

GRAFTING EFFICIENCY OF APPLE TREES IN THE NURSERY BY APPLYING DIFFERENT TECHNOLOGY ELEMENTS

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Abstract

Considering the close relationship between soil, water and the plant, the current research aims to establish the influence of irrigation, fertilization, and cultivar on some morphological characters of the apple trees in the nursery. The nursery research sector in our country has demonstrated the necessity of specialization and modernization of this field, due to the growing demand for high-quality certified planting materials. The main aim is to increase continuously the quality and quantity of valuable planting material and guaranteed in terms of authenticity, health, and suitability for the new orchard systems with large plots per hectare and high potential. The research was carried out in the climate conditions of the northwestern Romania and the studied apple cultivars were Florina and Idared, organized on five repetitions, with irrigation as the primary factor, cultivar as the secondary factor and fertilization as the tertiary factor. Following the research, it is found that both the irrigation and the application of different doses of NPK have allowed a significant increase in the survival rate of grafting trees of the two apple cultivars.

Key words: apple cultivar, fertilization, grafting, irrigation, nursery.

INTRODUCTION

The production of high-quality tree planting material associated with an economically efficient activity at the level of nurseries, requires considering both the pedo-climatic conditions in the area and the applied technology elements.

In Romania, due to its geographical location at the confluence of continental and Mediterranean climates, generally offers favourable climate and soil conditions for many fruit nurseries. Numerous autochthonous cultivars attest to the presence of fruit growing on the lands of Romania since ancient times. Initially, the fruit nurseries were concentrated in areas with a rich rainfall regime, so that the capture of rootstocks depended to a greater extent on the rainfall regime, human intervention at the beginning being modest in this sense.

Water is indispensable for plants, being a basic component of living cells and tissues. Only in the presence of water can the processes of assimilation and dissimilation and gas exchange take place. Once inside the plant, water keeps

the cell walls stretched and thus gives the cells and tissues turgidity, which ensures the mechanical balance of the various organs (Venig & Stănică, 2024). Together with dissolved substances, water determines the osmotic pressure of cells and tissues, ensuring intercellular exchanges. As a participant in plant metabolism, water is involved in the fundamental processes of the living world, photosynthesis, respiration, transpiration.

The importance of water as a vegetation factor in plants' life is known and appreciated since humans began to practice agriculture and horticulture (Waller, 2016). Corresponding to the interaction of influencing factors, the water consumption requirements specific to fruit plants vary within relatively wide limits according to the species and cultivar, rootstocks, the age period of the plants and the vegetation phase, climatic factors through the precipitation regime, thermal and wind regime, eco-pedological factors through the orography of the land, the state of fertility and technological factors through the culture system and the agrophytotechnical measures applied.

With fruit trees in the nursery, as with all cultivated plants, the growth process depends to the greatest extent on the climate and soil conditions. Out of these, along heat, light, air and mineral substances, water plays a very important role (Smith, 2022). It enters the composition of various tree organs in proportion of 75-85% and sometimes even more, of their total weight. In addition to the fact that water ensures the circulation of fertilizing elements from the soil to the plant, water participates as a basic element in the synthesis of all the organic substances that make up the tissues of the rootstocks, respectively of the trees. This is the reason why it is necessary for the trees to always have water available, in sufficient quantity, for the growth processes to take place with as much intensity as possible (Arthur & Bejaei, 2025).

In the climatic conditions of Romania, irrigation is a measure to supplement the amounts of water that come naturally, from precipitation, in periods when they are insufficient compared to the requirements of the crops (Stănică & Peticilă, 2012). It is, in fact, the mean used to correct a natural factor, which, as it appears, results in large fluctuations in harvest from one year to another. The use of irrigation systems aims to obtain as stable productions as possible, close to the productive potential of the plants in the given pedo-climatic conditions (Braniște et al., 2010). This, more since, during the current research, it was found that there were years in which, due to insufficient rainfall in certain periods, harvests were greatly reduced, going as far as total compromise.

The most common method of irrigation in fruit nurseries is the drip irrigation method. Drip irrigation consists of the distribution of small amounts of water over a long period of time (Cronin, 2019). Spot irrigation is known as a method by which limited amounts of water are distributed from a point source directly to the roots of the plant (Żarski & Kuśmierk-Tomaszewska, 2023). However, the advantages of drip irrigation systems lie in the saving of water and the possibility of obtaining rich harvests thanks to the particularly favourable conditions created in the soil in terms of the humidity regime, aeration process, etc. The economy of water is achieved by the fact that it can be directed to the area where the plant can consume it most easily, and can be easily dosed

in relation to the needs of the plant. In the same time, losses through evaporation and infiltration are almost completely reduced. Drip irrigation also contributes to the transport of harmful salts to the surface of the soil, below the root zone (Patzwahl, 2023). As a direct effect on the plant, a faster growth rate is observed, which leads to obtaining earlier harvests than those obtained with irrigation by other methods. Other advantages of localized irrigation are: it allows the free movement of machinery for all maintenance work, thus avoiding soil settlement, it reduces weed control treatments, it requires much less energy consumption compared to sprinkling (1 bar at the end of the watering pipe) (Megh, 2021).

The important fact that must be remembered is that the way in which the researches carried out in the field of plant water consumption and their results were designed, fully correspond to the requirements of both the sizing of irrigation systems, including feasibility calculations (which also include production data), and those regarding the exploitation of irrigated lands in the context of the rational use of irrigation water (Faulkner, 2022). It is also important to emphasize that the soil is the most important component of the environment and, as such, in this direction, all attention must be channelled to maintain and permanently increase the fertility of the soils from the irrigation facilities (Stănică, 2004). When discussing the use of irrigation systems, a set of measures must be considered, intended to accompany this action, such as fertilization, maintenance works etc. It should be remembered that irrigated horticulture is not only the application of watering rules at the most appropriate time. This type of horticulture must be seen as a concept that sums up a complex of interventions integrated into a whole, including a series of components, that substantially differentiates it from conventional horticulture, applied to unirrigated lands (Maurer, 2016). With the introduction of water artificially, through irrigation, essential changes occur, primarily in the soil, but also in the plant, which must not escape the attention of the producer who has this facility (Neupane et al., 2024).

For irrigated crops, additional fertilization becomes one of the main links of the fertilization system (Schmid, 2021). To improve the physical and chemical characteristics of the soil and

increase its fertility, the nursery's fertilization system consists of several long-term activities. These activities are designed to meet the needs of the species, rootstocks, and cultivar/rootstock associations in relation to the age and vegetation phases of the plants (Jäger, 2021). The application of mineral fertilizers containing nitrogen, phosphorus, and potassium; the buildup of organic matter in the soil through crop rotations and the addition of unique plant residues for green fertilizers are some of the primary components of the fertilization system in a contemporary fruit tree nursery. Fertilizers must be used in horticulture to replenish the supply of nutrients that plants consume or that have leached deeply, as well as to enhance the soil's overall physical condition, and fertilization status. Fertilizers are regarded as the most crucial component of the soil fertilization system. When horticultural plants are growing, they are the primary source of nutrients for the plants (Mayer, 2019). Thus far, it has been established that when fertilizing, factors such as species, cultivar, rootstock, density, predicted production, and soil conditions must be considered (Soman, 2022). After examining several soil characteristics and being aware of the demands made by the culture as well as those associated with guaranteeing a particular level of production, both quantitative and qualitative, the ideal dosages for each situation in the field must be determined (Ladikou et al., 2025). Fertilization work in nurseries must provide workable solutions for each unique situation because conditions and situations vary greatly (Otto et al., 2015). To increase the synthesis of organic matter and achieve large, cost-effective productions with higher quality indices in the nursery, fertilizers are used to optimize the nutritional conditions without polluting the environment or reducing the plants' resistance to disease and pest attacks (Fischer et al., 2025). Only when fertilizers are incorporated into a system of carefully ranked technological measures and their dosages are correlated with the plant, soil, climate, and culture technology they can contribute optimally to increased fruit tree production (Ozherlieva et al., 2025). Therefore, the main aim of this research was to establish the influence of technology elements, such as irrigation and fertilization, on a

morphological character in the apple species, namely grafting efficiency.

MATERIALS AND METHODS

This research was carried out in a private nursery, in the pedo-climatic conditions of the Northwestern part of Romania. The study was conducted based on a 4 x 2 x 4 trifactorial experiment, organized in five repetitions, with plots comprising four rootstocks planted at 0.7 x 0.25 m, the entire number of used rootstocks was 480. The biological material was represented by wax cherry rootstock seedlings and the two apple cultivars were Florina and Idared. Irrigation was the primary factor, variety was the secondary factor and fertilization was the tertiary factor. Irrigation was carried out using a drip hose with a diameter of 16 mm and a thickness of 0.4 mm, equipped with droppers spaced at 25 cm, each dropper having four exit holes and a flow rate of 2 l/ha at a pressure of 1 bar. The daily duration of watering for the administration of the different watering rates was 3.5 hours for irrigation with the 10 mm rate, 7 hours for the 20 mm rate and 10.5 hours for the 30 mm rate. Fertilization treatments were applied together with mechanical tillage, respectively in the spring of 2024. The amounts of fertilizers used were N₈P₈K₈ in the amount of 50 kg, N₁₆P₁₆K₁₆ in amount of 100 kg and 150 kg for N₂₄P₂₄K₂₄. Florina cultivar is almost immune to turnip, tolerant to flouring, precocious and extremely productive. It does not need a lot of spraying. The fruit is medium to large, spherical-flattened, about 150-200 g, slightly truncated with 5 ribs, striped, light red with whitish dots all over the surface, like some freckles. The pulp is juicy, suitably sweet, and slightly acidic, crunchy, very pleasantly aromatic, but becomes floury when overcooked. The ripening period is October. Idared cultivar is an autumn apple cultivar, obtained by crossing the award-winning Ionahan "Jonathan" x Wagener cultivars. It is a tree of medium vigour with a height of approximately 200-300 cm. The leaves have a sharp oval shape with slightly jagged edges in a dark green, semi-glossy colour. The fruits have a very asymmetric flattened spherical shape with a weight of approximately 170-200 g. The skin of the fruit is thin in shades of red-burgundy on a yellow-

green background. The pulp is whitish, smooth, and juicy. The taste of the fruit is acidic to sweet, with an intense aroma close to the Jonathan cultivar. Idared is an apple cultivar sensitive to the attack of *Erwinia amylovora*. The harvest period is September.

The grafting method used during in this research was chip budding. This grafting method is the most widespread used in the nursery (first field) and when replanting young trees in the orchard. During this research, grafting took place in August of 2023 and the observations regarding the grafting efficiency were made in the spring of 2024, after winter frosts. The grafting success has been evaluated by a simple touch of the petiole portion of the bud. If this fell easily and left a scar grafting was declared successful. In the contrary, if the petiole portion did not fall when touched, and the graft bud and bark shield were dehydrated (wrinkled) and browned, indicated that grafting was not successful.

The research results were statistically processed using the least significant difference (LSD) test.

RESULTS AND DISCUSSIONS

The main purpose of grafting is the vegetative propagation of trees. In addition, this process improves the trees' resistance to external factors, such as drought, frost, or various diseases. By grafting, a new cultivar of tree and new seeds are obtained, adapted to the climatic conditions specific to the area. Grafting trees is beneficial and even necessary for obtaining healthy, high-quality, and large-sized fruits. In addition, it is an efficient method to control the height and shape of the trees, thus facilitating the maintenance and harvesting works. Grafting is widespread because it ensures the faithful transmission of characters to offspring, the material has a great uniformity, and the stability

of planting material production is maintained year after year, unlike propagation by seeds and kernels, which can be affected by unfavourable conditions during flowering. Grafting also has the advantages of early fruiting, as it bypasses the juvenile stage.

The relationship between the dose of NPK and the percentage of grafted trees in Florina cultivar is highlighted with a precision of approximately 87% by means of an exponential function (Table 1). Thus, against the background of a grafting percentage of 93% in the absence of fertilization, the average growth rate of this indicator was 0.093%/kg NPK applied, with different values from one dose to another (-0.02-0.26%/kg NPK).

Table 1. The effect of cultivar and fertilization on survival rate of grafted trees

Cultivar	NPK dose				$\bar{x} \pm s_{\bar{x}}$	S _%
	N ₀ P ₀ K ₀	N ₈ P ₈ K ₈	N ₁₆ P ₁₆ K ₁₆	N ₂₄ P ₂₄ K ₂₄		
Idared	y 90.75 a	y 92.50 b	y 92.25 b	x 94.75 a	92.56 ±0.68	5.37
Florina	y 92.50 a	xy 94.55 a	xy 94.40 a	x 94.75 a	94.05 ±0.48	4.60
$\bar{x} \pm s_{\bar{x}}$	91.62 ±0.91	93.53 ±0.88	93.33 ±0.82	94.75±0.67	93.31 ±0.42	
S _%	6.29	5.96	5.55	4.49	5.68	

Cultivar - DL (LSD)_{5%}=1.92
DL (LSD)_{1%}=2.54 DL (LSD)_{0.1%}=3.29 (a, b)
Fertilization - DL (LSD)_{5%}=2.09
DL (LSD)_{1%}=2.77 DL (LSD)_{0.1%}=3.57

After comparing the grafted trees of the two cultivars on different fertilization treatments (Table 2), it was found that the unfertilized trees exhibited a reduced grafting percentage which was not statistically ensured. Under the effect of 8 and 16% NPK doses, the grafting rate in Florina cultivar was significantly higher than that recorded in Idared by 2.05-2.15%. The grafted trees of the two cultivars were equally fertilized with 24% NPK.

Table 2. The effect of cultivar on the survival rate of grafted trees under different fertilization schemes

Cultivars x N ₀ P ₀ K ₀	Average (%)		Relative values (%)	Difference/Significance
Florina - Idared	92.50	90.75	101.93	1.75
Cultivars x N ₈ P ₈ K ₈	Average (%)		Relative values (%)	Difference/Significance
Florina - Idared	94.55	92.50	102.22	2.05*
Cultivars x N ₁₆ P ₁₆ K ₁₆	Average (%)		Relative values (%)	Difference/Significance
Florina - Idared	94.40	92.25	102.33	2.15*
Cultivars x N ₂₄ P ₂₄ K ₂₄	Average (%)		Relative values (%)	Difference/Significance
Florina - Idared	94.75	94.75	100.00	0.00

DL (LSD)_{5%} = 1.92 DL (LSD)_{1%} = 2.54 DL (LSD)_{0.1%} = 3.29

Considering the interaction between fertilization and the percentage of grafted seedlings in the Idared cultivar (Table 3), it was observed that only fertilization with 24% NPK allowed a significant increase (4.0%) of this indicator,

while the effects of the other treatments were reduced and insignificant (1.5-1.75%). Also, changing the dose from 8 and 16 % respectively to 24% NPK determined significant increases of 2.25-2.50% in the grafting percentage.

Table 3. The effect of fertilization on survival rate of grafting trees of the two apple cultivars

NPK dose x Idared	Average (%)		Relative values (%)	Difference/Significance
N ₈ P ₈ K ₈ – N ₀ P ₀ K ₀	92.50	90.75	101.93	1.75
N ₁₆ P ₁₆ K ₁₆ – N ₀ P ₀ K ₀	92.25	90.75	101.65	1.50
N ₂₄ P ₂₄ K ₂₄ – N ₀ P ₀ K ₀	94.75	90.75	104.41	4.00***
N ₁₆ P ₁₆ K ₁₆ – N ₈ P ₈ K ₈	92.25	92.50	99.73	-0.25
N ₂₄ P ₂₄ K ₂₄ – N ₈ P ₈ K ₈	94.75	92.50	102.43	2.25*
N ₂₄ P ₂₄ K ₂₄ – N ₁₆ P ₁₆ K ₁₆	94.75	92.25	102.71	2.50*
NPK dose x Florina	Average (%)		Relative values (%)	Difference/Significance
N ₈ P ₈ K ₈ – N ₀ P ₀ K ₀	94.55	92.50	102.22	2.05
N ₁₆ P ₁₆ K ₁₆ – N ₀ P ₀ K ₀	94.40	92.50	102.05	1.90
N ₂₄ P ₂₄ K ₂₄ – N ₀ P ₀ K ₀	94.75	92.50	102.43	2.25*
N ₁₆ P ₁₆ K ₁₆ – N ₈ P ₈ K ₈	94.40	94.55	99.84	-0.15
N ₂₄ P ₂₄ K ₂₄ – N ₈ P ₈ K ₈	94.75	94.55	100.21	0.20
N ₂₄ P ₂₄ K ₂₄ – N ₁₆ P ₁₆ K ₁₆	94.75	94.40	100.37	0.35

DL (LSD)_{5%} = 2.09 DL (LSD)_{1%} = 2.77 DL (LSD)_{0.1%} = 3.57

Under the effect of different fertilizing treatments, trees of Florina cultivar recorded a grafting percentage with its limits ranging from 92.50% in the case of the unfertilized variant, to 94.75% in the variant with 24% NPK, against the background of a variability between treatments of 4.60%. Compared to the unfertilized agricultural background, the treatment with 24% had a significantly higher efficiency materialized by an increase of 2.25%.

The progressive modification of NPK doses from 8 to 16 and 24%, respectively, was not associated with significant effects on grafting. Considering the combined effect of irrigation and fertilization on the percentage of grafting (Table 4), in the absence of watering, fertilization had the highest influence on this indicator, while in the variant related to the watering norm of 30 mm, the effect of fertilization was less.

Table 4. The effect of irrigation and fertilization on survival rate of grafting trees

Watering norm	NPK dose				$\bar{x} \pm s_{\bar{x}}$	S _%
	N ₀ P ₀ K ₀	N ₈ P ₈ K ₈	N ₁₆ P ₁₆ K ₁₆	N ₂₄ P ₂₄ K ₂₄		
0 mm	y 84.50 c	x 90.00 b	x 89.30 c	x 91.00 c	88.70 ±0.85	6.07
10 mm	xy 91.00 b	y 89.10 b	xy 92.00 bc	x 93.00 bc	91.28 ±0.58	3.99
20 mm	xy 94.50 a	x 96.50 a	y 92.50 b	x 95.50 b	94.75 ±0.56	3.77
30 mm	y 96.50 a	xy 98.50 a	x 99.50 a	x 99.50 a	98.50 ±0.39	2.91
$\bar{x} \pm s_{\bar{x}}$	91.62 ±0.91	93.53 ±0.88	93.33 ±0.82	94.75 ±0.67	93.31 ±0.42	
S _%	6.29	5.96	5.55	4.49	5.68	

Irrigation - DL (LSD)_{5%} = 2.91 DL (LSD)_{1%} = 3.85 DL (LSD)_{0.1%} = 4.96 (a, b, c)
Fertilization - DL (LSD)_{5%} = 2.96 DL (LSD)_{1%} = 3.91 DL (LSD)_{0.1%} = 5.05 (x, y)

Considering the results presented in Figure 1, based on the exponential regression, it can be observed that in the case of the unirrigated variant, the percentage of grafting showed an average growth rate of 0.027% for each kg of NPK, with the limits from -0.09%/kg to 0.69%/kg. The respective estimates have a precision of 71%, given a catch percentage of

approximately 85.86% in the absence of fertilization. For the watering norm of 10 mm, the effect of fertilization on the grafting of grafted trees is expressed by an exponential regression that is based on a determination coefficient of 77.71% and indicates an irregular variation of this indicator related to an average rate of 0.096%/kg. Under the effect of the

watering norm of 20 mm, fertilization showed a reduced influence on grafting, associated with a sinuous variation from one dose to another. Under the conditions of irrigation with 30 mm, there is an increase in the catching rate proportional to the dose of NPK only up to the level of 16%, associated with a rhythm with values of 0.1-0.02%/kg. In the conditions of the unfertilized agricultural -background (Table 5), a variation of the catching rate can be observed from 84.50% for the unirrigated variant to 96.50% for the watering rate of 30 mm. On this agricultural land, all three watering norms showed significant increases of 6.5-12% compared to the unirrigated variant. Only changing the watering rate from 10 to 20 mm was materialized by a significant effect on the grafted trees, while increasing the watering rate

from 20 to 30 mm had a statistically uncertain effect.

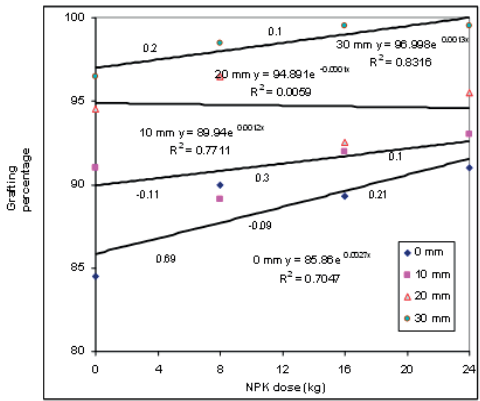


Figure 1. Variation of survival rate of grafting trees under the effect of different watering norms and fertilizations

Table 5. The effect of irrigation on survival rate of grafted trees under different fertilizations

Watering norm x NPK	Average (%)		Relative values (%)	Difference/Significance
N ₀ P ₀ K ₀				
10 mm – 0 mm	91.00	84.50	107.69	6.50***
20 mm – 0 mm	94.50	84.50	111.83	10.00***
30 mm – 0 mm	96.50	84.50	114.20	12.00***
20 mm – 10 mm	94.50	91.00	103.85	3.50*
30 mm – 10 mm	96.50	91.00	106.04	5.50***
30 mm – 20 mm	96.50	94.50	102.12	2.00
N ₈ P ₈ K ₈				
10 mm – 0 mm	89.10	90.00	99.00	-0.90
20 mm – 0 mm	96.50	90.00	107.22	6.50***
30 mm – 0 mm	98.50	90.00	109.44	8.50***
20 mm – 10 mm	96.50	89.10	108.31	7.40***
30 mm – 10 mm	98.50	89.10	110.55	9.40***
30 mm – 20 mm	98.50	96.50	102.07	2.00
N ₁₆ P ₁₆ K ₁₆				
10 mm – 0 mm	92.00	89.30	103.02	2.70
20 mm – 0 mm	92.50	89.30	103.58	3.20*
30 mm – 0 mm	99.50	89.30	111.42	10.20***
20 mm – 10 mm	92.50	92.00	100.54	0.50
30 mm – 10 mm	99.50	92.00	108.15	7.50***
30 mm – 20 mm	99.50	92.50	107.57	7.00***
N ₂₄ P ₂₄ K ₂₄				
10 mm – 0 mm	93.00	91.00	102.20	2.00
20 mm – 0 mm	95.50	91.00	104.95	4.50**
30 mm – 0 mm	99.50	91.00	109.34	8.50***
20 mm – 10 mm	95.50	93.00	102.69	2.50
30 mm – 10 mm	99.50	93.00	106.99	6.50***
30 mm – 20 mm	99.50	95.50	104.19	4.00**

DL (LSD)_{5%} = 2.91 DL (LSD)_{1%} = 3.85 DL (LSD)_{0.1%} = 4.96

Under the effect of the applied treatments with 8% NPK, the grafting percentage was between 90 and 98.5%. As such, in this case only the watering norms of 20 and 30 mm showed a significant effect of 6.5-8.5% on the grafting of the grafted trees. The addition of irrigation from

10 to 20 mm allowed a significant increase of 7.4% in the catch percentage.

Against the background of fertilization with 16% NPK, the application of irrigation with 20 and 30 mm favored a significant increase in the percentage of grafting by 3.2-10.2%. In the case

of this agricultural land, the increase in the watering rate from 20 to 30 mm showed a high efficiency materialized by an increase of 7.50%. In the conditions of the agricultural fund fertilized with 24% NPK, the same trends are manifested, but the irrigation effect is less. Considering the interaction between fertilization and grafting the rootstocks in the absence of irrigation (Table 6), it was observed that the applied fertilization variants allowed obtaining values between 84.50% for the unfertilized agricultural background and 91% for the dose of 24% NPK, with an amplitude of variation of 6.50% and a variability of 6.07% between

treatments. In these conditions of soil moisture, all three fertilization treatments generated significant increases in the percentage of capture. But the increase of fertilization dose from 8 to 16 and respectively 24% NPK reduced the efficiency and showed an insignificant impact on grafting. Under the effect of irrigation with 10 and 20 mm, fertilization showed a reduced and insignificant efficiency on grafting. In the case of the agricultural background where the 30 mm watering norm was applied, the grafted trees efficiently utilized only the doses of 16 and 24% NPK, registering significant increases in the catch percentage of 3%.

Table 6. The effect of fertilization on survival rate of grafting trees under different watering norms

NPK dose x Watering norm	Average (%)		Relative values (%)	Difference/Significance
0 mm				
N ₈ P ₈ K ₈ – N ₀ P ₀ K ₀	90.00	84.50	106.51	5.50***
N ₁₆ P ₁₆ K ₁₆ – N ₀ P ₀ K ₀	89.30	84.50	105.68	4.80**
N ₂₄ P ₂₄ K ₂₄ – N ₀ P ₀ K ₀	91.00	84.50	107.69	6.50***
N ₁₆ P ₁₆ K ₁₆ – N ₈ P ₈ K ₈	89.30	90.00	99.22	-0.70
N ₂₄ P ₂₄ K ₂₄ – N ₈ P ₈ K ₈	91.00	90.00	101.11	1.00
N ₂₄ P ₂₄ K ₂₄ – N ₁₆ P ₁₆ K ₁₆	91.00	89.30	101.90	1.70
10 mm				
N ₈ P ₈ K ₈ – N ₀ P ₀ K ₀	89.10	91.00	97.91	-1.90
N ₁₆ P ₁₆ K ₁₆ – N ₀ P ₀ K ₀	92.00	91.00	101.10	1.00
N ₂₄ P ₂₄ K ₂₄ – N ₀ P ₀ K ₀	93.00	91.00	102.20	2.00
N ₁₆ P ₁₆ K ₁₆ – N ₈ P ₈ K ₈	92.00	89.10	103.25	2.90
N ₂₄ P ₂₄ K ₂₄ – N ₈ P ₈ K ₈	93.00	89.10	104.38	3.90*
N ₂₄ P ₂₄ K ₂₄ – N ₁₆ P ₁₆ K ₁₆	93.00	92.00	101.09	1.00
20 mm				
N ₈ P ₈ K ₈ – N ₀ P ₀ K ₀	96.50	94.50	102.12	2.00
N ₁₆ P ₁₆ K ₁₆ – N ₀ P ₀ K ₀	92.50	94.50	97.88	-2.00
N ₂₄ P ₂₄ K ₂₄ – N ₀ P ₀ K ₀	95.50	94.50	101.06	1.00
N ₁₆ P ₁₆ K ₁₆ – N ₈ P ₈ K ₈	92.50	96.50	95.85	-4.00 ⁰⁰
N ₂₄ P ₂₄ K ₂₄ – N ₈ P ₈ K ₈	95.50	96.50	98.96	-1.00
N ₂₄ P ₂₄ K ₂₄ – N ₁₆ P ₁₆ K ₁₆	95.50	92.50	103.24	3.00*
30 mm				
N ₈ P ₈ K ₈ – N ₀ P ₀ K ₀	98.50	96.50	102.07	2.00
N ₁₆ P ₁₆ K ₁₆ – N ₀ P ₀ K ₀	99.50	96.50	103.11	3.00*
N ₂₄ P ₂₄ K ₂₄ – N ₀ P ₀ K ₀	99.50	96.50	103.11	3.00*
N ₁₆ P ₁₆ K ₁₆ – N ₈ P ₈ K ₈	99.50	98.50	101.02	1.00
N ₂₄ P ₂₄ K ₂₄ – N ₈ P ₈ K ₈	99.50	98.50	101.02	1.00
N ₂₄ P ₂₄ K ₂₄ – N ₁₆ P ₁₆ K ₁₆	99.50	99.50	100.00	0.00

DL (LSD)_{5%} = 2.96 DL (LSD)_{1%} = 3.91 DL (LSD)_{0.1%} = 5.05

Regarding the combined effect of the three factors (Table 7), in the case of Idared cultivar, fertilization generally showed a reduced and insignificant influence on the grafting percentage. In the case of the agricultural background where irrigation was applied with 10 mm, fertilization with 24% NPK favored a significant increase in the catch percentage compared to the unfertilized variant or the one

where 8% NPK was applied. Under the conditions of fertilizing trees of the Idared cultivar with reduced doses of up to 8% NPK, it can be observed that irrigation with 20- 30 mm caused a significant increase in the percentage of grafting by 6-13% compared to the other irrigation options. The highest effect of irrigation on the grafting of trees is found on the agricultural background fertilized with 16%

NPK, where all three watering norms generated significant increases of this indicator. In the case of trees fertilized with 24% NPK, the highest values of the grafting percentage are recorded for this cultivar, against the background of significant effects of 5-11% of irrigation.

Against the background of irrigation with the three watering norms, the seedlings of the Florina cultivar capitalized to a reduced extent the fertilization with NPK, registering insignificant variations of 3.8-4% of the percentage of capture.

Table 7. The effect of irrigation and fertilization on survival rate of grafting trees of the two apple cultivars

Watering norm	0 mm			
Cultivar	NPK dose			
	N ₀ P ₀ K ₀	N ₈ P ₈ K ₈	N ₁₆ P ₁₆ K ₁₆	N ₂₄ P ₂₄ K ₂₄
Idared	y 84.00 a	xy 86.00 b	xy 86.00 b	x 89.00 a
Florina	y 85.00 a	x 94.00 a	x 92.60 a	x 93.00 a
Watering norm	10 mm			
Cultivar	NPK dose			
	N ₀ P ₀ K ₀	N ₈ P ₈ K ₈	N ₁₆ P ₁₆ K ₁₆	N ₂₄ P ₂₄ K ₂₄
Idared	y 88.00 b	y 88.00 a	xy 91.00 a	x 94.00 a
Florina	x 94.00 a	x 90.20 a	x 93.00 a	x 92.00 a
Watering norm	20 mm			
Cultivar	NPK dose			
	N ₀ P ₀ K ₀	N ₈ P ₈ K ₈	N ₁₆ P ₁₆ K ₁₆	N ₂₄ P ₂₄ K ₂₄
Idared	x 94.00 a	x 97.00 a	x 93.00 a	x 96.00 a
Florina	x 95.00 a	x 96.00 a	x 92.00 a	x 95.00 a
Watering norm	30 mm			
Cultivar	NPK dose			
	N ₀ P ₀ K ₀	N ₈ P ₈ K ₈	N ₁₆ P ₁₆ K ₁₆	N ₂₄ P ₂₄ K ₂₄
Idared	x 97.00 a	x 99.00 a	x 99.00 a	x 100.00 a
Florina	x 96.00 a	x 98.00 a	x 100.00 a	x 99.00 a

Cultivar - DL (LSD)_{5%} = 4.12 DL (LSD)_{1%} = 5.44 DL (LSD)_{0.1%} = 7.01 (a, b)
 Fertilization - DL_{5%} = 4.18 DL_{1%} = 5.53 DL_{0.1%} = 7.15 (x, y)
 DL (LSD)_{5%} = 4.04 DL (LSD)_{1%} = 5.35 DL (LSD)_{0.1%} = 6.89

Only in the case of unirrigated agricultural land, it was observed that fertilization with NPK had a significant effect on the grafted trees, associated with increases of 7.6-9%. On the unfertilized agricultural background, irrigation caused a significant increase in grafting by 9-11%, under the conditions of small and insignificant variations between the three watering norms.

In the case of fertilizing with 8 % NPK, a significant increase in the percentage of grafting was observed by 20-30 mm compared to the norm of 10 mm. Under the effect of fertilization with 16 and 24 % NPK, irrigation showed a considerably lower influence on grafting, so that only the application of the 30 mm rule allowed a significant increase.

CONCLUSIONS

Compared to the unfertilized variant, it was found that the application of different doses of NPK allowed a significant increase in the

grafting percentage by 1.71-3.13%. On the other hand, increasing the nutrient concentrations from 8 to 16 and respectively 24% NPK had reduced and statistically uncertain effects on grafting. Fertilization with 24% NPK was equally utilized by the grafted trees of the two apple cultivars.

Future research directions that can be considered include studying tree production, as well as an analysis of economic efficiency under irrigation and fertilization conditions.

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