

Productive and adaptive potentials of Renet Simirenko variety on rootstocks with different growth rates in arid conditions

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Abstract. This article presents the results of the economic and biological assessment of the Renet Simirenko variety grown on rootstocks of different growth rates under conditions of insufficient moisture and high thermal stress in the arid zone of the Northern Caspian region. The purpose of the research is to study and identify scion-rootstock combinations of the Renet Simirenko variety, which most fully realize the potential of productivity, early maturity, and resistance to unfavorable environmental factors. Studied variety grew more intensively on dwarf rootstocks (SK4, SK7), semi-dwarf (SK2, SK5), and average height 54-118, restrained growth of tree-holes was provided by dwarf rootstocks SK3, P16, P59, P60. In most combinations of dwarf and semi-dwarf rootstocks, flowering began in the year of planting, fruiting - in the second year of garden growth, which indicates the potential of early maturity. Rootstocks SK3, SK4, SK2, and 54-118 provided the maximum average and total yield of marketable fruiting in comparison with the control for 7 years. In the Astrakhan region, it is advisable to grow the Renet Simirenko variety on low-growing rootstocks SK3, SK4, SK2, and average growth 54-118, the most resistant to the destabilizing factors of the climate of the arid zone and providing high regularity.

1 Introduction

In modern horticulture, the centerpiece of intensive technology is the scion-rootstock combination. Numerous studies have established that the same scion-rootstock combinations behave differently when grown under different conditions. Therefore, it is necessary to know how rootstocks affect the growth processes and productivity of trees, resistance to limiting factors and other indicators in specific soil and climatic conditions [1-3].

In recent years, household and peasant-farm gardening in the Astrakhan region has been developing more and more. The area of the new plantings has now reached 400 hectares. Of the 20 apple varieties approved for use in the region, the Renet Simirenko variety, which is very in demand when setting gardens, which has proven itself especially well in the steppe regions.

It is well known that the potential of the variety can be fully realized only with the correct selection of rootstock, combining early maturity, high productivity and adaptability to a

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specific climatic zone [4, 5]. In this regard, a natural need arose to assess the economic and biological indicators of the Renet Simirenko variety on rootstocks of different growth rates in order to isolate adapted combinations that most fully realize the production and adaptive potentials in plantings of intensive type in arid zone.

2 Materials and methods

The work was carried out in the Caspian Agrarian Federal Scientific Center of the Russian Academy of Sciences in 2011 ... 2020. The object of research was the variety Renet Simirenko, grafted onto 15 rootstocks of different growth rates of domestic (Michurinsky SAU - 62-396, 54-118, 57-545; North Caucasian FSCHVW – SK1, SK2, SK3, SK4, SK5, SK7) and foreign selection (Poland – P16, P59, P60). As a control, we used combinations on rootstocks of English selection M9, M26 and M4. Depending on the growth force of the rootstock, the planting density of trees in the experiment was 1250 tree/ha on the dwarf rootstock, 1000 tree/ha for semi-dwarf and 833 tree/ha for medium-sized rootstocks. In each variant, there were from 5 to 8 accounting trees, the arrangement of the variants was systematic. The research was carried out in accordance with the generally accepted methodology "Program and methodology for the variety study of fruit, berry and nut crops". To assess winter hardiness, freezing of generative buds was taken into account annually during the separation of buds; after flowering - freezing of the bark, tops of annual shoots, branches on a 6-point scale, followed by an assessment of the total score of freezing. Drought resistance and heat resistance were assessed during periods of the highest thermal stress (July-August). Drought resistance was assessed by the loss of water during wilting and the ability to quickly restore water content. Heat resistance was determined by the ability of leaves to quickly restore water content after heating them in a thermostat for 1.5 hours at $t + 50\text{ }^{\circ}\text{C}$ and subsequent wilting for 4 hours. A sharp decrease in saturation capacity indicates irreversible damage to leaf tissue by high temperatures. Samples for analyzes were taken in the morning, 5 leaves in five replicates. The experimental results were processed by the method of mathematical statistics using the EXCEL application program

The Astrakhan region is characterized by a sharply continental climate. Winters are frosty, with little snow with sharp temperature contrasts, summers are very hot, dry, accompanied by constant dry winds, very little precipitation falls during the year (250...260 mm). The sum of active temperatures above $10\text{ }^{\circ}\text{C}$ – 3200...3400 $^{\circ}\text{C}$.

3 Results and discussion

In modern technologies, with the help of rootstocks, the problem of controlling the size of crowns has been successfully solved, which, in turn, made it possible to significantly increase the planting density, shorten the onset of marketable fruiting, and significantly increase the early maturity and productivity of the plantings [6,7]. The height of trees at the age of 10 years, depending on the growth force of the rootstock, varied from 2.3 to 3.8 m. The smallest height (2.3...3.2 m), the average crown diameter (2.4...2.9 m), the cross-sectional area of the stem (37.4...47.8 cm^2) Renet Simirenko had on dwarf rootstocks SK3, P16, P59, P60 and semi-dwarf 62-396, respectively, and the indicators of crown architectonics on these rootstocks had the lowest values: 2.7...5.9 m^3 – volume and 4.5...6.6 m^2 – crown projection area.

The tendency to an increase in the height, diameter and, accordingly, the crown volume was observed in trees on dwarf (SK4, SK7) and semi-dwarf (SK2, SK5) rootstocks, with an average height of 54-118, which by 2.7...5.7 % exceeded the height of the trees and by 3.0...9.4 % the diameter of the crown of the control variants corresponding in strength of

growth. The same pattern was noted in the analysis of radial growth. Differences in the area of the transverse stem between the control and trees on dwarf rootstocks amounted to 9.2...10.9 %, on semi-dwarf – 13.0...15.8 %, on medium-sized – 6.3 %.

Early maturity is one of the most important economically valuable traits of varieties of intensive type, in which fruiting begins at an early age, accordingly, the unproductive period of the garden's life is reduced and there is a possibility of quick reimbursement of costs [8, 9]. In most trees on dwarf and semi-dwarf rootstocks, flowering could be observed already in the year of planting, and fruiting in the second year of growth in the garden. In the 3rd year after planting on all rootstocks, with the exception of SK1 and SK5, the studied variety began to bear fruit. To determine the influence of rootstocks of various strengths on the production process of the grafted variety, the productivity components of 15 combinations were analyzed for 7 years of commercial fruiting (Table 1).

Table 1. Productivity, yield, and frequency of fruiting of the Renet Simirenko variety on rootstocks of different growth rates

Rootstock		Productivity, kg/tree.		Average yield, for 2014 ... 2020, t / ha	Fruiting frequency index (J), %
		total for the period of the commodity fruiting	average for 2014 ... 2020		
dwarf	M9	124.0	17.7 ± 5.0	22.1 ± 6.2	0.46
	P16	66.7	9.5 ± 3.6	11.9 ± 4.5	0.71
	P59	37.5	5.4 ± 1.0	6.6 ± 1.3	0.27
	P60	71.4	10.2 ± 2.2	12.8 ± 2.7	0.38
	SK3	157.5	22.5 ± 3.1	28.1 ± 3.9	0.52
	SK4	152.6	21.8 ± 4.5	27.3 ± 5.6	0.69
	SK7	127.7	18.2 ± 5.1	22.8 ± 6.3	0.69
	HCP ₀₅	4.7	3.4	4.9	
semi-dwarf	M26	135.9	19.4 ± 5.0	19.4 ± 5.0	0.55
	62-396	144.7	20.7 ± 6.7	20.7 ± 6.7	0.59
	SK2	165.0	23.6 ± 4.8	23.6 ± 4.8	0.39
	SK5	119.7	17.1 ± 5.0	17.1 ± 5.0	0.46
		HCP ₀₅	6.1	4.0	4.0
medium-sized	M4	135.8	19.4 ± 5.2	16.2 ± 4.4	0.36
	54-118	199.4	28.5 ± 8.5	23.7 ± 7.1	0.44
	57-545	131.8	18.8 ± 1.8	15.7 ± 1.5	0.13
	SK1	169.3	24.2 ± 6.6	20.2 ± 5.5	0.50
		HCP ₀₅	5.9	6.7	5.5

The data in the table indicate that the highest yield and the highest rates of productivity increase in the variety Renet Simirenko were statistically reliably provided by dwarf rootstocks SK3, SK4, semi-dwarf SK2, and medium-sized 54-118, on which the yield exceeded the values of the control corresponding to the strength of growth by 21.6...46.3 %.

According to the fruiting frequency index, it was found that annual yields were obtained on dwarf rootstocks P59 and P60, semi-dwarf SK2, medium-sized M4, and 57-545 (0.13...0.39). The greatest interest for this indicator have combinations with rootstocks SK2 (0.36) and 54-118 (0.41), characterized by the high productivity and tendency to regular fruiting.

Winter hardiness is one of the limiting factors that reduce the productivity of a fruit plant [10-12]. Extreme winter periods made it possible to reveal differences in the resistance of the combinations to damaging factors. Trees froze most strongly on the P60 rootstock (2.6

points) with a sharp drop in temperature to -29 °C after a thaw in mid-January, winter 2013/2014; on all rootstocks of the SK and 54-118 series, freezing did not exceed 0.8 points. Due to the strong temperature drop at the end of winter 2016/2017. Renet Simirenko's annual shoots were damaged on absolutely all rootstocks (0.7...1.2 points), while the shoots froze more strongly on rootstocks P59, M26, and M4.

Drought resistance and heat resistance are valuable biological properties of the variety, which determine the possibility of its cultivation in areas of insufficient moisture with hot and dry summers [13-15]. The influence of rootstocks on the drought resistance and heat resistance of the Renet Simirenko variety is shown in Figure 1.

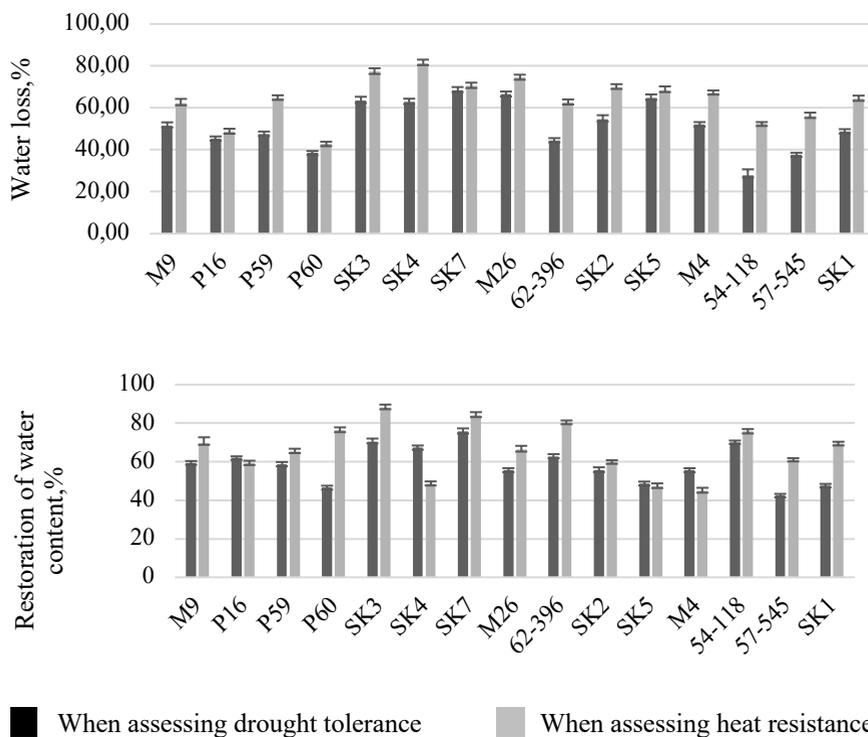


Fig. 1. Indicators of drought resistance and heat resistance of the Renet Simirenko variety on rootstocks of different growth rates

Combinations on rootstocks P16, 62-396, and 54-118 are the most drought-resistant, as they used water more economically during wilting (29.1...45.0 %) than other combinations and sufficiently restored water content upon saturation (61.5...70.0 %). Renet Simirenko was also characterized by good drought resistance on dwarf rootstocks SK3, SK4, and SK7, in combination with which water losses were greater (62.4...68.6 %), however, with saturation, water content recovered better and reached 67.6...75.9 %. In terms of heat resistance, the combinations were distributed similarly to drought resistance. The group of the most heat-resistant includes combinations on rootstocks SK3, SK7, 62-396, and 54-118, in which, after exposure to temperature and wilting, the water loss was in the range of 52.8...77.0 % and the recovery of water content reached 75.9...80.4 %. Renet Simirenko was also characterized by high heat resistance on the P60 rootstock, the loss of water was only 42.9%, and the recovery of water content was 76.7 %.

Thus, the rootstocks of the domestic selection SK4, SK7, 62-396 and 54-118, due to adaptive rearrangements at the level of physiological processes, provided the grafted variety

with the ability to maintain and quickly restore water content under conditions of dehydration and overheating.

4 Conclusion

Based on the data obtained, a significant effect of the type of rootstock on the strength of growth and productivity of trees was revealed. The maximum weakening effect on the parameters of the crown was provided by dwarf rootstocks: domestic SK3 and Polish – P16, P59, P60, allowing the creation of low-volume non-thickened crowns (crown volume – 2.7...5.9 m³, projection area – 4.5...6.6 m²).

The most productive and stably fruiting combinations of the Renet Simirenko variety on SK3, SK4, SK2 and 54-118 rootstocks were identified, which during 7 years of commercial fruiting significantly exceeded the control variants in terms of average yield and total productivity.

The genetic potential of winter hardiness, drought resistance, and heat resistance of the Renet Simirenko cultivar, when grown on rootstocks of different growth rates, has been revealed. The degree of freezing of trees in extreme weather conditions in winter periods on rootstocks of domestic selection did not exceed 1.2 points, while on soil from foreign selection it reached 2.6 points. The optimal combination of drought resistance and heat resistance was provided by the rootstocks SK4, SK7, 62-396, and 54-118.

By the total identified advantages in the research process, it was found, that in areas with insufficient moisture the variety Renet Simirenko is most promising to grow in intensive plantings with different planting densities on rootstocks such as SK3, SK4, SK2 and 54-118, in combination with which, the maximum potential of productivity, early maturity, sufficient winter hardiness and resistance to summer stressors is realized.

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