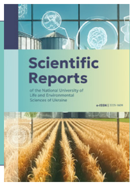
Received 04.07.2025 Revised 03.10.2025 Accepted 27.11.2025

Vol. 21, No. 6
2025



Scientific Reports of the National University of Life and Environmental Sciences of Ukraine

Journal homepage: https://scireports.com.ua/en

UDC 634.11:631.526.32

DOI: 10.31548/dopovidi/6.2025.158

Plasticity and stability of quantitative productivity traits of apple cultivars under the conditions of Podillia

Kateryna Tarnavska
PhD in Agricultural Sciences
Podillia Experimental Horticultural Station of the Institute of Horticulture of the National Academy of Agrarian Sciences of Ukraine
23226, 1 Naukova Str., Medvezhe Vushko village, Vinnytsia region, Ukraine
https://orcid.org/0009-0000-7939-9381

Sergiy Babiy*
PhD in Agricultural Sciences
Podillia Experimental Horticultural Station of the Institute of Horticulture of the National Academy of Agrarian Sciences of Ukraine
23226, 1 Naukova Str., Medvezhe Vushko village, Vinnytsia region, Ukraine
https://orcid.org/0009-0000-6402-1001

Oleh Venediktov
PhD in Agricultural Sciences, Senior Research Fellow
Podillia Experimental Horticultural Station of the Institute of Horticulture of the National Academy of Agrarian Sciences of Ukraine
23226, 1 Naukova Str., Medvezhe Vushko village, Vinnytsia region, Ukraine
https://orcid.org/0009-0006-7167-9526

Abstract. Apple was one of the leading fruit crops worldwide, ranking third in production volumes after bananas and watermelons, and the continuously increasing demand for apples determined the need to improve cultivars with high productivity and adaptability. The aim of the study was to evaluate apple cultivars in terms of ecological plasticity in order to identify promising genotypes for breeding programmes. The results of cultivar testing of apple of Ukrainian and foreign breeding (orchard established in 2017, planting scheme 2.5 × 4.5 m, rootstock MM106) were presented based on yield and average fruit weight. Five apple cultivars ('Free Gold', 'Juliet', 'Luna', 'Red Topaz', 'Rosela') selected from 27 introduced genotypes tested during 2021-2024 were evaluated. The highest values of environmental indices, both for apple yield and fruit weight, were recorded in 2023 and amounted

Suggested Citation:
Tarnavska, K., Babiy, S., & Venediktov, O. (2025). Plasticity and stability of quantitative productivity traits of apple cultivars under the conditions of Podillia. *Scientific Reports of the National University of Life and Environmental Sciences of Ukraine*, 21(6), 158-169 doi: 10.31548/dopovidi/6.2025.158.

*Corresponding author

to 1.80 and 6.15, respectively. The lowest environmental indices were observed in 2022 and 2024, when the average yields were 0.28 and 1.3 t ha^{-1}, respectively. This analysis demonstrated the strong influence of annual climatic fluctuations on cultivar productivity and emphasised the need to consider genotype adaptability in breeding programmes. Based on mathematical processing of yield and average fruit weight data, regression equations and ecological plasticity indices were derived. It was established that, in terms of fruit yield, the cultivars 'Rosela' and 'Juliet' belonged to the intensive type and were characterised by high sensitivity to changes in environmental conditions, with regression coefficients of 2.743 and 0.921, respectively. For average fruit weight, a high level of ecological plasticity was demonstrated by the cultivars 'Rosela', 'Luna', and 'Free Gold', whereas 'Juliet' belonged to the neutral type. Assessment of ecological stability showed that, for yield, 'Free Gold', 'Luna', and 'Red Topaz' were the most stable cultivars. The cultivar 'Juliet' was relatively stable, although it did not exhibit a high yield level. The highest average yield over the years was recorded for 'Rosela', which was simultaneously the least stable. For average fruit weight, 'Free Gold' and 'Luna' proved to be stable cultivars

Keywords: yield; fruit weight; attractiveness; flavour quality; adaptability parameters; environmental index

Introduction

Apple (*Malus domestica* Borkh.) was one of the most important fruit crops worldwide and a key component of horticulture in Ukraine. The high nutritional value of the fruits, versatility of use, long period of productive fruiting, and stable market demand ensured the strategic importance of apple orchards for the economy of the agricultural sector. Ukrainian orchards traditionally cultivated apple as a major industrial and food crop, which was an important factor in ensuring food security and the development of the processing industry.

Under current conditions of global climate change, fruit crop production was subjected to significant challenges. Increases in average annual temperatures, the occurrence of abnormal temperature fluctuations in spring and autumn, uneven distribution of precipitation, and the growing frequency of extreme weather events directly affected the structure of the apple vegetation cycle, pollination efficiency, fruit set formation, and fruit growth. M. Deori *et al.* (2024) considered that these factors had a substantial impact on fruit productivity and quality, which was manifested in pronounced interannual variability of yield even in well-established cultivars. In this context, understanding the mechanisms of adaptive responses of cultivars to changing environmental conditions and their ability to maintain productivity under variable conditions was of particular importance.

According to R.E. Sestras & A.F. Sestras (2023), adaptability parameters, in particular ecological plasticity and stability of productive traits, were regarded as key characteristics determining the suitability of a cultivar for cultivation under specific geographical and climatic conditions. Plasticity defined the ability of a cultivar to change the level of expression of economically important traits in response to variations in environmental conditions, whereas stability reflected the variability of these traits across different growing years. High plasticity could be desirable under favourable conditions, as it allowed the maximum realisation of potential productivity. At the same time, low stability could lead to substantial fluctuations in yield, which was undesirable for predictable production. Conversely, excessively stable cultivars could be less responsive and fail to exploit their productive potential in favourable years (Kryvoshapka *et al.*, 2020).

In their study, X. Li *et al.* (2023) demonstrated that a range of mathematical approaches was applied to assess plasticity and stability, including regression analysis, environmental indices, variation parameters, and other statistical methods. These approaches allowed an objective evaluation of cultivar response types to changing environmental conditions, the identification of genotypes with high adaptability, and the prediction of their performance under climatic uncertainty. In modern fruit crop breeding, comprehensive assessment based on such parameters was an important component in the selection of genotypes for commercial cultivation. Podillia represented an area characterised by high variability of hydrothermal conditions during the growing season. I.S. Sadovskyi & V.M. Matsievskyi (2023) demonstrated that weather conditions within a single year could vary from favourable for the formation of generative organs to stressful, creating serious challenges for the adaptability of apple cultivars. Under such conditions, intensive cultivars could exhibit unpredictable changes in yield, which emphasised the need for regional evaluation of cultivars based on adaptability parameters.

Although numerous cultivars of foreign breeding were being introduced in Ukraine, reliable data on their plasticity and stability under the conditions of Podillia remained insufficient or fragmented. The study by G. Locatelli *et al.* (2022) focused mainly on absolute indicators of yield, fruit weight, or product quality, without a comprehensive analysis of the adaptive responses of cultivars to changes in growing conditions. Such limitations in scientific information restricted the possibilities for forming an optimal cultivar assortment for intensive horticulture, especially in the context of increasing climatic risks. Ukrainian researchers K.P. Tarnavska & T.M. Kovalenko (2022) emphasised the need for multi-year evaluation of apple cultivars based on adaptability parameters, including ecological plasticity and productivity stability. This approach made it possible not only to identify the most promising cultivars for specific conditions but also to establish a foundation for breeding programmes aimed at developing genotypes with an optimal combination of productivity, fruit quality, and adaptive reliability. The practical significance of their research lay in the ability to recommend specific cultivars for commercial cultivation under conditions of variable abiotic factors, which had a positive effect on production stability and the economic efficiency of horticulture.

Thus, the study of plasticity and stability of quantitative productivity traits of apple cultivars under the conditions of Podillia was a scientifically substantiated and practically important task. It allowed the integration of phenotypic evaluation results with regional environmental conditions, ensured breeding-relevant selection of cultivars, and enabled the development of recommendations for optimising the cultivar assortment for intensive apple cultivation under conditions of a changing climate.

The aim of the study was to evaluate the plasticity and stability of productivity and fruit weight of apple cultivars and to identify valuable genotypes among them as source material for breeding for adaptability, as well as cultivars promising for intensive orchards.

Materials and Methods

The experimental part of the study on ecological parameters of apple productivity was conducted in the research orchard of the Department of Cultivar Testing and Technologies of Fruit and Berry Crop Cultivation of the Podillia Horticultural Research Station of the Institute of Horticulture of the National Academy of Agrarian Sciences (NAAS) of Ukraine, located in Vinnytsia District, Vinnytsia Region, during 2021-2024. The territory of the experimental plots of the Podillia Horticultural Research Station belonged to the Dniester Upland and the second geomorphological region of the Zhmerynka Upland, which resulted in the formation of grey podzolised medium loamy soils. The soil cover of the experimental plots was represented by grey forest heavy loamy soil. According to agrochemical analyses, the humus content was low, amounting to 2.1% (Tyurin method), while the content of easily hydrolysable nitrogen ranged from 3.4 to 5.4 mg eq. per 100 g of soil (Cornfield method). A pronounced deficiency of potassium was observed, with its content in the humus–eluvial horizon reaching only 12-14 mg eq. per 100 g of soil. The content of available phosphorus was at a medium level, amounting to 10-12 mg eq. per 100 g of soil. The depth of the humus–eluvial horizon did not exceed 25-30 cm, with a sharp transition to the illuvial horizon. The soil colour was grey, and a morphologically distinct eluvial horizon was absent, which was considered the main diagnostic feature. The plough layer was loose, with a bulk density of 1.32 g cm^{-3}, whereas the subsoil layer was compacted and granular. The transitional horizon occurred at a depth of 42-70 cm; it was weakly illuvial, almost devoid of humus, brownish-grey in colour, compacted, and nut-shaped in structure. Overall, the physicochemical properties of the soil at the experimental site were typical of those found across large areas of Podillia. Despite certain limitations of grey forest soils, they were suitable for the cultivation of perennial fruit plantations.

The territory where the experimental field was located was characterised by a mild temperate continental climate according to agroclimatic indicators. Winters were prolonged but mild, while summers were warm. During the years of the study, weather conditions in the region were unstable, with dry years alternating with wetter ones. The most favourable weather conditions for apple yield formation during the study period were observed in 2023. The hydrothermal conditions in that year, particularly during critical stages of the growing season, were characterised by moderate precipitation. In April, 81.9 mm of precipitation was recorded, which was sufficient for the formation of generative organs and the initial stage of fruit growth. Moisture supply in June and July was fully satisfactory for the course of all physiological processes in plants, amounting to 39.6 and 68.1 mm of precipitation, respectively. The temperature regime during the tree growing season in 2023 was close to optimal for the formation of high apple yields. The average daily air temperatures in May, June, and July were 15.3, 19.6, and 21.4°C, respectively.

The least favourable weather conditions were recorded in 2022 and 2024. The hydrothermal conditions of the growing season in these years were specific and insufficiently favourable, particularly during the stages of formation and pollination of generative organs. In 2022, apple flowering occurred under conditions of critical soil moisture deficit during the first and second ten-day periods of May. Precipitation in May was recorded only in the third ten-day period, amounting to 35.3 mm, which represented 50% of the long-term average. The average daily air temperature during this month was 15.4°C, corresponding to the norm, whereas the minimum dropped to +2.0°C. Similar weather conditions were observed in 2024. The average daily air temperature in April exceeded the norm by 2.4°C and amounted to 12.1°C, while the minimum decreased to -1.2°C (20 April). In May, minimum night-time temperatures dropped to +1.1°C. Such weather conditions during the flowering period had a significant effect on pollination of fruit tree flowers and substantially reduced fruit set.

For the experiment, five apple cultivars were selected from a total collection of 27 introduced cultivars based on high indicators of marketable fruit quality and organoleptic evaluation of taste (Forster *et al*., 2021). The studied apple cultivars were 'Free Gold', 'Juliet', 'Luna', 'Red Topaz', and 'Rosela'. The orchard was established in 2017 with a planting scheme of 2.5 × 4.5 m on MM106 rootstock. Three replications were provided for each cultivar. The trees were maintained according to standard intensive horticulture technology, including pruning, fertilisation, and protection against pests and diseases (Delgado *et al*., 2021; Chaploutskyi *et al*., 2024; Szpyrka *et al*., 2025). All studies conducted at the Podillia Horticultural Research Station of the Institute of Horticulture of the NAAS of Ukraine complied with the requirements of the Convention on Biological Diversity (1992), which regulates the use of biological resources and ensures biodiversity conservation.

For a comprehensive evaluation of the cultivars, modern methods for determining the plasticity and stability of economically valuable traits were applied:

- the environmental index (I), which was determined as an indicator reflecting the deviation of yield in a particular year from the mean value across all years of observation (Mather & Jinks, 1982; Kang, 1998);
- the regression coefficient (b_i), which indicated the average response of a cultivar to changes in environmental conditions, characterised its plasticity, and allowed prediction of changes in the studied trait within a range of environmental conditions ($b_i < 0.75$ – neutral type; $0.75 \leqslant b_i \leqslant 1.25$ – moderately sensitive; $b_i > 1.25$ – highly sensitive) (Yan & Kang, 2003; Grando, 2020);
- stability variances (S_i) and deviations from the mean variance (S_i^2-$S^2_{average}$), which allowed the stability of yield and fruit weight traits to be assessed independently of weather fluctuations (Crossa *et al.*, 2022).

Statistical data processing was performed using MS Excel and Statistica 12, which corresponded to modern methodological approaches for regression and variation analysis (Crossa *et al.*, 1988; Yan & Kang, 2003). Regression line graphs and stability histograms were constructed to visually represent the behaviour of the cultivars under variable environmental conditions.

Results and Discussion

The average yield of the studied apple cultivars over four years amounted to 1.73 t ha^{-1} (Table 1). The most favourable year in terms of conditions for yield formation was 2023, which was confirmed by the maximum environmental index (I_{2023} = 1.80). In contrast, 2022 was characterised by the poorest conditions (I_{2022} = -1.45), which resulted in a sharp decline in average yield to 0.28 t ha^{-1}. Such fluctuations indicated a substantial influence of weather factors on the realisation of the productive potential of the cultivars.

***Table 1.** Adaptability parameters of apple cultivars based on yield*

Cultivar	Yield, t ha^{-1}				Average (2021-2024)	Regression coefficient, b_i	Stability variance, S_i^2	S_i^2-$S^2_{average}$
	2021	2022	2023	2024				
‘Free Gold’	0.8	0.1	1.5	1.7	1.03	0.343	0.5	-3.1
‘Juliet’	2.4	0.8	3.6	1.0	1.95	0.921	1.7	-2.0
‘Luna’	0.8	0.1	2.2	1.2	1.08	0.610	0.8	-2.9
‘Red Topaz’	2.5	0.3	1.5	0.8	1.28	0.383	0.9	-2.8
‘Rosela’	2.5	0.1	8.8	1.8	3.30	2.743	14.5	10.8
Mean	1.80	0.28	3.52	1.30	1.73	1.00	3.7	0.0
Environmental index (I)	0.08	-1.45	1.80	-0.43				

Note: orchard established in 2017; planting scheme 2.5 × 4.5 m; rootstock MM106
Source: developed by the authors

The highest average yield over the study period was recorded for the cultivar ‘Rosela’ (3.30 t ha^{-1}), which significantly exceeded the overall mean value. At the same time, this cultivar was characterised by the highest stability variance (S_i^2 = 14.5) and a positive deviation from the mean variance (S_i^2-$S^2_{average}$ = 10.8), indicating low ecological stability and a high dependence on environmental conditions. Regression coefficients showed that the cultivars ‘Rosela’ (b_i = 2.743) and ‘Juliet’ (b_i = 0.921) were characterised by increased ecological plasticity, actively responding to improvements in growing conditions. Such cultivars were considered suitable for intensive production systems under a high level of agricultural inputs. In contrast, the cultivars ‘Free Gold’, ‘Luna’, and ‘Red Topaz’ (b_i < 0.75) belonged to the neutral type, which indicated a limited response to changes in environmental conditions and relatively stable yield performance.

Assessment of yield stability showed that the most stable cultivars were 'Free Gold' ($S_i^2 = 0.5$), 'Luna' ($S_i^2 = 0.8$), and 'Red Topaz' ($S_i^2 = 0.9$); however, they were characterised by lower average yield levels. This indicated a trade-off between stability and productivity, which was typical for perennial fruit crops. The graphical representation of ecological stability based on yield was presented in Figure 1 using the deviation from the mean variance (S_i^2-$S^2_{average}$).

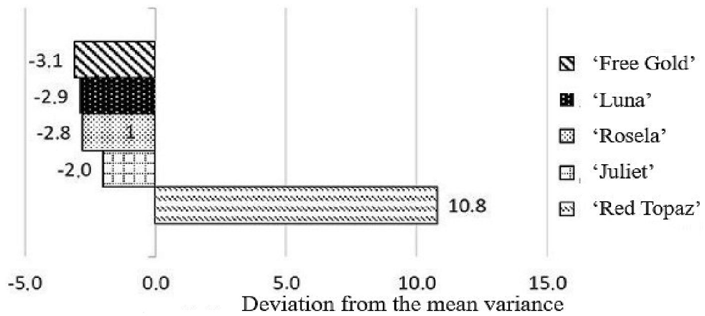


***Figure 1.** Yield stability of apple cultivars*

Note: average for 2021-2024

Source: developed by the authors

The average fruit weight over the years of the study amounted to 149.45 g (Table 2). The most favourable years for the formation of large fruit size were 2023 and 2024, as indicated by the high environmental indices ($I_{2023} = 6.15$; $I_{2024} = 5.75$). The least favourable year was 2021 ($I_{2021} = -9.45$), which negatively affected the average fruit weight values.

***Table 2.** Adaptability parameters of apple cultivars based on average fruit weight*

Cultivar	Average fruit weight, g				Average (2021-2024)	Regression coefficient, b_i	Stability variance, S_i^2	S_i^2-$S^2_{average}$
	2021	2022	2023	2024				
'Free Gold'	140	155	148	173	154.0	1.217	198.0	-327.9
'Juliet'	125	190	140	150	151.3	0.462	772.9	247.0
'Luna'	120	120	135	153	132.0	1.697	246.0	-279.9
'Red Topaz'	175	130	180	120	151.3	-1.055	939.6	413.7
'Rosela'	140	140	175	180	158.8	2.679	472.9	-53.0
Mean	140.0	147.0	155.6	155.2	149.45	1.00	525.9	0.0
Environmental index (I)	-9.45	-2.45	6.15	5.75				

Note: orchard established in 2017; planting scheme 2.5×4.5 m; rootstock MM106

Source: developed by the authors

Based on average fruit weight, the cultivar 'Rosela' stood out with the highest value (158.8 g), whereas the cultivars 'Free Gold' and 'Juliet' showed values close to the overall average (154.0 and 151.3 g, respectively). High values of the regression coefficient for the cultivars 'Rosela' ($b_i = 2.679$), 'Luna' ($b_i = 1.697$), and 'Free Gold' ($b_i = 1.217$) indicated their high ecological plasticity with respect to fruit weight. This implied that under improved environmental conditions these cultivars were able to substantially increase fruit size. At the same time, the cultivar 'Juliet' ($b_i = 0.462$) exhibited a neutral response to changes in growing conditions, while 'Red Topaz' showed a negative regression coefficient (b_i = -1.055), indicating a non-standard response and a potential decrease in fruit weight in favourable years.

In terms of stability parameters, the most uniform fruit weight was formed by the cultivars 'Free Gold' (S_i^2 = 198.0) and 'Luna' (S_i^2 = 246.0). At the same time, the cultivars 'Juliet' and 'Red Topaz' were characterised by high variance values (772.9 and 939.6, respectively), indicating considerable variability of the trait and lower predictability of results. The graphical representation of ecological stability of the cultivars based on average fruit weight was presented in Figure 2 using the deviation from the mean variance (S_i^2-$S^2_{average}$).

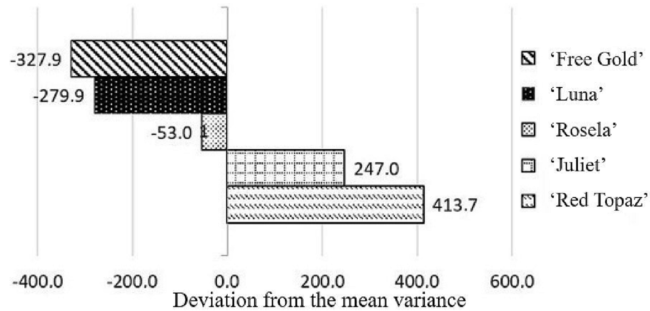


Figure 2. *Stability of the average fruit mass of apple varieties*

Note: average for 2021-2024
Source: developed by the authors

The slope of the regression lines provided additional information on the adaptive responses of apple cultivars to changes in environmental conditions. As the angle of inclination of the regression line increased, cultivar sensitivity to the variability of ecological factors also increased. The study established that the regression lines for yield and average fruit weight had nearly identical slopes, which confirmed the presence of a direct correlation between these economically valuable traits. The calculated regression coefficients, representing the tangent of the angle of inclination, made it possible to construct graphs for the visual assessment of ecological plasticity of the cultivars. The corresponding graphical representations of the regression lines for yield and average fruit weight were presented in Figures 3 and 4, providing a clear illustration of the adaptive characteristics of the studied cultivars.

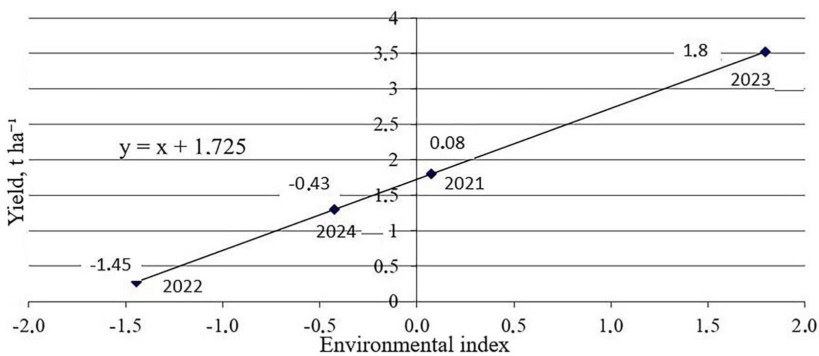


Figure 3. *Regression line and ecological plasticity indices of apple cultivar yield in relation to changes in environmental conditions (2021-2024)*

Source: developed by the authors

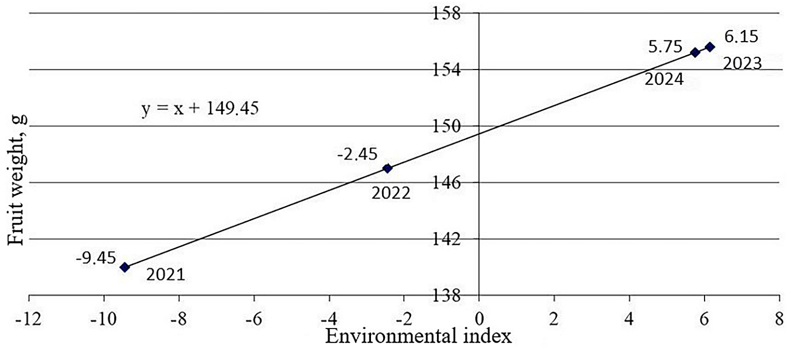


Figure 4. *Regression line and ecological plasticity indices of average fruit weight of apple cultivars in relation to changes in environmental conditions (2021-2024)*
Source: developed by the authors

Based on mathematical processing of yield and average fruit weight data, regression equations were derived, namely $y_1 = x_1 + 1.725$ and $y_2 = x_2 + 149.45$, on the basis of which the ecological plasticity index was determined. A comprehensive analysis of ecological plasticity and stability parameters indicated that the cultivar 'Rosela' combined a high potential for yield and fruit weight but was characterised by low stability, which limited its use under conditions of an unstable climate. The cultivars 'Free Gold' and 'Luna' demonstrated an optimal balance between stability and adaptability, making them promising for cultivation across different agroecological zones. The obtained results confirmed the appropriateness of using regression analysis parameters for the justified selection of apple cultivars in breeding programmes and commercial production.

The obtained research results confirmed the decisive role of the "genotype × environment" interaction in the formation of productivity of apple cultivars, which was consistent with the concepts of adaptive breeding of fruit crops proposed by H. Muranty *et al.* (2015) and C. Ma *et al.* (2024). These studies stated that the conditions of Podillia were characterised by pronounced interannual variability of hydrothermal factors, which determined differentiated cultivar responses to changes in the ecological background and required a comprehensive assessment of plasticity and stability of economically valuable traits. In the course of the present study, it was established that the weather conditions of 2023 were the most favourable for the formation of yield and average fruit weight, as reflected by the maximum values of the environmental index. The optimal combination of temperature regime and moisture supply during critical phases of organogenesis contributed to a more complete realisation of the genetic potential of the cultivars, which was consistent with the results reported by P. Pfleiderer *et al.* (2021) and C. Jena & K. Pramanik (2025) obtained in temperate climate zones. In contrast, 2022 and 2024 were characterised by abiotic stresses during the flowering period, which negatively affected pollination, fruit set, and final yield. The use of regression coefficients (b_i) allowed clear differentiation of cultivars according to the type of ecological response. The cultivar 'Rosela' demonstrated a high level of ecological plasticity for yield, which was expressed by a sharp increase in productivity in favourable years and pronounced fluctuations in unfavourable ones. According to T. Kondratenko & P. Kondratenko (2020), such a response type was typical of intensive genotypes that were advisable to cultivate under conditions of a high agricultural background and the possibility of regulating the water regime.

The cultivars 'Free Gold', 'Luna', and 'Red Topaz' belonged to the neutral type in terms of yield, with $b_i < 1$, indicating a weaker dependence on weather variability. Such genotypes were more stable over time and were recommended for areas of risk-prone horticulture, where ensuring a predictable level of yield was of particular importance (Berven *et al.*, 2025). Similar patterns were reported in the studies of G. Locatelli *et al.* (2022) concerning the stability of fruit crops in Central and Eastern Europe. Assessment of stability based on the variance of deviations from regression (S^2) showed that cultivars with high plasticity generally exhibited lower stability. In particular, the cultivar 'Rosela' had the highest S^2 values for yield, which confirmed the inverse relationship between the intensity of the genotypic response and the stability of trait expression. A similar pattern has been widely described in breeding studies by G. Sanford *et al.* (2021) and is considered typical for perennial crops.

Analysis of the regression lines for yield and average fruit weight showed a similar pattern of slope, indicating the presence of a correlation between these traits. This supported the position of S. Knapp & M.G.A. van der Heijden (2018) on the necessity of a comprehensive assessment of cultivar productivity, as selection based solely on a single trait could lead to undesirable trade-offs. In modern breeding programmes, multifactorial approaches combining the evaluation of G × E interactions, plasticity, and stability are increasingly applied. The obtained results confirmed the suitability of using the environmental index, regression coefficients, and stability parameters as effective tools for assessing the adaptive potential of apple cultivars. Such an approach allowed not only the justified recommendation of cultivars for production but also the identification of directions for their use in breeding, either as donors of stability or of potential productivity.

Thus, the research results indicated that under the conditions of Podillia the most promising cultivars were those combining moderate ecological plasticity with high stability of expression of economically valuable traits, which ensured the adaptation of orchards to current climatic challenges and increased the efficiency of commercial horticulture.

Conclusions

As a result of the four-year cultivar evaluation of apple cultivars, a substantial influence of interannual variability of hydrothermal conditions on the formation of yield and average fruit weight under the conditions of Podillia was established. The most favourable conditions for the realisation of the productive potential of the cultivars were formed in 2023, which was confirmed by the maximum environmental indices for the traits "yield" ($I = 1.80$) and "average fruit weight" ($I = 6.15$), as well as by the highest average productivity values over the study period. It was determined that, in terms of fruit yield, the cultivars 'Rosela' ($b_i = 2.743$) and 'Juliet' ($b_i = 0.921$) were characterised by increased ecological plasticity and an intensive type of response to environmental conditions, which ensured high yield levels in favourable years but was accompanied by reduced stability. The cultivars 'Free Gold', 'Luna', and 'Red Topaz' belonged to the neutral type of ecological response and provided a relatively stable level of productivity under different growing conditions. The highest average yield during the study was recorded for the cultivar 'Rosela' (3.30 t ha^{-1}); however, it proved to be the least stable for this trait ($S^2 = 14.5$), indicating a high dependence of its productivity on favourable weather conditions.

In terms of average fruit weight, a high level of ecological plasticity was established for the cultivars 'Rosela' ($b_i = 2.679$), 'Luna' ($b_i = 1.697$), and 'Free Gold' ($b_i = 1.217$), which determined their ability to form large fruits in years with optimal growing conditions. The most stable cultivars for this trait were 'Free Gold' ($S^2 = 198.0$) and 'Luna' ($S^2 = 246.0$), whereas 'Juliet' ($S^2 = 772.9$) and 'Red Topaz' ($S^2 = 939.6$) were characterised by considerable variability of this trait. A comprehensive assessment of plasticity and stability of yield and average fruit weight allowed the conclusion that, under the conditions of Podillia, the optimal combination was moderate ecological plasticity with high stability of trait expression, which ensured predictable productivity and reduced production risks. Based on the set of adaptability parameters, the cultivars 'Free Gold' and 'Luna' showed the greatest practical and breeding value, as they combined yield stability with an adequate level of marketable fruit quality. The obtained results confirmed the appropriateness of using the environmental index, ecological plasticity coefficients, and stability parameters for the selection of promising apple genotypes and could be applied in breeding programmes and in the formation of cultivar assortments for the Podillia region.

For an objective assessment of the potential of new apple tree genotypes in the conditions of Podillia, it is advisable to use a comprehensive set of adaptability indicators, including environmental indices, ecological plasticity and stability coefficients, which allows improving the efficiency of variety selection at the early stages of varietal testing.

Acknowledgements

None.

Funding

None.

Conflict of Interest

None.

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Пластичність і стабільність кількісних ознак продуктивності сортів яблунь в умовах Поділля

Катерина Тарнавська
Кандидат сільськогосподарських наук
Подільська дослідна станція садівництва Інституту садівництва Національної академії аграрних наук України
23226, вул. Наукова, 1, с. Медвеже Вушко, Вінницька обл., Україна
https://orcid.org/0009-0000-7939-9381
Сергій Бабій
Кандидат сільськогосподарських наук
Подільська дослідна станція садівництва Інституту садівництва Національної академії аграрних наук України
23226, вул. Наукова, 1, с. Медвеже Вушко, Вінницька обл., Україна
https://orcid.org/0009-0000-6402-1001
Олег Венедіктов
Кандидат сільськогосподарських наук, старший науковий співробітник
Подільська дослідна станція садівництва Інституту садівництва Національної академії аграрних наук України
23226, вул. Наукова, 1, с. Медвеже Вушко, Вінницька обл., Україна
https://orcid.org/0009-0006-7167-9526

Анотація. У світі яблуня є однією з провідних плодових культур, що займає третє місце за обсягами виробництва після бананів та кавунів, і постійно зростаючий попит на яблука обумовлює необхідність вдосконалення сортів з високими показниками продуктивності та адаптивності. Метою дослідження була оцінка сортів яблуні за показниками екологічної пластичності для визначення перспективних генотипів для селекційних програм. Наведено результати сортовивчення яблуні української та зарубіжної селекції (насадження 2017 року, схема 2,5 × 4,5 м, підщепа ММ106) за показниками врожайності та середньої маси плодів. Проведено оцінювання п'яти сортів яблуні (‘Фрі Голд’, ‘Джульєт’, ‘Луна’, ‘Ред Топаз’, ‘Розела’), відібраних із 27 інтродукованих генотипів, що проходили сортовивчення у 2021-2024 рр. Найвищі значення індексів середовища, як за врожайністю яблунь, так і масою плодів, були відмічені в 2023 році, і відповідно були – 1,80 та 6,15. Найменші індекси середовища відмічені у 2022 р. і 2024 р., середня врожайність в які відповідно становила 0,28 та 1,3 т/га. Такий аналіз демонструє високий вплив річних коливань кліматичних факторів на продуктивність сортів та підкреслює необхідність врахування адаптивності генотипів у селекційних програмах. За результатами математичної обробки показників врожайності плодів і середньої маси плоду виведено рівняння регресії та індекси екологічної пластичності. Встановлено, що за врожайністю плодів сорти ‘Розела’ і ‘Джульєт’ є сортами інтенсивного типу, які характеризуються високою чутливістю до змін умов середовища, коефіцієнти регресії відповідно становлять 2,743 і 0,921. За середньою масою плоду високий рівень екологічної пластичності демонструють сорти ‘Розела’, ‘Луна’ та ‘Фрі Голд’, тоді як сорт ‘Джульєт’ належить до нейтрального типу. Оцінка екологічної стабільності сортів показала, що за врожайністю найбільш стабільними були ‘Фрі Голд’, ‘Луна’ та ‘Ред Топаз’. Сорт ‘Джульєт’ виявився відносно стабільним, хоча він не відзначився високим рівнем врожайності. Найвищу врожайність у середньому за роками показав сорт ‘Розела’, який одночасно є найменш стабільним. За середньою масою плоду стабільними виявилися сорти ‘Фрі Голд’ та ‘Луна’

Ключові слова: врожайність; маса плоду; привабливість; смакові якості; параметри адаптивності; індекс середовища