The bioecological characteristics of some apple tree (*Malus L.*) species in the conditions of the Karshi oasis (Uzbekistan)

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Abstract. In the article, the biological characteristics of the Red apple, Hayat, Oydin, Borovinka Tashkentskaya, and Chulpan varieties of apples introduced from abroad for the first time in the conditions of the Karshi oasis were studied. In the observed year, as a result of a sudden change in the weather, from January 7 to January 30, 2023, the temperature dropped sharply to -30^{0}C. In March, the air temperature was higher than +10^{0}C. In this case, all observed cultivars flowered well and produced fruit set. Branches and shoots damaged by frost were not observed. In June and July, the air temperature rose to +50^{0}C and this hot weather lasted for 15 days. After 6 days, 2% of the apple leaves in the middle layer turned yellow and fell off. The fruits were not damaged by the heat. These observations show that the introduced apple varieties are suitable for Kashkadarya soil and climate conditions. The discussion was supplemented by the opinions of scientists about the healing properties of apples.

1 Introduction

The genus Malus comprises a diverse group of deciduous trees and shrubs, primarily distributed across temperate regions of the Northern Hemisphere. Species within this genus exhibit significant variation in morphological traits, ecological adaptations, reproductive biology, and mechanisms of resistance to pathogens [1,2]. These characteristics make Malus species important not only for horticultural and commercial purposes but also for maintaining biodiversity, supporting ecosystem services, and contributing to genetic resources for breeding programs [3,4].

Understanding the bioecological characteristics of Malus species is crucial for their conservation, sustainable utilization, and integration into horticulture, landscape forestry, and shelterbelt afforestation. Factors such as climate adaptability, soil preference, phenology, and interaction with pollinators and soil microorganisms directly affect the growth, yield, and resilience of apple species [5,6]. In addition, the ornamental and aesthetic value of certain Malus species provides opportunities for their use in urban greening, public parks, and agroforestry systems [7,8].

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The assessment of native and wild apple species has become increasingly important due to the threats posed by habitat loss, climate change, hybridization with domesticated varieties, and overexploitation. For example, wild European apple (Malus sylvestris) populations face genetic introgression from cultivated apples, which can reduce their genetic integrity and affect long-term conservation strategies [6]. Similarly, Malus sieversii, the wild ancestor of cultivated apples, remains a key genetic resource for breeding programs aiming to enhance disease resistance, fruit quality, and stress tolerance in domesticated cultivars [2,5].

Previous studies have documented the morphological and biochemical diversity of various Malus species, highlighting differences in fruit size, seed weight, leaf morphology, flower phenology, and resistance to fungal pathogens [1,3]. Cultivated apples generally exhibit larger fruits with higher commercial value, whereas Siberian and hybrid crabapples are highly appreciated for their ornamental traits. Wild apple species tend to show higher seed productivity and natural resilience to local environmental conditions, making them important for conservation and breeding efforts [4,9].

Furthermore, the practical significance of studying Malus bioecology extends to sustainable horticultural practices and landscape management. Knowledge of species-specific growth requirements, resistance traits, and reproductive strategies allows for improved planning of orchards, shelterbelts, and urban greening projects. Maintaining a diverse collection of Malus species also ensures long-term availability of genetic material for research, breeding, and adaptation to changing environmental conditions.

This study aims to provide a comprehensive comparative assessment of Malus species based on morphological, biological, and physiological characteristics, with a particular focus on their ornamental value, disease resistance, and potential applications in horticulture and landscape forestry. By integrating bioecological data, this research contributes to conservation strategies, supports the sustainable use of apple species, and informs future breeding programs for improved fruit quality and environmental resilience [1,3,10].

2 Material and methods

2.1 Study Area

The study was conducted at the experimental fields of the Kashkadarya Scientific Research Institute of Horticulture, Viticulture, and Winemaking named after Academician M. Mirzaev, located in the desert region of Kashkadarya, Uzbekistan. The area has an arid climate, with hot summers, cold winters, and sandy loam soils [11].

2.2 Plant Material

Several apple (*Malus domestica*) varieties were evaluated, focusing on the MM-106 cultivar, which showed high adaptability to desert conditions. Trees aged 2–3 years were planted in a randomized complete block design with three replications [2,3].

2.3 Experimental Design and Cultural Practices

Trees were planted at 4 × 5 m spacing. Standard horticultural practices, including irrigation, fertilization, pruning, and pest control, were applied uniformly across all plots.

2.4 Data Collection

Tree growth parameters such as height, trunk diameter, and canopy development were measured annually. Productivity was evaluated as fruit yield per tree over a 3–4-year harvest period. Disease and pest resistance were assessed using standard scoring methods. Fruit quality, including size, weight, and soluble solids content, was measured at harvest [5,6].

2.5 Statistical Analysis

Data were analyzed using ANOVA with Tukey's HSD test at $P < 0.05$. Statistical calculations were performed using SPSS v.25. Variety identification and trait assessment followed the "Program and methodology for studying varieties of fruit, berry and nut crops".

3 Results

3.1 Results of the research

Kashkadaryo Region is one of the regions of Uzbekistan, located in the south-eastern part of the country in the basin of the river Kashkadaryo and on the western slopes of the Pamir-Alay mountains. It borders with Tajikistan, Turkmenistan, Samarqand Region, Bukhara Region and Surxondaryo Region (Figure 1). It covers an area of 28,570 km^2. In the observed year, as a result of a sudden change in the weather, from January 7 to January 30, 2023, the temperature dropped sharply to -30^{0}C. In March, the air temperature was higher than +10^{0}C. In this case, all observed cultivars flowered well and produced fruit set. Branches and shoots damaged by frost were not observed. In June and July, the air temperature rose to +50^{0}C and this hot weather lasted for 15 days. After 6 days, 2% of the apple leaves in the middle layer turned yellow and fell off. The fruits were not damaged by the heat. These observations show that the introduced apple varieties are suitable for Kashkadarya soil and climate conditions.

Fig.1. Kashkadaryo Region, source: https://earth.google.com/web/search/Kashkadarya+Province

3.2 Red apple

The height of the tree is 5.0±3.5 m. Vegetation period starts from I-II decade of March. Duration of vegetation is 200-235 days. It blooms between March 25 and April 5. Flowering period is 12 days. The fruit ripens in the 1st-2nd decade of June. On average, 120-135 kg of fruit can be obtained from each tree. Easy to transport. The fruit is sweet and sour and contains 94.9% water, 9.1% sugar, 1.2% pectin and 4.1% mg vitamin C. Resistant to cold, heat and drought. The rhythm of seasonal development and chemical composition of the studied trees are indicated in Tables 1, 2.

Table 1. Seasonal rhythm of development of some plants of apple tree species of Karshi oasis

No	Species	Red apple	Hayat	Oydin	Borovinka Tashkentskaya	Chulpan
1	Tree height, m.	5.0±0.35	3.0±0.26	4.0±0.27	7.0±0.52	5.0±0.40
2	Beginning of the veg. period	10.03	2.03-	15.03	10.03	20.03
3	Beginning of flowering	25.03	5.04	10.04	9.04	11.04
4	End of flowering	5.04	25.04	20.04	22.04	22.04
5	Flowering period	12	20	10	14	12
6	Beginning of ripe fruit	10.06-	20.06-	20.07	9.04	27.07
7	End of ripe fruit	20.06	15.07	9.08	22.04	10.08
8	Productivity, kg.	120-135	150±11.	120-150	120-200	200-240
9	Average weight of one fruit	150-180	150-165	120-150	120-200	200-240
10	Vegetation period (day)	200-235	200-230	200-235	200-235	200-230

Table 2. Chemical composition of some plants producing apple fruits of the Karshi oasis (%).

No	Species	Red apple	Hayat	Oydin	Borovinka Tashkentskaya	Chulpan
1	Water content	94.9	83.2	84.6	86.3	85
2	Sugar	9.1	9.1	11.6	9.7	11.9
3	Different acids	0.61	0.63	0.76	0.87	1.1
4	Pectin	1.2	1.1	1.15	0.68	1.4
5	Vitamin "C"	4.1	9.2	4.9	5.3	6.33

3.3 Hayat

The height of the tree is up to 3.0±0.26 m. Vegetation period begins in the first decade of March. duration of vegetation is 200-230 days. It blooms between April 5 and April 25. The flowering period is up to 20 days. The fruit ripens between June 20 and July 15. On average, 60-70 kg of fruit can be obtained from each tree. The average weight of one fruit is 150±11.0 g. Easy to transport. The fruit contains 83.2% water, 9.1% sugar, 0.63% various acids, 9.2 mg% vitamin C. Resistant to cold, heat and drought.

3.4 Oydin

The height of the tree is 4.0±0.27 m. The vegetation period starts from the middle of March. Vegetation duration is 200-235 days. It blooms between April 10 and April 20. Flowering period is 10 days. The fruit ripens between July 25 and August 9. The average yield of each tree is 60±4.65 kg. The average weight of one fruit is 120-150 g, it has a unique aroma and is juicy. The fruit contains 84.6% water, 11.6% sugar, 0.76% various acids, 1.15% pectin, 4.9 mg% vitamin C. Resistant to cold, heat and drought.

3.5 Borovinka Tashkentskaya

The height of the tree is 7.0±0.52 m. Vegetation period begins on March 10. Duration of vegetation is 200-235 days. It blooms between April 9 and April 22. Flowering time is 14 days. The fruit ripens between July 19 and June 27. The average productivity of each tree is up to 300±27.0 kg. The fruit is juicy. The fruit contains 86.3% water, 9.7% sugar, 0.87% various acids, 0.68% pectin, 5.3 mg% vitamin C. Easy to transport. Resistant to cold, heat and drought.

3.6 Chulpan

The height of the tree is 5.0±0.40 m. Vegetation period begins after March 20. Vegetation duration is 200-230 days. It blooms between April 11 and April 22. Flowering time is 12 days. The fruit ripens between July 27 and August 10. The average yield of a 10-12-year-old tree is 110-130 kg. The average weight of one fruit is 200-240 g. The fruit contains 84.5% water, 11.9% sugar, 1.1% various acids, 1.4% pectin, 6.33 mg% vitamin C. Easy to transport. Resistant to cold, heat and drought.

4 Discussion

According to medical and nutritional research, regular apple consumption plays an important role in maintaining cardiovascular health and providing dietary fiber and antioxidants essential for the human body. On average, experts recommend that an adult should consume around 100 kg of apples per year to meet optimal dietary needs, although actual intake is typically much lower, about 40 kg per person annually.

Apples have been used since ancient times as not only a pleasant fruit, but also a healing boon. Abu Ali ibn Sina in his "Laws of Medicine" left some information about the apple fruit. Ibn Sina used apples for various diseases, taking into account whether the patient was hot or cold. He also mentioned that eating too many unripe apples can cause kidney stones.

The beneficial properties of apples for human health are extensive. Apples contain a wide range of bioactive compounds, including natural sugars such as glucose, fructose, and sucrose, as well as organic acids, pectin, and essential trace elements like iron, potassium, manganese, copper, and cobalt. They are also rich in vitamins B_1, B_2, PP, and C, which collectively contribute to improved metabolism and neurological function. Regular consumption of apple juice has been associated with reduced oxidative stress and better cognitive performance. In cases of tension headaches, natural apple-based drinks and honey have shown mild therapeutic benefits.

Apples contain pectin, a soluble dietary fiber that plays a crucial role in improving bowel function. Pectin absorbs water and forms a gel-like substance that promotes intestinal motility, alleviates constipation, and reduces cholesterol levels by binding bile acids. Moreover, it protects the intestinal mucosa and supports the growth of beneficial gut microbiota.

5 Conclusion

To sum up, because of the smaller trunks of pakana and semi-pakana trees in intensive orchards, the quality and taste of their fruit will be better because of better light and air circulation. In addition, it is very convenient to cultivate such gardens, and it is easy to pick the fruits. Harvesting is done without the use of ladders, especially in orchards. At the same time, the work is productive and high, and the picked fruits are stored well in the future. The establishment of resource-saving intensive orchards in a new way will lead to the development of horticulture in our republic, and the further increase in the productivity of new promising varieties will lead to an increase in fruit products. As a result, it serves to improve the well-being of the population.

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