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# CORRELATIONS BETWEEN GENETIC CHARACTERISTICS AND AGRONOMIC TRAITS OF SOME GENOTYPES IN THE SELECTION PROCESS OF NEW POTATO VARIETIES

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## ABSTRACT

**Potato (*Solanum tuberosum* L.) is a key crop for global food security. Therefore, under actual climatic changes, it is important to search for genotypes with steady characteristics in contrasting weather conditions. The aim of the present study was to establish the relationship between the development of the biomass and the number, respectively, the weight of the tubers in order to introduce into the breeding program new genotypes, future varieties, with increased adaptability to environmental factors.**

**The paper presents the results of a field study conducted to NIRDPSB Braşov, Romania, between 2021-2022, to evaluate some agronomic traits in potato genotpyes. A total of 15 potato genotypes (1901/6, 1930/3, 1901/12, 1927/1, 1897/2, 1979/5, 1891/1, 1927/3, 1901/11, 1941/8, 1895/4, 19-1876/7, 1939/2, 21-1895/1, 21-1901/7) along with one commercial cultivar (Braşovia) were evaluated. The experiment was laid out in a randomized complete block design with three replications.**

**Data was recorded on plant height, main stem number per plant, tuber number and weight per plant and total tuber yield. Significantly positive phenotypic correlations for the height and mass of the plants were observed to the both determinations in the both years (r=0.90175, r=0.889, r=0.54505, r=0.562). The number and the weight of tubers were in an evolutionary process during the two experimental years. Genotypes 21-1901/7 (45.55 t/ha in 2021 and 34.17 t/ha in 2022) and 1939/2 (47.93 t/ha in 2021, respectively, 30.70 t/ha in 2022) recorded significantly high productions and even in the extreme conditions of 2022 maintained their high production capacity.**

**The present findings show the existence of proper genetic variability and divergence among traits, and the identified traits can be used in a potato improvement program.**

**Keywords:** agronomic traits, breeding, correlation, potato, yield.

## INTRODUCTION

The potato (*Solanum tuberosum* L.), because of its adaptability, yield capacity and nutrition contribution and as an important component of diversified cropping systems, has a long history of helping relieve food insecurities and contributing to improve household incomes in times of crisis and today's population expansion (Devaux et al., 2021).

After wheat, rice and maize, potato is now the fourth most important global food crop due to yield and high nutritive value. Potatoes are a good source of carbohydrates, vitamins, and minerals. Vitamins include niacin, thiamin, riboflavin and vitamin C (Cotton et al., 2004; Khalil et al., 2021). Potato can grow in warmer as well as cooler climates, however it cannot thrive in harsh climatic conditions such drought, high temperature and high humidity (Guo et al., 2017). In many countries potato is grown as a major crop under different climatological zones, such as temperate regions, the sub-tropics and tropics, under very different agro-ecological conditions, lowlands and highlands. Presently, the potato crop is cultivated in about 160 countries and there are nearly 5000 potato varieties worldwide (Zaheer and Akhtar, 2016). With regard to the global food consumption, potato ranks third as an important non-grain crop. FAO has declared potato as the food security crop because it provides nutritious food to poor and hungry where the world is facing issues with food accessibility (Devaux et al., 2014).

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Breeding better potato varieties is a key component in responding to a range of future challenges facing the potato industry across the value chain. Climate change, increased sophistication in end-user requirements, sustainability policies, emerging markets, food security and nutrition are among the complex problems in which new potato varieties with improved specific product profiles can contribute to solutions. However, potato breeding is both slow and imprecise. It takes over a decade to produce a new variety, so rapidly responding to emerging threats and opportunities is difficult.

Average tuber weight, tubers/plant, stems/plant, tuber weight/plant and big tuber percentage are the most important components in potato improvement for increasing tuber yield (Aytaç and Esendal, 1996; Islam et al., 2002) because of direct and indirect correlation with tuber yield (Burhan, 2007).

Plant development can be affected by a number of variables, including climate, soil and crop conditions. Therefore, to characterize the superiority of genotypes, it is important to consider their responses to the different environments (da Silva, 2020). Potato tuber yield losses in the absence of water can reach as much as 69% and also reduces the development of the aboveground part: leaf and stem biomass (Jama-Rodzenska et al., 2021). Yield under water stress has been and continues to be the main index of selection used in many breeding programs to improve the drought tolerance of crops (Petcu et al., 2019).

Breeding programs have traditionally focused on commercially important traits, the major one being yield. Plant performance, along with economic yield, has been shown to be strongly associated with traits related to plant growth and development (de Jesus Colwell et al., 2021).

Despite many available potato cultivars, there is a need for new cultivars. New cultivars must produce high yields under low inputs, have disease and pest resistance, and environmental stress tolerance such as high or low temperature, drought, and salinity. If possible, they should also have improved nutritional and health properties (Bradshaw, 2007; Pandey et al., 2021).

## MATERIAL AND METHODS

The activity carried out aimed to highlight the main features of the new breeding lines in order to propose some of them as future potato varieties.

Production capacity or production potential means the maximum level of useful biomass that a genotype can achieve, benefiting from optimal culture and technology conditions. Among the numerous meteorological and hydrological extreme events, droughts are less understood, but often disastrous due to their higher occurrence frequency, long duration, and widespread impacts across larger spatial scales (Yu et al., 2018; Racz et al., 2021).

The experiment was laid out in a randomized complete block design with three replications. The experimental plot size was 10.8 $m^2$ planted with 4 rows spaced 0.75 m to each other and 0.30 m plant to plant spacing in a row.

15 genoptyes and a control variety were studied, as follows: 1901/6, 1930/3, 1901/12, 1927/1, 1897/2, 1979/5, 1891/1, 1927/3, 1901/11, 1941/8, 1895/4, 19-1876/7, 1939/2, 21-1895/1, 21-1901/7 and Brașovia.

Plant height (cm) was taken as the average of two plants height per plot measured from the soil surface to the top-most growth point of plants. Number of main stem/hill was counted also. Only stems that had directly grown from the mother tuber and acted as an independent plant above the soil were considered as main stems. (Lung`aho et al., 2007). Also aboveground and belowground biomass was determinated. Average tuber number/hill was recorded and average tuber weight (g/tuber) was determined by dividing the total fresh tuber yield to their respective total tubers number.

The statistical and rating differences between mean values regarding the yield were performed by LSD test and the correlations between different traits were performed with Statistica Six Sigma (2018).

## RESULTS AND DISCUSSION

In 2021 April month was colder than normal, with minimum negative air temperatures recorded for 10 consecutive days. Negative values were also recorded at ground level. The amount of precipitation that fell in April was 39.2 mm, which is 10.8 mm lower than the MAA. In May, the air temperature was lower by 1.3°C compared to the multiannual average, and the amount of precipitation was lower by 4.97 mm compared to the MAA value. June was a rainy month (106.1 mm), with precipitation in the first two decades even daily and with slightly higher temperatures than average (+0.8°C). In July the situation changed completely, registering much higher temperatures (+2.9°C) and a lower level of precipitation, by 28.7 mm compared to the multiannual average.

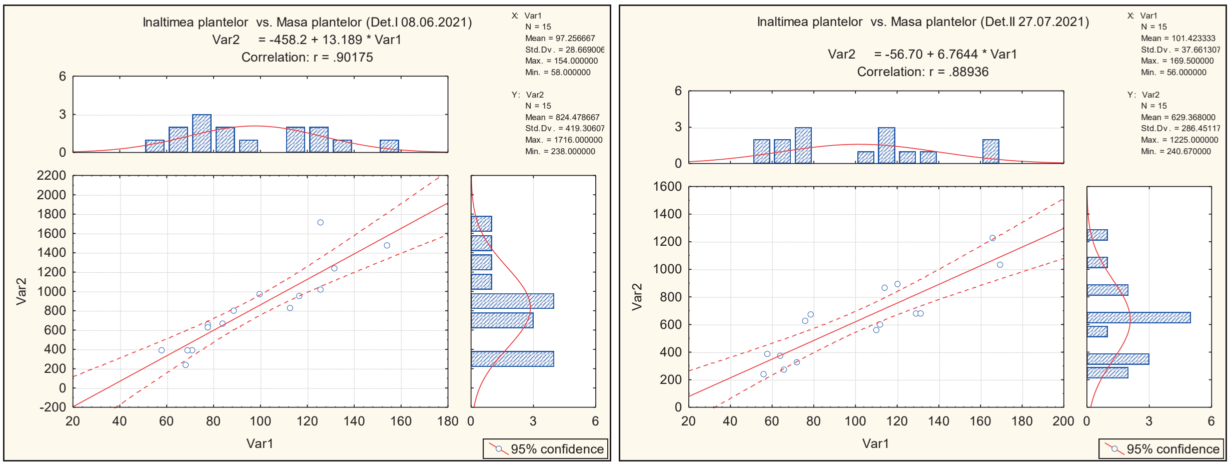
The month of April 2022, was rich in precipitation, exceeding the multiannual amount by 14.8 mm/m$^2$, and the temperatures (8.3°C) were close to the multiannual average (8.5°C), ensuring a good start to potato crops. In May, temperatures were recorded with +1.2°C compared to the average and a much lower amount of rainfalls (40.0 l/m$^2$), but despite all this, the potato crop sprouted evenly.

*Table 1.* Air temperature and rainfalls during the experiment
(according to data processing from the Ghimbav Weather Station)

| Year | Month | | | | | |
|---|---|---|---|---|---|---|
| | May | June | July | August | September | Average |
| | **Air temperature (°C)** | | | | | |
| 2020 | 13.8 | 17.3 | 21.0 | 19.7 | 16.3 | 18.0 |
| 2021 | 14.8 | 19.0 | 20.6 | 19.2 | 12.8 | 17.3 |
| Multiannual average of air temperature | 13.6 | 15.9 | 18.1 | 17.5 | 13.6 | 17.7 |
| | **Amount of rainfall (mm)** | | | | | Total |
| 2020 | 77.5 | 109.0 | 71.1 | 100.9 | 75.5 | 434.0 |
| 2021 | 48.3 | 62.2 | 20.1 | 53.4 | 32.0 | 216.0 |
| Multiannual average of rainfall | 82.0 | 96.7 | 99.8 | 76.4 | 52.5 | 407.4 |

Between the height and mass of the plants at BBCH 43 (30% of total final tuber mass reached) the correlation coefficient was r=0.90175. Based on the comparison of the value of the correlation coefficient with the probability of 5%, r=0.901 > 0.50 it can be stated that there is a significant positive correlation coefficient between the height and mass of the plants. The degree of association of the points on the graph indicates a positive direction. The value of 0.90 signifies a strong association between the two analyzed factors, the linear form being directly proportional to the value of the correlation coefficient (Figure 1). Very significant correlations at the first assessment between the length of the plant and the weight of the aerial part in lines 1941/8, 1939/2, 1927/3 and significantly positive in line 1901/6. The 1941/8 line was very significant and at the second assessment, also 1901/6 and 1979/5. Lines 1939/2 and 1927/3 also showed a positive correlation.

At the second determination, BBCH 64 (40% of flowers in the first inflorescence open), the correlation coefficient was r=0.88936, and the correlation coefficient value with 5% probability, r=0.889 > 0.50 also indicates a significantly positive correlation (Figure 2).

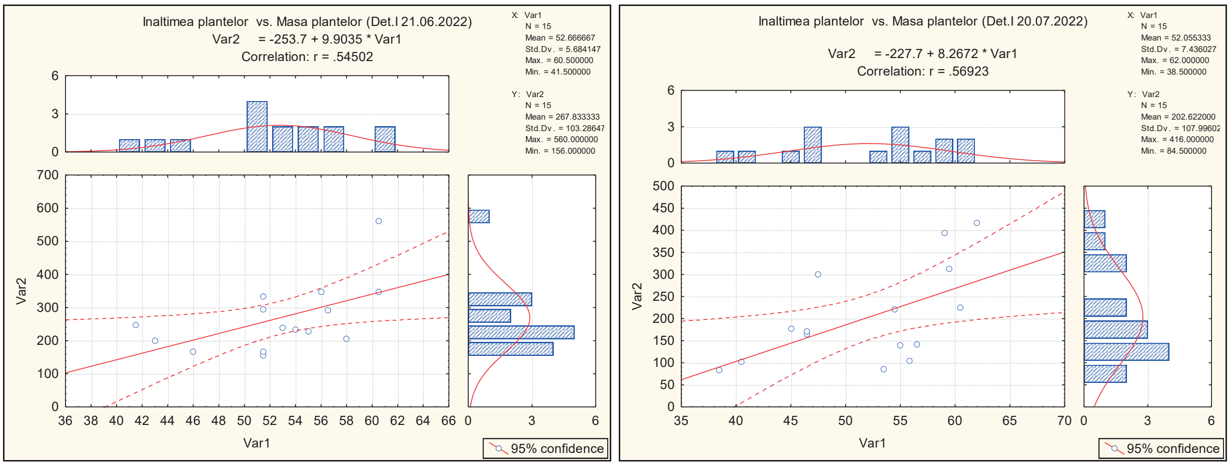



*Figures 1-2.* Phytomass structure and the evolution of components in dynamics (Braşov, 2021)

In 2022 at BBCH 60 (first open flowers in population) the correlation coefficient between the height and mass of the plants was r=0.54505, a significant positive one. The degree of association of the points on the graph indicates a positive direction, but compared to the year 2021, several genotypes were below average, due to unfavorable climatic conditions (Figure 3).

At the second determination, (BBCH 75), the correlation coefficient was r=0.56923, and the correlation coefficient value with 5% probability, r=0.562 > 0.50 also indicates a significantly positive correlation (Figure 4), but a weaker development of the two parameters compared to 2021.

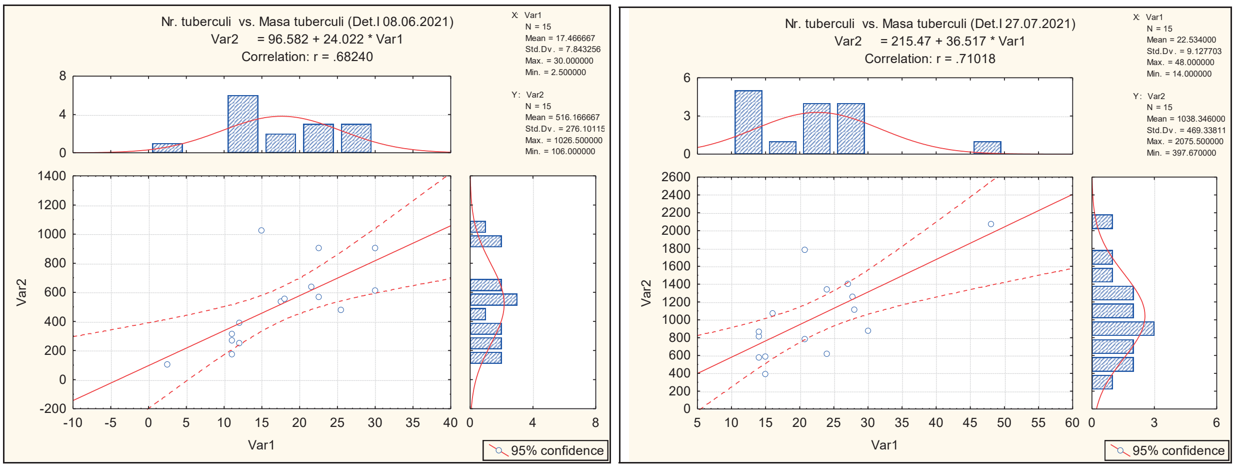
Improper climatic conditions, the installation of the pedological drought in 2022, negatively influenced the development of the genotypes, as a whole the values were below those of the reference variety.



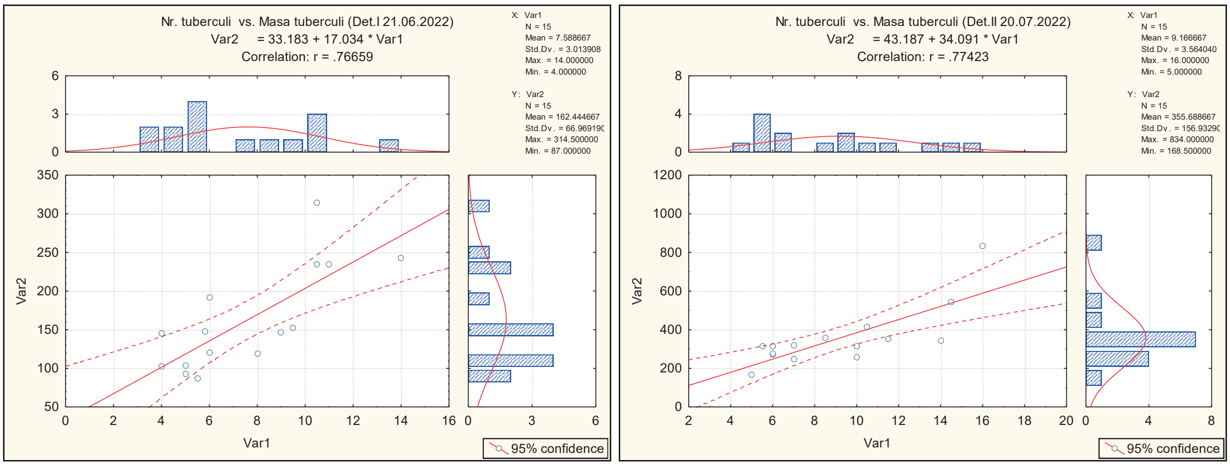

*Figures 3-4.* Phytomass strucutre and the evolution of components in dynamics (Braşov, 2022)

In Figure 5 at BBCH 43 (first determination in 2021), a correlation coefficient r=0.68240 can be noted between the number and the weight (mass) of the tubers. Comparing the value of the correlation coefficient with the 5% probability, r=0.68 > 0.50, it can be stated that the correlation coefficient between the number of tubers and their weight to some genotypes is less significant, but all the genotypes were in an evolutionary process.

In Figure 6 at BBCH 75 (development of berries in fructifications), to the second determination, the correlation coefficient r=0.71018 compared with the probability of 5% r=0.71 > 0.50 indicates a distinctly significant positive correlation, having genotypes with a large number of tubers and with high weight too.




*Figures 5-6.* The number and the weight of tubers in dynamics (Braşov, 2021)




*Figures 7-8.* The number and the weight of tubers in dynamics (Braşov, 2022)

In Figure 7, BBCH 60, in 2022, there is a correlation coefficient r=0.76659 between the number and the weight (mass) of the tubers. Comparing the value of the correlation coefficient with the 5% probability, r=0.76 > 0.50 it can be stated that the correlation coefficient between the number of tubers and their weight is significant, the genotypes are in the evolutionary process, differentiating from each other.

In Figure 8, BBCH 75, the correlation coefficient r=0.77423 compared with the probability of 5% r=0.77 > 0.50 indicates a distinctly significant positive correlation, having genotypes with a large number of tubers and with high weight, but also quantitatively weaker genotypes.

During the vegetation of the plants, frequently there are significant variations between the genotypes regarding the dynamics of the number of tubers and their weight.

*Table 2.* Influence of genotype on total tuber production/hectare (Brașov, 2021-2022)

| Genotype | Year 2021 | | | Year 2022 | | |
|---|---|---|---|---|---|---|
| | Production (t/ha) | Dif. (t) | Sign. | Production (t/ha) | Dif. (t) | Sign. |
| 1901/6 | 34.27 | 10.62 | ns | 16.43 | -3.07 | ns |
| 1930/3 | 30.11 | 6.45 | ns | 10.59 | -8.91 | oo |
| 1901/12 | 34.34 | 10.69 | ns | 14.97 | -4.53 | ns |
| 1927/1 | 43.33 | 19.67 | * | 11.69 | -7.81 | o |
| 1897/2 | 40.31 | 16.66 | * | 8.39 | -11.11 | oo |
| 1979/5 | 42.52 | 18.87 | * | 21.41 | 1.91 | ns |
| 1891/1 | 18.61 | -5.04 | ns | 5.37 | -14.13 | ooo |
| 1927/3 | 24.33 | 0.67 | ns | 13.12 | -6.38 | o |
| 1901/11 | 39.87 | 16.21 | ns | 10.45 | -9.05 | oo |
| 1941/8 | 43.04 | 19.39 | * | 17.19 | -2.31 | ns |
| 1895/4 | 42.52 | 18.87 | * | 21.09 | 1.59 | ns |
| 19-1876/7 | 42.52 | 18.87 | * | 30.15 | 10.65 | ** |
| 1939/2 | 47.93 | 24.27 | ** | 30.70 | 11.20 | ** |
| 21-1895/1 | 29.13 | 5.47 | ns | 19.33 | -0.17 | ns |
| 21-1901/7 | 45.55 | 21.89 | ** | 34.17 | 14.67 | *** |
| Brașovia (control) | 23.65 | - | - | 19.50 | - | - |
| | *DL5% = 16.24 t* | | | *DL5% = 6.34 t* | | |
| | *DL1% = 21.65 t* | | | *DL1% = 8.55 t* | | |
| | *DL0,1% = 28.20 t* | | | *DL0,1% = 11.35 t* | | |

The main causes of lower yields to some genotypes are the lack of water in the soil during the growth of the tubers and the uneven distribution of precipitation during the growing season.

It should also be mentioned that the intensive varieties, respectively the genotypes that fall into this category, in the context of difficult climatic conditions, have significant production decreases.

The continental climate, characterized by hot summers and low precipitation in the second part of the vegetation period, negatively influences the formation and accumulation of production.

Water consumption does not have the same intensity throughout the potato's vegetation period. The most intense water consumption occurs during the period of formation and growth of the tubers, respectively, from budding to the physiological maturation of the plants (fall of the buds and yellowing of the basal leaves). The drought most strongly affects production in this period.

In 2021, genotypes 21-1901/7 and 1939/2 recorded significantly high productions, which even in the extreme conditions of 2022 maintained their high production capacity. Genotype 19-1876/7 also had a high production (30.15 t/ha) (Table 2).

## CONCLUSIONS

The obtained results suggest that the selection of genotypes characterized by a lower sensitivity to higher temperatures contributes to counteracting the effects of climate change. Therefore, the development of the phytomass and the number, respectively the weight of the tubers should be considered as potential objectives in improving the subsequent structure of a genotype to reduce the impact of climate change.

In the two years under study, positive correlations can be observed between the height of the plants and their mass, with the significant influence of the climatic conditions during the growing season, in

2021 there will be a weaker development of both parameters compared to 2022.

Correlations regarding the number and weight of the tubers were significant, the process was evolutionary, as the canopy developed, the tubers also developed, but in a different way, depending on the response of the genotype to the thermo-hydric stress conditions.

Genotypic variation was found among the genotypes in producing biomass. The unfavorable climatic conditions (hydric stress) negatively influenced the rate of accumulation and the tubers growth rate, the lowest reduction in tuber yield was found in 2022 to the genotype 1891/ followed by 1897/2 genotype. In the other hand, genotypes 21-1901/7 and 1939/2 recorded high yield, giving proof of adaptability to unfavorable climatic conditions.

In conclusion, correlation coefficient analysis determines the relationship between different plant traits and can establish the character of the components on which selection can be based to improve potato tuber yield.

The development of genotypes that combine resistance/tolerance to drought (changing climatic conditions) with the agronomic qualities of tubers is a decisive step in obtaining varieties that meet the current requirements of farmers and consumers.

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