18.1	2–6	4.2 ± 1.47	35.2	4.5 ± 0.2
LSD_{005}		3.27					0,923

Note: SD – standard deviation; CV – coefficient of variation, %; LSD – Least Significant Difference ($P \leq 0.05$)

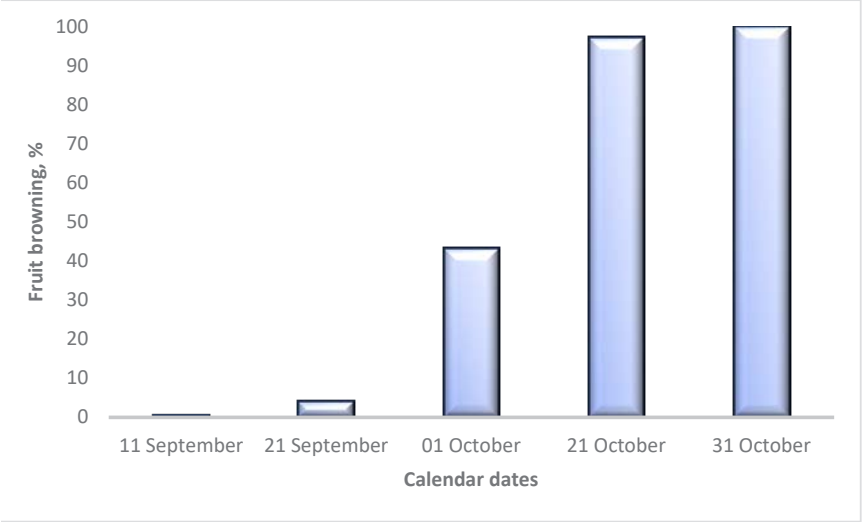

Fig. 5. Dynamics of ripening of *Z. jujuba fruits*

of seedlings are characterised by long straight thorns (e.g. 6–3–17 and 5–3–11 – 'Khorolska Krupnoploda'), or short straight thorns (e.g. 6–3–25 and 6–3–18), or no thorns at all (e.g. 5–3–17 – 'Osoblyva'). Fruit weight does not correlate with the length of erect spines (r = -0.01). A weak negative correlation (r = -0.22) between the spinescence index and fruit weight indicates that an increase in spines is accompanied by a slight decrease in fruit weight; however, the strength of this relationship is weak and not statistically significant. There is no real linear relationship between fruit weight and the spinescence index, and the obtained relationship may be the result of random fluctuations. Therefore, large-fruited genotypes without spines can be selected through breeding, which is the breeding goal.

The Khorol Botanical Garden's hybrid seedling population is located in the northern part of the *Z. jujuba* cultural area in Ukraine, which has limited thermal resources. As Krasovskyi & Cherniak (2021) point out, jujube fruits ripen during the last ten days of October and the first ten days of November. The fruits ranged in colour from light to dark brown or dark red, depending on the genotype. In 2025, 40% of trees had more than half of their fruits with completely browned skin at the beginning of October. By the middle of October, this figure had risen to 77% (fig. 5).

The average daily air temperatures above 5 °C and 10 °C in the study area are 23.185 °C and 14.68 °C, respectively (Krasovskyi et al., 2024). These temperatures are sufficient for the normal development of jujube plants and the ripening of their fruit.

Jujube is characterised by annual fruiting. In 2025, the vast majority of hybrid forms bore fruit at a level of 8–9 points. However, a quarter of the hybrids had an average fruiting score and some trees had a low fruiting capacity.

October 2025 saw heavy rainfall, leading to fruit cracking. For instance, 8% of the fruit in hybrid form 5–3–3 cracked. Cracking was observed in 1–5% of the fruit in many hybrid forms, but in 37.5% of hybrid forms, no cracking was observed.

Conclusions

The hybrid *Z. jujuba* population demonstrates high adaptation and vitality in the Ukrainian Forest-Steppe. The identified high variability of traits is ideal for further breeding. The selection of the thornless, large-fruited 'Osoblyva' (5–3–17) proves that combining highly desirable traits like spinelessness and large fruit size is possible, significantly advancing the prospects for the commercial cultivation and further breeding of jujube in non-traditional areas.

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Дата першого надходження статті до видання: 07.10.2025
Дата прийняття статті до друку після рецензування: 17.02.2026
Дата публікації (оприлюднення) статті: 30.04.2026

Conflict of interest: none.

Authors' contribution:

Krasovskyi V.V. – research idea, information search, morphometric measurements, photo documentation, development of the article algorithm;

Mezhenskyj V.M. – literature search, article text compilation, statistical calculations, conclusions, translation;

Mezhenska L.O. – information search, text supplementation and correction;

Cherniak T.V. – information search, morphometric measurements, text correction;

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