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APPRAISAL OF LESS-CULTIVATED GRAPE (*VITIS VINIFERA* L.) CULTIVARS THROUGH PRODUCTIVITY INDICATORS IN THE NAKHCHIVAN REGION, AZERBAIJAN

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SUMMARY

The comparative analysis of the productivity indicators of several less-cultivated technical grape (*Vitis vinifera* L.) cultivars in comparison with the standard cultivar Ag Aldara was the focus of this study conducted in the Nakhchivan Region of Azerbaijan. The results revealed that in the studied grape cultivars, the main productivity indicators were relatively high, ranging from 73.7% to 84.8%. However, except for the cultivar AgKalampur (51.0%), the proportion of two-clustered shoots was quite low in other grape cultivars. In certain cultivars, the total number of fruitful shoots ranged from 10.6% (Khatmi) to 23.5%, having an association with the biological traits of Eastern grape cultivars. The average number of clusters per fruitful shoot ranged between 1.15 and 1.60, and the highest fertility coefficients varied from 0.84 to 1.35 clusters per shoot based on genotypes. Although the fertility coefficient of the buds on the canes with load was considerably low, the large size of the clusters ranged from 237 to 285 g. This ensured that, on average, the vineyards established with the studied grape cultivars yielded between 24.3 and 31.2 tons per hectare.

Keywords: Grape (*V. vinifera* L.), cultivars, ecological farming, productivity indicators, fertility coefficients, vine, shoots, buds, clusters

Key findings: The results based on the comparative analysis of less cultivated technical grape (*V. vinifera* L.) cultivars in the Nakhchivan Region of Azerbaijan revealed that the productivity indicators were quite high.

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INTRODUCTION

Azerbaijan is an ancient region of the world where viticulture has long been widespread. The farming community of the Nakhchivan Autonomous Republic, Azerbaijan, has grown grapes (*Vitis vinifera* L.) over time with the highest adaptability to various soil and climatic conditions. The local germplasm has the optimum nutritional and medicinal properties, with more than 180 highly valuable cultivars grown for various purposes. The local grape cultivars currently grown in the Nakhchivan Autonomous Republic are Alimardan, Ashrafi, Gilami, Khazany, Nakhchivani, Shafei, Sahibi, Huseyni, Shahany, Gulabi, Naby-uzum, Bandi, Khatun barmagi, Shekerbura, and Gizil uzum. The grape bunches and berries, aroma and taste, as well as the medicinal properties, appeared varied among the numerous cultivars worldwide (Najafov, 2022; Najafov *et al.,* 2025).

The wine experts rightly consider the purposeful cultivation of vines, both in the process of developing a productive vineyard and each individual vine, based on the biological and economic-technological characteristics of the grape cultivars, as a period requiring greater responsibility (Al-Saif *et al.,* 2023). However, the wine experts also pointed out the accurate choice of the technological form of grapes for wine ensures their timely fruiting, normal growth, and development throughout the entire period, with high-quality enhanced yield (Beybulatov, 2002; Krivoshei, 2003; Sharifov, 2004).

In harsh winters of the Nakhchivan Autonomous Republic, farming aimed to facilitate the planting of vines in the soil and, most importantly, prevent their perennial branches and fingers from breaking and becoming damaged. In the trellis system vineyards, including the collection vineyards, and in the traditional trellis system, a stemless, multi-branched, medium, and large-volume fan-shaped form takes effect. Another vital advantage of using the multi-arm fan shape is that the application of this system allows the development of large-volume stems and their loading with fingers and eyes at any level. Additionally, it creates very favorable conditions for normal ventilation, illumination of its green organs, and the maximum use of solar energy (Sharifov, 2004; Najafov, 2022; Asadullayev *et al.,* 2024).

Thus, in higher plants, including grapes, organic substances are the only material source used for the formation of underground and aboveground plant organs, including sugar accumulated in the grapevine. It formed as a result of a complex synthesis process taking place in the leaves as influenced by sunlight energy (in a large range equal to 5,000–10,000 lux). This includes the utilization of water entering through roots, organic acids, mineral substances, and carbon dioxide absorbed from the air (Stranishevskaya and Baranets, 2002; Wurz *et al.,* 2021).

In the agricultural sector, grape cultivation also aimed to obtain high-yielding crops with better quality every year. For this purpose, the grape cultivars that are fully compatible with the climatic and soil conditions of each region, as well as the intended goals for biological and economic characteristics, should succeed in their selection (Monteiro *et al.,* 2022; Marmorshtein *et al.,* 2023). In the field, the vines should receive food areas corresponding to the cultivars they belong to. The grape plants should acquire the most efficient shape, developing the necessary leaf area by loading them with fingers and eyes at an optimal level. Consequently, it provides agrotechnical care to the vineyard throughout its entire period of operation based on the high cultivation technologies. Therefore, ensuring the fulfillment of such requirements should be crucial.

Past research revealed that to achieve high-quality biological and economic productivity, the formation of a sufficient leaf surface potential should emerge on each vine. This ascertains the development of favorable conditions that allow the use of sunlight energy to the maximum extent (Hasanov and Narimanov, 2006; Huseynov *et al.,* 2026a). Experts also mentioned that although 10%–20% of the organic substances synthesized in potential growing canes, spending 10%–30% resulted in weak-growing canes on the respiratory process, with 80%–90% and 70%–90%, respectively, directed to the formation of the plants’ vegetative organs (Volynkin, 2002;

Atak and Chorak, 2025). Aliyeva and Shukurov (2005) also considered that the most effective load limit for the cane in Absheron conditions should be 75–80 eyes. Based on the above discussion, the following study aimed to carry out the comparative analysis of productivity indicators of less-cultivated technical grape cultivars in comparison with the standard cultivar Ag Aldara in the Nakhchivan Region of Azerbaijan.

MATERIALS AND METHODS

Eleven local grape (*V. vinifera* L.) cultivars entailed planting in the vineyard at the Botanical Experimental Area of the Institute of Bioresources, Nakhchivan State University, Nakhchivan, Azerbaijan (Table 1, Figure 1). The cultivar plants under the experiment received a load of 78–80 buds. By counting and weighing, the number of opened buds, formed and normally developed buds, including fruiting buds, with one and two clusters, and the total number of clusters per vine incurred calculations. Based on this data, determining the percentage of opened buds and fruiting buds, the number of clusters per fruiting bud, the average mass of a cluster (g), the productivity of one bud (g), and the fruiting coefficients of buds succeeded (Huseynov and Aghayev, 2024; Salimov *et al.,* 2025).

The productivity per vine determination continued by weighing all the clusters on it, with the productivity per hectare determined by multiplying the average productivity per vine by the number of vines located in a hectare (Gumbatov *et al.,* 2024; Huseynov *et al.,* 2026b). The main factors affecting productivity and its quality underwent detection. These are the total number of flower buds, flowers that turned into berries and fallen, and the normally developed and thinned berries, succeeding in their identification by counting them in 30 clusters located on those vines (Aurand, 2017; Salimov and Huseynov, 2025).

Statistical analysis

Indicators studied and properties of the wine sustained evaluation using one-way analysis of variance (factorial ANOVA). The Tukey's b post-hoc test ($p < 0.05$), as applied, used the IBM SPSS software version 27. A Pearson correlation matrix also reached calculations for all parameters at a significance level of $\alpha = 0.05$.

Table 1. Fruiting and yield indicators of the studied grape cultivars.

No.	Grape cultivars	The load of a bud on the eyes	Formation of shoots expressed as a percentage	Number of fruit-bearing shoots				Number of clusters per fruit-bearing shoot	Bud fertility (g)	Shoot productivity (g)	Bud fruitfulness coefficient	Shoot fruitfulness coefficient	Average cluster weight (g)	Cultivar's yield	
				Single-clustered	Two-clustered	Three-clustered	Total							Average yield per tree (kg)	Productivity from (t ha^{-1}) $\bar{x} \pm t_{0,05} S_{\bar{x}}$
1	Ag Aldara	79.00	69.00	27.67	15.00	-	42.67	1.35	184	267	0.730	1.058	252	14.514	24.189± 0.37
2	Ag Kalampur	79.33	70.00	28.33	17.00	-	45.33	1.38	203	290	0.785	1.112	258	16.084	26.800 ± 0.39
3	Jalali	79.67	74.50	31.50	19.67	-	51.17	1.38	212	286	0.889	1.203	238	16.859	28.098 ± 0.40
4	Dash gara	79.33	70.50	29.00	18.00	-	47.00	1.30	166	239	0.819	1.162	202	13.130	21.882 ± 0.35
5	Khatini (Nakh.)	80.00	75.67	27.33	20.00	-	47.33	1.42	196	259	0.842	1.112	233	15.688	26.147 ± 0.39
6	Khatmi	78.67	68.33	29.33	10.67	-	40.00	1.27	149	215	0.644	0.943	228	11.552	18.924 ± 0.33
7	Shahtakhti	78.67	74.00	26.67	22.33	-	49.00	1.46	207	279	0.907	1.226	228	16.263	27.104 ± 0.32
8	Talibi	79.67	73.00	31.00	12.67	-	43.67	1.29	213	291	0.707	0.969	301	16.958	28.263 ± 0.40
9	Tula gozu	79.67	73.00	33.00	21.31	-	54.31	1.40	216	296	0.949	1.299	228	17.241	28.334 ± 0.40
10	Tulku guyrughu	78.67	67.67	28.33	12.33	-	40.67	1.30	216	320	0.674	0.996	321	17.013	28.353 ± 0.41
11	Zalkha	80.00	74.33	27.67	14.00	-	41.67	1.34	186	250	0.696	0.936	267	14.864	24.772 ± 0.38

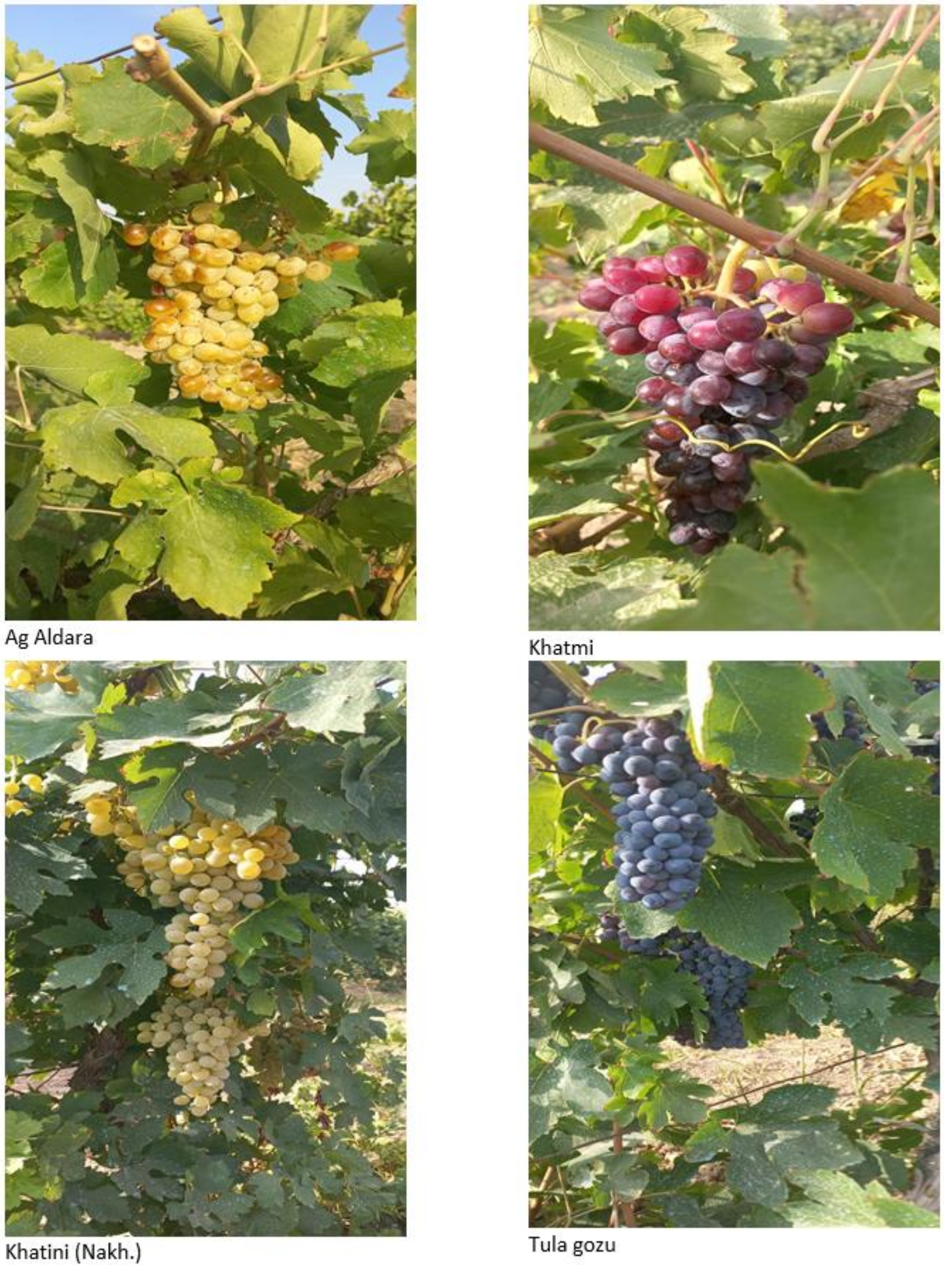

Figure 1. The promising grape cultivars.

RESULTS AND DISCUSSION

The phenological observations conducted on the autochthonous grape (*V. vinifera* L.) cultivars showed that based on the fertility indicators, the productivity in the continental climate conditions typical of the Nakhchivan Autonomous Republic was quite high (Huseynov and Aghayev, 2024; Salimov *et al.,* 2025).

The results revealed that although the germination percentage in the first to fifth days of the 100-year-old vines was relatively low, overall, it was quite high, ranging from 77% to 82% in the individual cultivar. Fertilization rate was considerably high for Eastern cultivars that include the studied grape cultivars. In all the studied grape cultivars, the germination percentage was high, ranging from 73.7% to

84.8%. However, except for the cultivar Ag Kalampur (51.0%), the share of bisected seeds was very low in all other cultivars. The total number of fruiting seeds in individual cultivars ranged from 10.6% (Khatmi) to 23.5%, which signifies a relation to the biological characteristics of the Oriental grape cultivars. Therefore, balanced application of fertilizers proved particularly important to ensure the stability and sustainability of the crop plants (Zhang *et al*., 2023; Huseynov *et al.,* 2026c). Proper management of nitrogen fertilizer dosage is crucial from both economic and environmental perspectives (Jat *et al*., 2012; Musayeva *et al.,* 2026).

The findings further disclosed that in the studied grape cultivars, the first three heads were relatively less abundant, and, on average, 37.1% of the heads that grew out of these were dead. This indicator was relatively quite high in the following seasons as well. However, this back succession was not evident in all the grape cultivars. Therefore, if the abundance ratio of the first three years in the best-yielding cultivar was 78.3%–80.6%, this ratio increased to 89.2% in the eighth year. Then it falls to 87.6% of the 12,000. The same indications were sharply notable in other cultivars, especially in the cultivars Dashgara, Zalkha, and Tula gozu. In the Azerbaijan agriculture sector, one of the current tasks is to obtain a sustainable and high-quality harvest of crops. In achieving this goal, it was necessary to carry out a set of agrochemical, agrotechnical, and land reclamation measures in a timely manner. It was also typical to obtain a higher yield with better quality of crop plants; it is vital to apply at proper times various types of mineral and organic fertilizers to the soil (Zarmaev and Borisenko, 2018; Makarova, 2019).

According to results, the number of single-cluster shoots was relatively high, ranging from 1.15 to 1.60 in some grape cultivars (Table 1). However, the said indicator seemed high for Eastern grape cultivars, including the autochthonous cultivars at the Nakhchivan Autonomous Republic, generally characterized by the formation of only one cluster per shoot. The shoot fertility coefficient varied from 0.84 to 1.35, depending on the cultivar, while the bud fruiting coefficient of some grape varieties ranged from 0.67 to 1.14 during the years of study. Reports on similar fertility patterns have come out for Oriental grape cultivars, where genetic parameters limit the formation of multiple clusters per shoot; however, these ensure stable fruiting under arid conditions (Maghradze *et al*., 2016; Huseynov *et al.,* 2025).

The agrobiological variables of the studied grape cultivars, including yield parameters, succeeded in their evaluation on vines planted at the spacing of 3 m × 2 m and trained on a three-wire horizontal trellis system. The formed vines came from using a multi-arm and a large-volume fan system without a trunk. Under these cultivation conditions, dry pruning with a load of 75–80 buds per vine appeared to be optimal for all studied cultivars, including the regionalized standard cultivar Ag Aldara. Previous studies have shown that multi-arm fan-shaped training systems, combined with moderate pruning loads, improved shoot distribution and productivity under warm and dry climates (Jackson, 2014; Poni *et al*., 2018; Röckel *et al.,* 2026).

In the vegetation period, an average of 67.67%–75.67% of the 75–80 retained buds germinated over three years. This resulted in the formation of a leaf surface area of 1.97–2.30 m^2 per one m^2 of vineyard area, equivalent to 19,700–23,400 m^2 per hectare, as determined by Morozova's (1986) ampelometric method. Such development of a canopy has become optimal for grapevines, as it ensures sufficient photosynthetic activity and assimilate accumulation in a better way. Similar threshold values of leaf surface area have reached the identification necessary for stable yield formation in grapevines under comparable environmental conditions (Morozova, 1986; Keller, 2020).

The results revealed that after bud break, 51.0–60.0 shoots materialized per vine in the studied grape cultivars. Of these, 26.67–33.00 shoots bore one cluster, while 10.67–22.33 shoots bore two clusters, resulting in a total of 40.67–54.31 fruiting shoots per vine. None of the grape cultivars formed shoots with three clusters, which was typical for the Eastern grape cultivar group. Consequently, the proportion of fruiting buds and the number of clusters per fruiting shoot remained moderate, ranging from 1.27 to 1.46. This cluster distribution pattern has had wide reports for Oriental grape cultivars, which emerged as associated with stable yield formation rather than excessive crop load (Carbonneau *et al*., 2007; Lazarevski, 2012).

Accordingly, the coefficients of buds and shoots fertility were also moderate, ranging between 0.644 and 0.949 and 0.936 and 1.299, respectively. However, these relatively moderate fertility indicators gained compensation from the highest average bunch weight, ranging from 202 to 321 g across all grape cultivars. As a result, the yield per bud reached 149–216 g, while the yield per fruiting shoot amounted to 215–320 g. Ultimately, the total yield varied from 11552 to 17241 kg per hectare. Between the moderate fertility coefficients and high bunch weight, reports of similar relationships have surfaced, emphasizing that bunch mass plays a decisive role in determining final yield in grapevines (Volynkin *et al*., 2019; Shukurova *et al.,* 2026).

Overall, the studied grape cultivars at the Nakhchivan Region of Azerbaijan demonstrated the highest level of productivity under the existing agroecological conditions. The cultivars' stable fertility, optimal canopy development, and relatively high bunch mass revealed robust potential for large-scale cultivation. Being technical cultivars, these grape genotypes proved particularly suitable for processing, especially for the production of dried products, such as raisins, characterized by the highest caloric value and long shelf life. Previous studies have also highlighted the importance of indigenous grape cultivars for sustainable production and food security, reinforcing the economic and practical significance of these present findings (This *et al*., 2006; FAO, 2017).

CONCLUSIONS

The results based on the phenological observations conducted on local grape (*V. vinifera* L.) cultivars at the Nakhchivan Region, Azerbaijan, revealed quite high productivity. These cultivars are Ag Aldara, Ag Kalampur, Jalali, Dash gara, Khatini (Nakh.), Khatmi, Shahtakhti, Talibi, Tula gozu, Tulku guyrughu, and Zalkha, grown in local continental climatic conditions. Overall, the main productivity indicators of the studied grape cultivars were relatively high and ranged from 73.7% to 84.8%. The total number of productive shoots in certain grape cultivars ranged from 10.6% (Khatmi) to 23.5%, which has an association with the biological attributes of Eastern grape cultivars. Although the yield coefficient of the shoots was significantly lower against the background of the given load, the variation in clusters' size (237 and 285 g) ensured an average yield of between 2.43 and 3.12 tons per hectare.

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