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# EVALUATION OF THE COMBINING ABILITY AND HETEROSIS IN EGGPLANT PARENTS FROM BRGV BUZĂU FOR OBTAINING VALUABLE F1 HYBRIDS

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***Abstract***

*This study evaluates the combining ability and heterosis phenomenon in eggplant (Solanum melongena L.) parents to obtain valuable F1 hybrids. The research was conducted at the Plant Genetic Resources Bank (BRGV) Buzău and included 70 parental lines selected for genetic stability and distinct phenotypic expression. Testing the general (GCA) and specific (SCA) combining ability led to the identification of 31 hybrid combinations with high potential. The results indicated a strong manifestation of heterosis in most combinations, with 23 hybrids showing a 30% yield increase compared to their parents. Additionally, 35 hybrid combinations demonstrated high offspring uniformity, crucial in selecting new genotypes. In conclusion, the study highlights the importance of using local genetic material in eggplant breeding, contributing to reducing dependence on imported hybrid seeds. These findings offer promising perspectives for developing competitive hybrids adapted to local climatic conditions, thereby supporting the progress of the Romanian vegetable sector.*

***Keywords***: *breeding, genetic diversity, hybridization, phenotype, resistance.*

## INTRODUCTION

The interest in using hybrid seeds of eggplant (*Solanum melongena* L.) has significantly increased in Romania, especially among growers practicing intensive vegetable farming, both in protected spaces and in open fields. These hybrids stand out due to their higher productivity, superior fruit quality, earliness, and greater resistance to specific pathogens (Kalloo, 1993; Kumar et al., 2020). Although eggplant is an important crop worldwide, modern varieties have a narrow genetic base, making it necessary to expand the germplasm pool used in breeding (Muñoz-Falcón et al., 2009).

The phenomenon of heterosis, which determines the superiority of hybrids over their parents, is well-documented in the specialized literature. Birchler et al. (2010) define heterosis as "a phenomenon in which the offspring resulting from the crossing of distinct individuals exhibit higher or lower trait values compared to the average of the initial parents". This manifestation of hybrid vigor translates into rapid growth, higher productivity, enhanced vitality, and superior plant uniformity (Kumar et al., 2020). Moreover, it has been demonstrated that $F_1$ hybrids can exhibit greater tolerance to abiotic stress, such as extreme temperatures and water deficiencies, making them more adaptable to changing climatic conditions (Kaushik et al., 2016).

Despite these evident advantages, Romania remains dependent on imported hybrid seeds, as domestic research in this field has been limited. This situation generates economic and agronomic challenges, as imported seeds are often expensive and not always well-adapted to local climatic conditions. Furthermore, in some cases, the import of seed material has facilitated the introduction of new pathogens, leading to significant production losses. According to recent studies, using local genetic material and wild species in breeding programs can contribute to increasing genetic diversity and developing more resistant hybrids (Knapp et al., 2013; Prohens et al., 2012).

To reduce this dependency and support national hybrid seed production, current research focuses on evaluating the combining ability of local genotypes and determining the heterosis potential of the obtained hybrids. The Plant Genetic Resources Bank (BRGV) Buzău plays a crucial role in this endeavour by collecting, conserving, and improving the local germplasm pool. Identifying the most valuable hybrid combinations and selecting the most performant parent lines are fundamental steps in obtaining competitive $F_1$ hybrids at both national and international levels (Prohens et al., 2012; Kaushik et al., 2016). Additionally, phenotypic and molecular descriptors, such as those proposed by UPOV and IBPGR, have been successfully used for evaluating segregating generations of interspecific crosses, providing valuable information for selecting the genotypes with the highest potential (Prohens et al., 2013).

## MATERIALS AND METHODS

BRGV Buzău has genebanked over 1,000 eggplants (*Solanum melongena* L.) lines at various stages of breeding, focusing on both genetic stability and variety authenticity improvement.
Among these, 443 genotypes are in an advanced breeding stage. Special attention has been given to old local varieties and populations. Notably, the bank's collection includes well-established traditional varieties that were once widely cultivated, such as 'Danubiana', 'Bucureștene', and 'Pana Corbului'. From these, 70 parent lines were selected for their genetic stability and distinct phenotypic expression: 1C, 2C, 3C, 8B, 8C, 12A, 13B, 20, 22A, 23A, 23A2, 23A3, 23F, 23F2, 23N, 24, 25A, 27B, 27B1, 27P, 27P1, 51A, 51A1, 51A2, 51A3, 58, 58A, 58B, 58C, 28, 29A, 29B, 29D, 30A, 30D, 30D1, 30D2, 30E, 31A, 32A, 33D, 33D1, 34A, 40C, 59, 59A, 60, 60A, 61A, 61A1, 61B, 61B1, 61B2, 62, 62A, 62B, 62C, 63, 63A, 63B, 64, 64A, 70, 74, 76, 77, 78, 79, 10, 10A1.
For testing general combining ability (GCA), the well-established traditional varieties 'Bucureștene' and 'Danubiana' were used, as they are known for their genetic recombination potential and have been previously used in hybrid development.
Subsequently, specific combining ability (SCA) testing was conducted using only the parental lines that exhibited both heterosis and uniformity in offspring during the GCA phase. These were subjected to diallel hybridization (each parental line being used as both a maternal and a paternal parent in different crosses), resulting in 31 hybrid combinations.
Parent lines that showed compatibility in hybrid combinations with the tester parents 'Danubiana' and 'Bucureștene' were further promoted to the intensive breeding field for specific combining ability (SCA) testing. Out of the 70 parent lines evaluated in the GCA phase, 31 demonstrated a pronounced heterosis effect, reflected in $\mathbf{F_1}$ hybrids through improved productivity, uniformity, and quality.

**Formulas used to determine heterosis intensity**

The formula used to calculate the production difference relative to the parental average is called "mid-parent heterosis" (or heterosis relative to the parental mean):

$$(\%) = F1 - \bar{P}/\bar{P} \times 100$$

Where:
$F_1$ = hybrid performance (e.g., hybrid yield);
$\bar{P}$ = average yield of the two parents ($P_1$ and $P_2$).

The formula used to calculate the production difference relative to the best parent is called "high-parent heterosis" (or heterosis relative to the best parent):

$$(\%) = F1 - Pmax/Pmax \times 100$$

Where:
$F_1$ = hybrid performance (e.g., hybrid yield);
$P_{max}$ = performance of the best parent.

For qualitative phenotypic description, international descriptors from UPOV and IPGRI were used. Statistical analysis was performed using ANOVA in SPSS software.

**Description of the 'Bucureștene' variety**

The 'Bucureștene' variety, used as a parent, has a globular and slender bush shape. The stem and shoots are light green, while the stem base is woody with a green-brown coloration. The stem height up to the first branching varies between 10 and 15 cm. The fruits are cylindrical, slightly tapered at the tip, with some showing a subtle curvature. At maturity, the fruit develops an intense purple-to-black hue with a strong gloss. The sepals are green and have white spines, which turn brown as the fruit matures. The fruit pulp is dense and pure white.
The main quantitative characteristics of the plant, recorded in two cultivation environments (greenhouse and open field), are presented in Table 1.

Table 1. ‘Bucureştene’ variety, main characteristics - cultivated in field/greenhouse

| Variety/growing medium | Plant height (cm) | Bush diameter (cm) | No. of fruits/plant | Fruit length (cm) | Median diameter of the fruit (cm) | Fruit weight (g) | Total fruit weight per plant (g) |
|---|---|---|---|---|---|---|---|
| ‘Bucureştene’ - field | $62.16\pm4.4^{a1}$ | $55.4\pm4.0^{a}$ | $9.66\pm0.8^{a}$ | $16.42\pm1.2^{a}$ | $5.56\pm0.4^{a}$ | $293.2\pm20.9$ | $2841.84\pm208.4^{a}$ |
| CV | 7% | 7% | 8% | 7% | 8% | 7% | 7% |
| ‘Bucureştene’ - greenhouse | $128.2\pm10.2^{b}$ | $78.4\pm5.9^{b}$ | $14.52\pm1.0^{b}$ | $20.42\pm1.5^{b}$ | $8.1\pm1.7^{b}$ | $417\pm28.2^{b}$ | $6076.6\pm449.0^{b}$ |
| CV | 8% | 8% | 7% | 7% | 21% | 7% | 7% |

[1]Letters represent Duncan test results with confidence interval of 95% and p<0.05

The ‘Danubiana’ variety, used as a parent, is characterized by a moderate green stem and leaves, with a globular bush shape. The stem height, from ground level to the first branching, varies between 8 and 12 cm. The fruit has an intense black color with a glossy appearance, being elongated-spherical and slightly more voluminous towards the rounded tip. The sepals are green with sparse brown spines. The pulp is slightly dense, with a characteristic white shade. The main quantitative characteristics of the plant, recorded in two cultivation environments (greenhouse and open field), are presented in Table 2.

Table 2. ‘Danubiana’ variety, main characteristics - cultivated in field/greenhouse

| Variety/growing medium | Plant height (cm) | Bush diameter (cm) | No. of fruits/plant | Fruit length (cm) | Median diameter of the fruit (cm) | Fruit weight (g) | Total fruit weight per plant (g) |
|---|---|---|---|---|---|---|---|
| ‘Danubiana’ - field | $59\pm4.74^{a1}$ | $48\pm3.84^{a}$ | $6.2\pm0.49^{a}$ | $15\pm1.27^{a}$ | $7.4\pm0.74^{a}$ | $328\pm29.47^{a}$ | $2033.6\pm169.24^{a}$ |
| CV | 8.04% | 8.00% | 7.93% | 8.71% | 9.98% | 8.98% | 8.32% |
| ‘Danubiana’ - greenhouse | $109\pm8.52^{b}$ | $76\pm6.36^{b}$ | $12.7\pm0.98^{b}$ | $15.2\pm1.38^{b}$ | $9.5\pm0.79^{b}$ | $458\pm39.72^{b}$ | $5816.6\pm481.77^{b}$ |
| CV | 7.81% | 8.37% | 7.68% | 9.06% | 8.32% | 8.67% | 8.28% |

[1]Letters represent Duncan test results with confidence interval of 95% and p<0.05.

## RESULTS AND DISCUSSIONS

Table 3. Testing of general combining ability with ‘Bucureştene’

| Genitor 1 | Genitor tester G2 | Compatibility | F1 heterosis | F1 uniformity |
|---|---|---|---|---|
| 1C | Bucureştene | NO | - | - |
| 2C | Bucureştene | NO | - | - |
| 3C | Bucureştene | YES | - X | non-uniform |
| 8B | Bucureştene | YES | - X X X | non-uniform |
| 8C | Bucureştene | YES | - X | Uniform |
| 12A | Bucureştene | YES | - X X | Uniform |
| 13B | Bucureştene | YES | + X X X | Uniform |
| 20 | Bucureştene | YES | + X X X | Uniform |
| 22A | Bucureştene | YES | + X X | Average |
| 23A | Bucureştene | YES | + X X | Uniform |
| 23A2 | Bucureştene | YES | + X X X | Average |
| 23A3 | Bucureştene | YES | + X X X | Uniform |
| 23F | Bucureştene | YES | + X X X | Uniform |
| 23F2 | Bucureştene | YES | + X X | Average |
| 23N | Bucureştene | YES | - X | non-uniform |
| 24 | Bucureştene | NO | - | - |
| 25A | Bucureştene | YES | - X X | Average |
| 27B | Bucureştene | YES | + X | Average |
| 27B1 | Bucureştene | YES | + X X | Uniform |
| 27P | Bucureştene | YES | + X X X | Uniform |
| 27P1 | Bucureştene | YES | + X X | Uniform |
| 51A | Bucureştene | YES | + X X X | Average |
| 51A1 | Bucureştene | YES | + X | Uniform |
| 51A2 | Bucureştene | YES | + X X | Uniform |
| 51A3 | Bucureştene | YES | + X X | Uniform |
| 58 | Bucureştene | YES | + X X X | non-uniform |
| 58A | Bucureştene | YES | + X X X | Uniform |
| 58B | Bucureştene | YES | + X X | Average |
| 58C | Bucureştene | YES | + X X X | Uniform |
| 28 | Bucureştene | YES | + X X X | Uniform |
| 29A | Bucureştene | NO | - | - |
| 29B | Bucureştene | NO | - | - |
| 29D | Bucureştene | NO | - | - |
| 30A | Bucureştene | YES | + X | Uniform |
| 30D | Bucureştene | YES | + X X | Average |
| 30D1 | Bucureştene | YES | - X X X | non-uniform |
| 30D2 | Bucureştene | YES | + X | Average |
| 30E | Bucureştene | YES | - X | Uniform |
| 31A | Bucureştene | YES | + X X | Uniform |
| 32A | Bucureştene | YES | + X X X | Uniform |
| 33D | Bucureştene | YES | + X X | Uniform |
| 33D1 | Bucureştene | YES | - X X | Average |
| 34A | Bucureştene | YES | + X X | Uniform |
| 40C | Bucureştene | NO | - | - |
| 59 | Bucureştene | YES | + X X X | non-uniform |
| 59A | Bucureştene | YES | + X X | Average |
| 60 | Bucureştene | YES | + X X X | Uniform |
| 60A | Bucureştene | YES | + X X | Uniform |
| 61A | Bucureştene | YES | + X X X | non-uniform |
| 61A1 | Bucureştene | YES | + X X X | Uniform |
| 61B | Bucureştene | YES | + X X | Uniform |
| 61B1 | Bucureştene | YES | + X X | Average |
| 61B2 | Bucureştene | YES | + X X X | non-uniform |
| 62 | Bucureştene | YES | - X X | Average |
| 62A | Bucureştene | YES | - X | Uniform |
| 62B | Bucureştene | YES | + X X | Uniform |
| 62C | Bucureştene | YES | + X X X | Uniform |
| 63 | Bucureştene | YES | + X X X | Uniform |
| 63A | Bucureştene | YES | + X X X | non-uniform |
| 63B | Bucureştene | YES | + X X | Uniform |
| 64 | Bucureştene | YES | + X X | Average |
| 64A | Bucureştene | YES | + X X | Average |
| 70 | Bucureştene | YES | + X X X | Uniform |
| 74 | Bucureştene | NO | - | - |
| 76 | Bucureştene | YES | + X X | Uniform |
| 77 | Bucureştene | YES | + X X | non-uniform |
| 78 | Bucureştene | YES | + X X | Average |
| 79 | Bucureştene | YES | + X X X | Uniform |
| 10 | Bucureştene | YES | + X X X | Average |
| 10A1 | Bucureştene | YES | + X X | Uniform |

*- XXX = -30% production; - XX = -20% production; - X = -10% production; + X = 10% production; + XX = 20% production; + XXX = 30% production

In Table 3 the hybrid combinations resulting from crosses with the tester parent line ‘Bucureștene’ are presented.
Compatibility is marked as "YES" or "NO." This reflects the ability of the parent lines to cross successfully, which is essential for the success of any hybridization program.

- "YES" means that the cross is possible and genetically viable.
- "NO" (recorded in 8 hybrid combinations) indicates genetic incompatibility, which may result in the inability to produce viable or productive offspring.

The intensity of the heterosis phenomenon was calculated based on the percentage by which the $F_1$ hybrid exceeded the parental average in terms of yield (Figure 1).

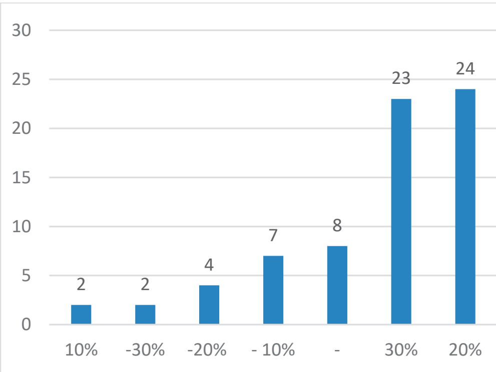


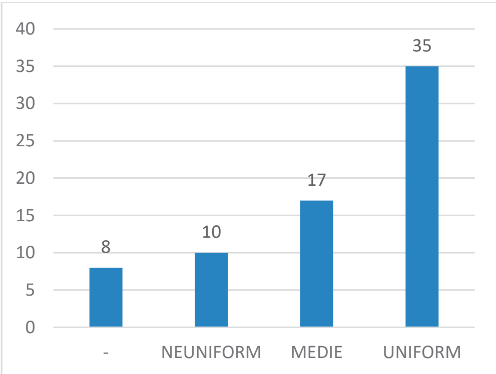

Figure 1. The intensity of the heterosis phenomenon for hybrid combinations with the ‘Bucureștene’ parent

The positive heterosis phenomenon is the most frequently observed and intense in hybrid combinations, with 30% and 20% heterosis values. In contrast, negative heterosis is rarer and less intense in this hybrid population.

- 24 hybrid combinations exhibited 20% heterosis;
- 23 hybrid combinations recorded a 30% increase in yield;
- Only 2 combinations showed negative heterosis (-30%).

This indicates that, in general, most tested lines exhibit a high heterosis intensity, suggesting good genetic compatibility between parents and a potential improvement in desirable traits.
Uniformity in $F_1$ offspring is an important indicator of the stability and predictability of traits expressed after crossing (Figure 2). The hybrid combinations were grouped into uniformity categories as follows:

- Uniform (35 hybrid combinations): All $F_1$ hybrids exhibit very similar traits, suggesting that the hybridization is consistent and stable.
- Non-uniform (10 hybrid combinations): The $F_1$ offspring are variable in traits, which may indicate genetic segregation due to the diversity of the parent lines.
- Average (17 hybrid combinations): This category suggests a moderate uniformity in $F_1$ offspring, neither perfectly uniform nor highly variable.




- Figure 2. Uniformity of $F_1$ offspring for hybrid combinations with the ‘Bucureștene’ parent

For example, lines 1C and 2C are marked as having non-uniform offspring, which could reflect greater variability in the inherited traits, impacting the stability of the $F_1$ generation. On the other hand, uniform lines in the offspring (e.g., 60, 62, 79, 70, 76, 10 A1, etc.) suggest stable genetic performance, favorable for the breeding process.
Line 58 represents a special case as it exhibits a high intensity of heterosis (30%) but shows non-uniform offspring. This could indicate significant potential for trait improvement and high variability, which might be more challenging to control in selection.
In general, the tested lines showed compatibility in hybridization, strong heterosis, and good uniformity in the offspring, suggesting that these crosses are viable and can lead to superior and high-performing hybrids.

In Table 4, the hybrid combinations resulting from crosses with the tester parent line ‘Danubiana’ are presented.

Table 4. Testing of general combining ability with ‘Danubiana’

| Crt. no. | Line G1 | Genitor tester G2 | Compatibility | F1 heterosis | F1 uniformity |
|---|---|---|---|---|---|
| 1 | 1C | Danubiana | NU | - | - |
| 2 | 2C | Danubiana | NU | - | - |
| 3 | 3C | Danubiana | DA | -X X X | non-uniform |
| 4 | 8B | Danubiana | DA | - X X | non-uniform |
| 5 | 8C | Danubiana | DA | - X X X | non-uniform |
| 6 | 12A | Danubiana | DA | - X | average |
| 7 | 13B | Danubiana | DA | + X X X | Uniform |
| 8 | 20 | Danubiana | DA | - X X | non-uniform |
| 9 | 22A | Danubiana | DA | - X | non-uniform |
| 10 | 23A | Danubiana | DA | + X X X | Uniform |
| 11 | 23A2 | Danubiana | NU | - | - |
| 12 | 23A3 | Danubiana | DA | + X X | Uniform |
| 13 | 23F | Danubiana | DA | + X | average |
| 14 | 23F2 | Danubiana | DA | - X | non-uniform |
| 15 | 23N | Danubiana | NU | - | - |
| 16 | 24 | Danubiana | DA | + X | non-uniform |
| 17 | 25A | Danubiana | DA | + X X | average |
| 18 | 27B | Danubiana | NU | - | - |
| 19 | 27B1 | Danubiana | DA | - X X | non-uniform |
| 20 | 27P | Danubiana | DA | - X X X | non-uniform |
| 21 | 27P1 | Danubiana | DA | + X | non-uniform |
| 22 | 51A | Danubiana | DA | + X | non-uniform |
| 23 | 51A1 | Danubiana | DA | + X X | Uniform |
| 24 | 51A2 | Danubiana | DA | + X | average |
| 25 | 51A3 | Danubiana | DA | - X | non-uniform |
| 26 | 58 | Danubiana | DA | + X X | average |
| 27 | 58A | Danubiana | DA | + X X X | Uniform |
| 28 | 58B | Danubiana | DA | - X | average |
| 29 | 58C | Danubiana | DA | + X X | Uniform |
| 30 | 28 | Danubiana | DA | + X X X | Uniform |
| 31 | 29A | Danubiana | NU | - | - |
| 32 | 29B | Danubiana | NU | - | - |
| 33 | 29D | Danubiana | NU | - | - |
| 34 | 30A | Danubiana | DA | - X X | average |
| 35 | 30D | Danubiana | DA | - X | non-uniform |
| 36 | 30D1 | Danubiana | NU | - | - |
| 37 | 30D2 | Danubiana | DA | - X X | average |
| 38 | 30E | Danubiana | DA | - X X X | non-uniform |
| 39 | 31A | Danubiana | DA | + X | Uniform |
| 40 | 32A | Danubiana | DA | + X X | average |
| 41 | 33D | Danubiana | DA | + X X X | Uniform |
| 42 | 33D1 | Danubiana | DA | - X X X | non-uniform |
| 43 | 34A | Danubiana | DA | + X X X | Uniform |
| 44 | 40C | Danubiana | DA | - X | average |
| 45 | 59 | Danubiana | DA | + X X | Uniform |
| 46 | 59A | Danubiana | DA | + X X | Uniform |
| 47 | 60 | Danubiana | DA | + X X X | Uniform |
| 48 | 60A | Danubiana | DA | + | Uniform |
| 49 | 61A | Danubiana | DA | + X X | average |
| 50 | 61A1 | Danubiana | DA | + X X X | Uniform |
| 51 | 61B | Danubiana | DA | + X X X | Uniform |
| 52 | 61B1 | Danubiana | DA | + X | non-uniform |
| 53 | 61B2 | Danubiana | DA | + X X | Uniform |
| 54 | 62 | Danubiana | DA | - X | Uniform |
| 55 | 62A | Danubiana | DA | + X | average |
| 56 | 62B | Danubiana | DA | + X X X | Uniform |
| 57 | 62C | Danubiana | DA | + X | average |
| 58 | 63 | Danubiana | DA | + X X | non-uniform |
| 59 | 63A | Danubiana | DA | + X X X | Uniform |
| 60 | 63B | Danubiana | DA | + X X | Uniform |
| 61 | 64 | Danubiana | DA | + X X X | Uniform |
| 62 | 64A | Danubiana | DA | + X X X | Uniform |
| 63 | 70 | Danubiana | DA | + X X X | Uniform |
| 64 | 74 | Danubiana | NU | - | - |
| 65 | 76 | Danubiana | DA | + X X X | Uniform |
| 66 | 77 | Danubiana | DA | + X | average |
| 67 | 78 | Danubiana | DA | - X | Uniform |
| 68 | 79 | Danubiana | DA | + X X X | Uniform |
| 69 | 10 | Danubiana | DA | + X X | Uniform |
| 70 | 10A1 | Danubiana | DA | + X X X | non-uniform |

*- XXX = -30% production; - XX = -20% production; - X = -10% production; + X = 10% production; + XX = 20% production; + XXX = 30% production.

Regarding compatibility, unlike the previous test where the tester parent ‘Bucureștene’ was used and 8 hybrid combinations were found to be incompatible, crossing with the tester parent ‘Danubiana’ resulted in 10 incompatible hybrid combinations.

The hybrid combinations 13B, 23A, 33D, 40C, 76 x ‘Danubiana’ recorded a 30% increase in yield, indicating a strong heterosis performance. These can be considered the best in terms of combining favorable traits from their parents (Figure 3).

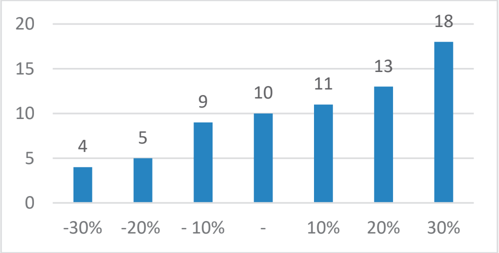



Figure 3. The intensity of the heterosis phenomenon for hybrid combinations with the ‘Danubiana’ parent

Hybrids with average performance, e.g., 12A, 17B, 30A x ‘Danubiana’, exhibit moderate heterosis.

In the case of hybrid combinations 1C, 2C, 8B x ‘Danubiana’, it can be observed that heterosis is not expressed uniformly across the entire offspring, and the traits are not distributed evenly.

Comparative with the results from the previous test, which involved the tester parent ‘Bucureștene’, where 30% heterosis was observed in 23 hybrid combinations, this time, only 18 combinations achieved this production increase. Additionally, it can be observed that the number of hybrid combinations exhibiting negative heterosis of -30%, -20%, -10% is very high, with 18 combinations, in contrast to the previous test where only 8 lines showed negative heterosis.

Regarding the uniformity of the offspring (Figure 4), the hybrid combinations were grouped as follows:

- Uniform (28 hybrid combinations), compared to 35 uniform hybrid combinations recorded in the test with the ‘Bucureștene’ tester parent.
- Non-uniform (18 hybrid combinations), a higher number than the 10 non-uniform

combinations recorded in the test with the 'Bucureștene' tester parent.

- Average (14 hybrid combinations), a lower value compared to the 17 hybrid combinations recorded in the previous test.

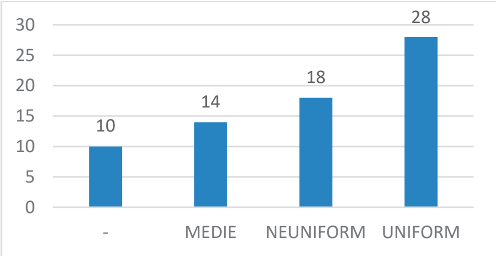



Figure 4. Uniformity of $F_1$ offspring for hybrid combinations with the 'Danubiana' parent

Lines with high heterosis are on row 1 – P1 (L20, 0.78 kg), P2 (L58, 4.13 kg), F1 Hybrid = 5.32 kg, resulting in average heterosis of 117.13% and BPH = 29%. This suggests that the resulting hybrid showed a significant increase in production compared to its parents. Similarly, the last entry (L10 A1 × L20) has heterosis of 246.8%, indicating an extremely successful combination (Figure 5).

Unfavorable combinations with negative heterosis, such as L76 × L61 A (-65%) or L58 C × L76 (-38%), indicate weaker hybrids than their parents. These combinations would not be suitable for further selection.

Hybrids with very high BPH:

- Row 16: L13 B × L58 C → 163.7%
- Row 31: L10 A1 × L20 → 246.8%

These could be good candidates for further testing or commercial production.

| Crt. no. | P1 | P1 kg/plant | P2 | P2 kg/plant | M.P. kg/plantă | H F1 kg/plant | heterosis % | BPH % |
|---|---|---|---|---|---|---|---|---|
| 1 | L 20 | 0.76 | L 58 | 4.13+E35E | 2.45 | 5.32 | 117.13 | 29% |
| 2 | L 23 A2 | 4.26 | L 10 | 8.31 | 6.29 | 9.78 | 55.62 | 56% |
| 3 | L 23 A3 | 1.75 | L 61 A1 | 4.39 | 3.07 | 7.16 | 133.29 | 63% |
| 4 | L 23 F | 3.92 | L 61 B | 7.65 | 5.78 | 5.84 | 0.94 | -24% |
| 5 | L 27 P | 1.64 | L 79 | 11.1 | 6.37 | 7.2 | 13.08 | -35% |
| 6 | L 51 A | 10.47 | L 64 | 10.67 | 10.57 | 11.96 | 13.15 | 12% |
| 7 | L 58 | 4.13 | L 62 B | 5.46 | 4.8 | 7.51 | 56.56 | 38% |
| 8 | L 58 C | 3.28 | L 76 | 11.3 | 7.29 | 6.95 | -4.62 | -38% |
| 9 | L 32 A | 5.26 | L 58 A | 4.54 | 4.9 | 7.72 | 57.55 | 47% |
| 10 | L 59 | 7.11 | L 70 | 10.73 | 8.92 | 14.98 | 67.8 | 40% |
| 11 | L 61 A | 4.39 | L 64 A | 6.87 | 5.63 | 9.36 | 66.35 | 36% |
| 12 | L 61 B2 | 7.52 | L 10 A 1 | 6.08 | 6.8 | 5.75 | -15.38 | -23% |
| 13 | L 62 C | 4.12 | L 13 B | 3.9 | 4.01 | 7.91 | 97.06 | 92% |
| 14 | L 63 B | 6.07 | L 63 A | 4.83 | 5.45 | 9.68 | 77.75 | 60% |
| 15 | L 10 | 8.31 | L 23 A | 2.9 | 5.6 | 5.83 | 4.08 | -30% |
| 16 | L 13 B | 3.9 | L 58 C | 3.28 | 3.59 | 9.47 | 163.76 | 143% |
| 17 | L 23 A | 2.9 | L 51 A | 10.47 | 6.69 | 8.93 | 33.62 | -15% |
| 18 | L 58 A | 4.54 | L 28 | 5.57 | 5.05 | 9.86 | 95.02 | 77% |
| 19 | L 28 | 5.57 | L 23 F | 3.92 | 4.74 | 2.82 | -40.6 | -49% |
| 20 | L 34 A | 4.1 | L 27 P | 1.64 | 2.87 | 3.75 | 30.84 | -8% |
| 21 | L 60 | 7.75 | L 59 | 7.11 | 7.43 | 11.74 | 57.96 | 51% |
| 22 | L 61 A 1 | 4.39 | L 62 C | 4.12 | 4.26 | 7.83 | 84.05 | 79% |
| 23 | L 61 B | 7.65 | L 63 | 5.81 | 6.73 | 4.73 | -29.8 | -38% |
| 24 | L 62 B | 5.46 | L 32 A | 5.26 | 5.36 | 6.98 | 30.22 | 28% |
| 25 | L 63 A | 4.83 | L 60 | 7.75 | 6.29 | 10.13 | 61.07 | 31% |
| 26 | L 64 | 10.67 | L 23 A 3 | 2.9 | 6.78 | 5.23 | -22.95 | -51% |
| 27 | L 64 A | 6.87 | L 79 | 11.1 | 8.98 | 12.96 | 44.3 | 17% |
| 28 | L70 | 10.73 | L 61B2 | 7.52 | 9.12 | 6.32 | -30.74 | -41% |
| 29 | L 76 | 11.3 | L 61 A | 4.39 | 7.84 | 3.92 | -50.07 | -65% |
| 30 | L 79 | 11.1 | L 63 A | 4.83 | 7.96 | 10.69 | 34.28 | -4% |
| 31 | L 10 A 1 | 6.08 | L 20 | 0.76 | 3.42 | 11.86 | 246.8 | 95% |

*The numerical positions on the Y-axis represent the serial number of the hybrid combination from Table 4

Figure 5. Testing of specific combining ability

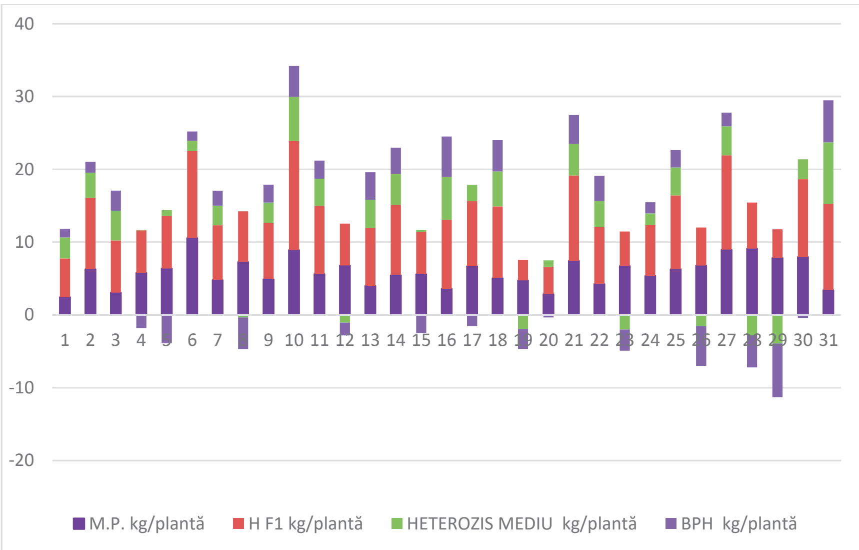



Figure 6. Graphical representation for combining ability testing

Figure 6 illustrates the performance of 31 hybrid combinations evaluated for yield-related traits, expressed in kilograms per plant. Four parameters are represented: the mean of the parents (M.P.) in purple, the F1 hybrid yield (H F1) in red, the mid-parent heterosis (green), and the best-parent heterosis (BPH) in light purple.

A notable number of hybrids display significant positive heterosis over both the mid-parent and the best parent, indicating favourable genetic interactions and superior hybrid vigour. For instance, 9, 11, and 31 combinations exhibit remarkably high F1 performance, suggesting strong specific combining ability.

On the other hand, a few combinations (e.g., 23 and 30) show negative BPH values, implying that their F1 performance fell below that of the better-performing parent. These results are critical for identifying the most promising hybrids for future selection and potential commercialization.

## CONCLUSIONS

A total of 70 genitors were evaluated for general combining ability (GCA), of which 31 demonstrated favorable aptitude for hybridization.

Testing the specific combining ability (SCA) resulted in the development of 31 hybrid combinations.

The heterosis phenomenon manifested differently among the combinations, highlighting significant variations in yield, with certain hybrids showing superior performance.

Research will continue with field trials of the highest-yielding hybrids, alongside well-established control hybrids in Romania, aiming for the official registration and patenting of the most promising variants.

The seeds of the new hybrids were distributed free of charge across Romania to be tested under diverse soil and climate conditions, thus facilitating the zoning and microzoning process.

The progenies resulting from both GCA and SCA testing will be further studied to identify new valuable genotypes, varieties, and hybrids.

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