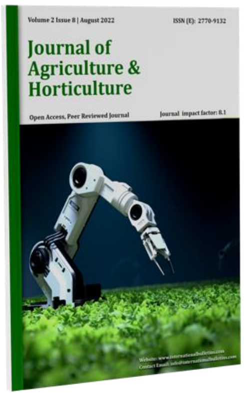

STUDY OF PHOTOSYNTHETIC CHARACTERISTICS OF APPLE ROOT STOCKS AND SEEDLINGS UNDER WATER DEFICIT CONDITIONS

Botirov Alisher Erkinovich
Doctoral student (DSc) of the Research Institute of Horticulture, Viticulture and Winemaking named after Academician M. Mirzayev
Islamov Sohib Yakhshibekovich
Doctor of Agricultural Sciences, Professor,
Tashkent State Agrarian University
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Abstract. In this article, the results of experiments carried out for the purpose of researching photosynthetic properties (leaf area) of root stockss and seedlings are presented with a deep scientific analysis.

Key words. root stock, seedling, photosynthetic properties, ontogeny, dwarf and super dwarf root stocks.

Introduction

Plants cannot grow if organic matter is not formed, moved and distributed. The formation of organic substances occurs in the process of photosynthesis. Photosynthesis provides the necessary energy for all biological functions, as well as creates a material and energetic basis (all other biosynthetic processes depend on it).[1].

The fruit grower must understand and take into account the external, internal and hereditary factors affecting the photosynthetic activity of fruit trees. He must not forget that all measures taken to obtain high and stable yields should be carried out taking into account the assimilation characteristics of the fruit plant variety and the rootstock [2]. When creating new forms of root stockss, great attention is paid to studying the photosynthetic activity of the selected clones [3] and the varieties root stocksed to them [4-5].

Initially I.V. Michurin [2], noted that the rate of photosynthesis in fruit trees from different root stockss is not the same, the reason for this is the difference in their ability to accumulate organic matter.

Many scientists who observed photosynthesis in fruit plants noted the influence of root stockss on absorption rate [8-13].

According to N.V. Titova [5], young trees on dwarf rootstocks (in Moldovan conditions) are distinguished by a higher photosynthesis rate than trees on semi-dwarf and strong-growing rootstocks. This, according to G.N. Shishkanu [7], is one of the main reasons for the early harvest of dwarf rootstocks, as well as their high productivity. Other authors [6], however, in Kyrgyzstan, where directly opposite data on the rate of photosynthesis were obtained. Some researchers also argue that the rootstock does not affect the photosynthetic rate of the rootstock [1]. Perhaps this is due to the fact that the rate of photosynthesis is quite strongly dependent on many external factors, soil and climatic conditions, and therefore it is difficult to compare this value in different varieties (or rootstocks) and take into account the degree of their influence [3]. Some scientists argue that the increase in the productivity of agricultural plants is not due to an increase in the rate of photosynthesis [8-10].

Materials and methods

The leaf surface area was determined using a palette and a curvimeter according to the

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method recommended by Professor V.A. Potapov (1976).

To study the distribution of photosynthesis products, 4 trees from each option were dug up at the beginning, middle and end of summer. Then, the bark of the plants was separated in the laboratory and, before being placed on a drying rack, the leaves, roots, bark and wood of each option were weighed separately, then dried at a temperature of 105° C (t°) to constant weight and weighed again.

The following formula (Grodzinsky 1973) was used to calculate the photosynthetic potential:

$$\Phi\Pi = \frac{S_1 + S_2}{2} \times t_1 + \frac{S_2 + S_3}{2} \times t_2 + \ldots + \frac{S_n + S_{n+1}}{2} \times t_n \quad ,$$

Here: S_1 is the leaf surface at the beginning of the time interval (t1);

S_2 is the leaf area at the end of the time interval (t; t1, t2, t3 are the number of days between measurements).

To calculate the net productivity of photosynthesis, the formula recommended by Kidd, West and Briggs (Grodzinsky, 1973) was used:

$$\Phi CM = \frac{m_2 - m_1}{\frac{S_1 + S_2}{2} \times t}$$

Here: m1 – dry weight of one plant at the beginning of the calculation period (third decade of May), g;

m^2 – dry weight of one plant at the end of the calculation period (third decade of August), g;

S_1 – leaf area of one plant at the beginning of the calculation period (third decade of May), cm;

S_2 – leaf area of one plant at the end of the calculation period (third decade of August), cm;

t – duration of the calculation period, days.

For each option, 4 plants were taken from the replicates.

Research results and discussion

Photosynthetic productivity is determined not only by the rate of photosynthesis, but also by the size of the photosynthetic apparatus, that is, primarily its area, as well as the duration of this activity and its qualitative orientation. In order to study photosynthetic activity in seedlings with different growth vigor, we measured the leaf surface area in fields 1, 2, and 3 of the nursery (Table 1).

Table 1

Leaf surface on cuttings in the 1st field of the nursery, cm per plant, 1st decade of August

Root stock	Years of research		
	2023	2024	Average
M-27	1149,0	885,3	1017,0
M-25	-	809,1	809,1

"Miyabi Fuji"	1268,1	1085,0	1176,0
M-9	1136,5	832,2	984.3
MM-102	882,5	1098,7	990,6
M-26	1216,1	985,0	1100,5
Dwarf JM7 Marubakaida x M.9	1642,1	1269,3	1455,7
M-7	1575,7	1086,3	1331,0
MM-104	1214,1	1197,0	1205,5
MM-106	1665,1	1209,8	1437,4
Semi-vigorous grower Marubakaido	1085,2	1373,2	2458,4
MM-111	985,2	1278,4	1131,8

The table data shows that the highest leaf area indicators were observed in medium-growing MM-106 and dwarf M-7 root stocks. Other dwarf and super dwarf root stocks, as well as semi-dwarf MM-104 root stock, had lower leaf area indicators than them. The smallest leaf area was recorded in super dwarf M-9 root stock. At the same time, in different years, these or those root stocks had different leaf area dimensions. Therefore, in 2023, the largest leaf area indicators were recorded in seed plants, and the smallest - in super dwarf root stocks (M-27, M-25 and M-9).

As it is known that leaf area is largely dependent on the water supply of the plant (Glimerot, 1983), it is possible that this nature of leaf area formation in super dwarf rootstocks may be their response to the weather conditions of 2005 (which were characterized by high rainfall and low active temperature accumulation compared to other years). The high leaf area indicators in all rootstocks in 2024 can be explained by the favorable weather conditions (both in terms of rainfall and active temperature accumulation) that prevailed in this year. Thus, leaf area in rootstocks may vary depending on weather conditions.

In general, it should be noted that the M-27, M-9, and M-25 super dwarf rootstocks lag behind the MM-106 rootstock, which grows moderately in terms of leaf area.

Table 2

The dynamics of the increase of the leaf surface in the 1st field of the nursery,
cm^2 in 1 plant, 2023.

Root stock	Observation date					
	25.05	05.06	17.06	05.07	17.07	01.08
M-27	246,3	329,4	509,4	542,4	878,1	885,4
M-25	226,5	245,4	409,0	488,0	808,5	809,1
"Miyabi Fuji"	254,5	318,2	565,7	658,8	1011,0	1068,4
M-9	112,0	150,2	299,7	496,6	820,7	832,2
MM-102	267,5	333,2	593,7	696,8	1020,0	1098,7
M-26	134,5	151,5	262,0	410,3	980,2	985,0
Dwarf JM7 Marubakaida x M.9	129,3	166,4	232,1	415,3	1201,4	1210,9
M-7	181,6	251,9	447,7	554,7	1082,1	1086,3
MM-104	125,4	156,8	225,9	410,5	1198,9	1200,5

MM-106	115,1	214,7	381,0	590,7	1188,7	1209,7
Semi-vigorous grower Marubakaido	321,8	364,0	647,2	767,8	1214,2	1258,4
MM-111	318,8	378,0	653,2	776,8	1224,2	1278,3

In the remaining dwarf and semi-dwarf rootstocks, the dependence of leaf area on growth force is not clearly noticeable. In all years, the highest leaf area indicators were recorded in the dwarf M-7 rootstock. To obtain detailed information on the growth of leaf area, we measured this indicator in dynamics (Table 2).

Dynamic measurements of leaf area have shown that the rate of leaf area growth varies among rootstocks. In general, dwarf and super dwarf rootstocks show a rapid increase in leaf area in early summer followed by a slight decrease in growth rate, while semi-dwarf and medium-growing rootstocks show a more uneven increase in leaf area.

The shoots of apple varieties root stocksed onto dwarf rootstocks differ from vigorous ones in a higher leaf area per unit of growth length. We tested the existence of this relationship on rootstocks from the first field of the nursery, since if this pattern is identified, it can be used as a criterion for the initial assessment of the growth force of rootstocks.

The results of the calculations are presented in Table 3 below. Analysis of the data obtained showed that there is no clear relationship between this indicator and the growth force of the rootstock.

Table 3

Leaf surface per unit length of shoots in the first field of the nursery, 1st decade of August, cm^2/cm

Root stock	Years of research	
	2023	2024
M-27	17,58	12,74
M-25	18,38	17,83
“Miyabi Fuji”	14,53	16,72
M-9	14,25	-
MM-102	14,19	16,84
M-26	15,40	13,13
Dwarf JM7 Marubakaida x M.9	17,55	14,52
M-7	20,66	20,45
MM-104	10,60	9,94
MM-106	15,52	13,46
Semi-vigorous grower Marubakaido	16,18	14,03
MM-111	10,40	12,20

Thus, the highest value of leaf area per unit of growth length (in both years of the study) was recorded in dwarf M-7 and super dwarf M-25 root stocks (22.66 cm^2/cm and 18.38 cm^2/cm - 2023). However, this indicator, which was quite high at this time, was also observed in the medium-growing MM-106 root stock (15.52 cm^2/cm - 2023), while it surpassed dwarf M-9 and MM-102 root stocks in this indicator. The lowest value of this indicator was observed in semi-dwarf MM-104 and seedlings of cultivated varieties. Changes in this indicator in different years were also noted (in M-27, MM-102 and MM-106 root stocks), while in other root stocks (M-7, MM-104 and MM-25) it changed insignificantly. This nature of the changes is associated with the different reactions of root stocks to climatic conditions in 2023 and 2024. The intensity of growth processes (in this case, expressed by the ratio of leaf area to plant height) is associated with the different requirements of different root stocks for water supply. Therefore, the ratio of leaf area to plant height cannot serve as an objective criterion for selecting new clonal root stocks based on growth vigor. One of the important photosynthetic indicators is the photosynthetic potential, which reflects the rate of increase in leaf area during the growth period (Table 4).

Table 4

Photosynthetic potential of root stocks in the first field of the nursery, m^2 days (calculated per 1 plant)

Root stock	Years of research		
	2023	2024	average
M-27	3,97	2,70	3,33
M-25	-	2,24	2,24
“Miyabi Fuji”	1,85	3,38	2,61
M-9	2,90	1,92	2,41
MM-102	1,87	1,03	1,45
M-26	1,88	3,34	2,61
Dwarf JM7 Marubakaida x M.9	2,87	1,84	2,35
M-7	3,66	2,83	3,24
MM-104	2,36	2,35	2,35
MM-106	4,13	3,02	3,27
Semi-vigorous grower Marubakaido	2,95	1,86	2,40
MM-111	3,19	4,99	4,09

The highest values of photosynthetic potential (average of 3 years of research) were observed in the medium-growing MM-106 root stock (3.59 m^2/day), dwarf M-7 (3.44 m^2/day) and superdwarf M-27 (3.30 m^2/day) root stocks. This indicator had the lowest value in the MM-104 root stock. Thus, no correlation was found between the growth force of the root stock and the magnitude of the photosynthetic potential. The study of photosynthetic indicators was continued in the 2nd field of the nursery. The results of measuring the leaf area in one-year-old seedlings are presented in Table 5 below.

The analysis of the obtained data shows that both the root stock and the variety affect the formation of the leaf surface in the 2nd field of the nursery. In almost all root stocks, the Keng David variety had higher indicators in terms of leaf surface than the Starkrimson variety. It can also be noted that the root stocks that were distinguished by a high value of photosynthetic potential (M-27, MM-106, M-7) and leaf area in the 1st field of the nursery also formed the largest leaf surface in the 2nd field of the nursery, especially when the Keng David variety was root stocksed to them (Keng David/MM-106 - 2637.4 cm^2, Keng David/M-27 - 2221.0 cm^2, Keng David/M-7 - 14971.8 cm^2).

Table 5

Leaf surface in nursery field 2, 2nd decade of August, cm^2 per plant

Variety-root stock combination	Years of research		
	2023	2024	Average

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Wide David/M-27	-	2221,0	2221,0
Starkrimson/M-27	-	-	-
Wide David/M-25	-	-	-
Starkrimson/M-25	-	-	-
Wide David/M-9	-	1584,0	1584,0
Starkrimson/M-9	-	1076,2	1076,2
Wide David/M-26	-	1479,9	1479,9
Starkrimson/M-26	-	1010,3	1010,3
Wide David/M-7	2421,5	1497,8	1959,6
Starkrimson/M-7	1865,5	1000,1	1432,8
Wide David/MM-102	2013,1	1330,0	1671,5
Starkrimson/MM-102	1633,9	1009,0	1321,4
Wide David/MM-104	1573,3	1157,9	1365,6
Starkrimson/MM-104	1387,1	909,8	1148,4
Wide David/MM-106	-	2637,4	2637,4
Starkrimson/MM-106	-	1446,3	1446,3
Starkrimson/MM-111	-	1770,0	1770,0

It should be noted that no correlation was found between the growth force and the leaf area. This indicator, as can be seen, may be related to the potential productivity of the variety-root stock combination. The leaf area of seedlings in the 2nd field of the nursery is also correlated with the productivity of this variety-root stock combination in the garden. For the Krasnodar Territory, it is recommended to reject variety-root stocks with a leaf area of less than 1000 cm^2 as a low-yielding combination. At the same time, varieties with this indicator above 2000 cm^2 may require special growth management (pruning, flower regulation, growth regulators). It should be noted that all studied variety-rootstock combinations had a leaf area greater than 1000 cm^2, and in three of them (Wide David/MM-106, Wide David/M-27, Wide David/M-7) this indicator exceeded 2000 cm^2 in some years. In field 3 of the nursery, the leaf area had the following characteristics (Table 6).

Table 6

Leaf surface in nursery field 3, 2nd decade of August, cm^2 per plant

Variety-root stock combination	Years of research		
	2023	2024	Average
Wide David/M-27	-	-	-
Wide David/M-9	-	-	-
Starkrimson/M-9	-	-	-
Wide David/M-26	-	-	-
Starkrimson/M-26	-	-	-
Wide David/M-7	-	4109,0	4109,0
Starkrimson/M-7	-	3719,3	3719,3
Wide David/MM-102	1966,7	2686,7	2326,7
Starkrimson/MM-102	-	-	-
Wide David/MM-104	1097,0	4438,5	2767,7
Starkrimson/MM-104	1784,2	4226,6	3005,4
Wide David/MM-106	3453,4	-	3453,4

Starkrimson/MM-106	2380,5	-	2380,5

In two-year-old seedlings of the Wide David variety, its dimensions were higher than those of the Starkrimson variety. The largest leaf area was observed in seedlings root stocksed on the medium-growing MM-106 root stock. High indicators were also noted in seedlings root stocksed on the dwarf M-7 root stock (4109.0 cm^2) and super dwarf M-9 root stock (3776.6 cm^2).

Conclusion

Thus, it was found in the experiment that rootstocks affect the formation of leaf surface, but there is no relationship between leaf surface and growth force, which depends on both endogenous (genetic, hormonal) and external factors. In variety-rootstock combinations, leaf surface area depends on both the rootstock and the root stocks.

References:

1.Gulyaev B.I. Photosynthesis and plant productivity: problems, achievements, research prospects // Physiology and biochemistry of cultivated plants. - 1996. - № 1-2. - P.15-31.
2.Michurin I.V. Selected Works. - M., OGIZ, 1948. - 791 p.
3.Solovieva L.V. Variability of hybrid apple seedlings as a result of their root stock at the juvenile stage of development. Abstract of Cand. of Biol. Sciences dissertation. - M.: 1968.-25 p.
4.Strelets V.D. Physiological and biochemical characteristics of root stocksed and own-rooted cherry and plum seedlings // Bulletin of agricultural science, 1978. - No. 12. - P. 70-75.
5.Titova N.V. Influence of nodvoya on photosynthetic activity of apple tree. Abstract of diss. Cand. of Biological Sciences. Chisinau, 1972. - 19 p.
6.Friedrich G. Photosynthesis // Physiology of fruit plants. - M., 1983. - Ch. 1.- P.17-38.
7.Shishkanu G.V. Photosynthetic activity of apple tree and possible aspects of its optimization. Diss. Doctor of Biosciences, Chisinau, 1974. - 431 p.
8.Bessho H., Haniuda T. Tsuchiya S. et.al. Selection criteria for dwarfing apple rootstock at the young seedling stage // Bull. Fruit. Tree. Res. Stat. Ser. C Morioka, Iwate. - 1989, - N 16. - p. 1 - 13.
9.Boritzki M., Plieske J., Struss D. Variety identification in sweet cherry using AFLP and microsatellite markers // Proceedings of the Eucarpia symposium on fruit breeding and genetics. Acta Hort., 2000. - N 538, vol 2. - p. 505-510.
10.Barden J.A. Ferree D.C. Rootstock does not effect net photosynthesis dark respiration, specific leaf weight and transpiration of apple leaves // J. Amer. Soc. Hart. Sci. 1979.-Vol. 104, N4.-p. 526-528.
11.Brown S.K. Genetics of apple / Plant breeding reviews. New York, et.c, Vol 9. -1992.-p. 333-366.
12.Cummins J.N. Aldwinckle H.S. New and dorthcoming apple rootstocks // Fruit varieties journal. - 1982. -N 3. - p. 66-73.
13.Decortye L. Etude de guelgues characters a controle genetigue simple chez le pommier / Malus sp. / et le Poirier / Pyrus communis // Ann. Amelior Plantes. -1967. -vol. 17. -p 243-265.