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RESEARCH REGARDING THE EFFECT OF IRRIGATION AND FERTILIZATION ON PHOTOSYNTHETIC RATE AT DIFFERENT PLUM CULTIVARS IN THE FRUIT TREES NURSERY, IN THE CONTEXT OF CLIMATE CHANGE

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Abstract

This paper aimed to present the effect of irrigation and fertilization on photosynthetic rate at trees of different plum cultivars in the fruit trees nursery, to obtain a good quality planting material, given the fact that in recent years Romania is facing the phenomenon of complex drought, which represents a climatic hazard phenomenon that induces the most serious consequences in horticulture. The research was carried out in the year 2022 in a fruit trees nursery located in the North- West Region of Romania. The initial biological material was represented by rootstock seedlings that belong to the "Certificate" biological category and for grafting were used buds from two plum cultivars: 'Stanley' and 'Cacanska Lepotica'. During the analysed period, trees of 'Cacanska Lepotica' utilized the fertilization with 16 and 24 kg of NPK at a significantly higher level, with an increases of photosynthesis rate by 7.55%-14.29%. In the case of 'Stanley', the treatment with NPK was associated with a significant intensification of the photosynthesis process compared to the unfertilized variant and smaller variations between fertilization doses.

***Key words**: fertilization, irrigation, photosynthetic rate, plum cultivars.*

INTRODUCTION

In the climate context of recent years, Romania is facing the phenomenon of complex agricultural drought, which represents a climate hazard phenomenon that induces the most serious consequences in agriculture. Drought is a prolonged dry period in the natural climate cycle, a slow-onset disaster. In this context, agriculture cannot be sustained without irrigation. Irrigation improves crop growth and quality, allowing farmers to farm on a consistent schedule, creating more reliable and quality food supplies. In the nursery sector, irrigation offers the possibility of obtaining vigorous, viable, quality, healthy, damage-free, disease- and pest-resistant planting material. In addition to water, another essential factor in obtaining a quality fruit tree planting material is the provision of the necessary fertilizers.

Water management and fertilizer applied nutrients are the two major factors affecting growth and productivity in the fruit tree nursery. Sustainable water and fertilizer use in the nursery has become a priority, with the adoption of management strategies that maintain satisfactory yields, thus improving both fertilizer and water use efficiency. In recent years, fruit trees have a very high demand on the market, and the fruits obtained are intended to provide an effective source of vitamins. Nursery stock also has a water requirement, requiring irrigation throughout the growing seasons (Schmid, 2021). In recent years, nurseries have experienced a difficult production period due to factors related to weather conditions.

The economy is mainly dependent on agriculture and climate change can have dramatic effects on it. Agricultural production is low due to the excessive fragmentation of properties but also to the reduction in the degree of mechanization of works, irrigation, and chemical treatment. Plants have adapted to specific environmental conditions, which allow them to carry out their vital processes in optimal conditions and ensure the perpetuation of the species (Schubert, 2022).

Climate changes also affect the rainfall regime: the volume of annual precipitation, their monthly distribution and favour the appearance of dry periods or, on the contrary, periods with excessive precipitation (Rickmann, 2014). Global warming intensifies the process of plant transpiration and water absorption, intensifies the process of water evaporation from the soil surface and reduces the amount of water available for plants (Polak, 2018). High temperatures, strong insolation, drought, and excessive irrigation also increase soil salinity, which has negative effects on plants (Mayer, 2019). The simultaneous action of these stress factors induces numerous morphological, physiological, biochemical, and molecular changes in crop plants, which have unfavourable effects on their growth, development, and production (Goyal, 2021). Like other branches of agricultural production, modern fruit trees growing cannot be conceived without ensuring a water regime corresponding to the requirements of the cultivated species and the culture system used (Miller, 2018). Through the strong root system that makes it possible to explore a large volume of soil and the increased absorption capacity of the roots, many of the fruit tree species ensure the achievement of favourable results even in areas with a lower pluviometric regime or when plantations are located on sloping land and on dry sands, where water is retained more difficult (Pinske, 2017). Being, however, plants with increased specific water consumption, for the development of the growth and fruiting processes at the appropriate level, in the crop areas where the periods of drought have a relatively constant frequency and with extensions over wider time intervals, completing the water deficit through irrigation in fruit trees plantations becomes a necessary, if not indispensable measure (Smith, 2022).

Our country, due to its geographical location at the confluence of the continental and Mediterranean climates, generally offers favourable climate and soil conditions for many fruit trees nurseries. Initially, the fruit trees nurseries were concentrated in the areas with a richer rainfall regime, so that the rootstock capture depended to a greater extent on the rainfall regime, the human intervention at the beginning being modest in this regard.

A characteristic shortcoming of the climatic regime of our country, which is reflected quite significantly in fruit growing, is the defective distribution of precipitation during the year, resulting in prolonged periods of drought in some areas (periods of time longer than 10 days during the vegetation and 14 days during the rest period, in which no rains greater than 5 mm fall). Considering these aspects, associated with the tendency to develop important fruit-growing centres in typically dry areas, on zonal soils and on sands, irrigation must be a concern of prime importance for the fruit trees -growing sector in our country, but which must to manifest differently, depending on the pedoclimatic zone, type of rootstock, etc. (Venig et al., 2022).

Irrigation of fruit trees is necessary in fruit growing, where annual precipitation is below 500 mm, and in areas with precipitation between 500-700 mm/year additional irrigation is applied (Venig, 2006).

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 available to them (Stănică & Peticilă, 2012). Of these, along with heat, light, air and mineral substances, water plays a very important role. It enters the composition of the various organs of the tree in the 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 (as well as in the entire 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. That is why it is necessary for the trees to always have water available, in sufficient quantity, so that the growth processes take place with as much intensity as possible (Faulkner, 2022).

The fertilization system in the nursery includes long-term activities, aimed at ensuring the improvement of the physical and chemical properties of the soil and raising its fertility, completing the requirement of assimilable nutrients according to the requirements of the species, rootstocks, cultivar/rootstock associations in relation to age and vegetation phases of plants (Asănică & Hoza, 2013). Among the main elements of the fertilization system in the modern tree nursery are: the accumulation of organic matter in the soil through crop rotations and the incorporation of special plant residues for green fertilizers; administration of mineral fertilizers with nitrogen, phosphorus, and potassium (Santos et al., 2023). The doses, terms and methods of fertilizer application are established differently for each sector of the nursery depending on the agrochemical properties of the soil and the requirements of the cultivated plants (Thomas, 2021).

The use of fertilizers in fruit trees culture becomes necessary to renew the reserve of nutrients consumed by plants or leached in depth, then to improve the physical condition, the chemical composition, and the general state of fertilization of the soil (Stănică, 2004).

In modern fruit growing, fertilization is one of the most important technological links (Braniște & Stănică, 2011). Due to their specificity, fruit trees plants occupy the same area of land for a long period of time, develop their root system to a considerable depth and due to the high productivity, they achieve, they extract from the soil, with the harvest, appreciable amounts of nutrients. Under these conditions, it is necessary to intervene every year, in several stages, with fertilizations that ensure, on the one hand, the achievement of a certain level of production, and on the other hand, a certain level and ratio of nutrients through returning the amounts of easily accessible nutrients extracted with the harvest to be able to maintain, in this way, the fertility of the soil in accordance with the age of the plantation and the level of production (Wallin, 2020).

The knowledge so far has proven that soil conditions, species, cultivar, rootstock, density, forecasted production etc. must be considered when applying fertilization. Establishing the optimal doses for each situation in the field must be done after analysing a series of soil properties, knowing the requirements imposed by the culture and those related to ensuring a certain quantitative and qualitative level of production.

To obtain high, constant, and quality productions in the nursery, a permanent control of the vegetation factors and especially of the nutritional ones is necessary. This control aims to maintain a balance between the main nutritional elements. The main objective of the research was to establish the influence of irrigation and fertilization on some physiological characteristics of plum in the nursery, in this case, the rate of photosynthesis. Through this research, the authors want to obtain a healthy, vigorous fruit tree planting material, superior to non-irrigated and non-fertilized nurseries.

MATERIALS AND METHODS

The research was carried out in the year 2022, in a private nursery. The nursery includes tree planting material of the following species: apple, pear, plum, apricot, cherry, peach, almond, cherry, quince, and walnut.

The study was carried out based on a trifactorial experiment of the 4 x 2 x 4 type, organized in five repetitions, with plots comprising four trees planted at 0.7 x 0.25 m, with irrigation as the primary factor, cultivar as a secondary factor and fertilization as tertiary factor. To obtain the doses of nitrogen; phosphorus: potassium (NPK) related to the fertilization treatments, complex fertilizer 16:16:16 was used, in the following amounts (kg/ha): 50 kg for $N_8P_8K_8$; 100 kg for $N_{16}P_{16}K_{16}$; 150 kg for $N_{24}P_{24}K_{24}$. Regarding irrigation, 4 watering norms were used, respectively non-irrigated, irrigated with 10 mm, irrigated with 20 mm and irrigated with 30 mm. The plum cultivars studied were ‘Stanley’ and ‘Cacanska Lepotica’. As general characteristics of the ‘Stanley’ cultivar, it can be mentioned the tolerance to viruses, it is partially self-fertile and a good pollinator for other cultivars like ‘Rivers’, ‘Agen’, ‘Anna Späth’. It is very productive and the production is constant. The trees are of medium vigour, with fruiting predominantly on May bunches. The fruit are medium, with a narrow and deep ventral furrow evident throughout the height of the fruit. ‘Stanley’ is heat demanding, it does well up to 500 m altitude, very precocious and productive. The tree of the ‘Cacanska Lepotica’ is of medium vigour, early, productive, partially self-fertile. The fruit is medium to large (45-50 g), ovoid, asymmetric, dark blue in colour. The flesh is yellowish-green, consistent, sweet-sour taste, non-adherent to the seed. Harvest maturity is the third decade of July. The rate of photosynthesis was calculated using CIRAS-3 equipment, which consists in closing a leaf in a closed, transparent flap and measuring the drop in CO_2 concentration. The pace of photosynthesis is not determined by a single formula, but rather by a complex process involving several reactions that occur in chloroplasts. The following formula can be used to summarize the enitre proces $6\ H_20+ 6\ CO_2 +$ light energy (captured by assimilatory pigments) = $C_6H_{12}O_6 + 6\ O_2$. In the presence of sunshine, carbon dioxide and water are transformed into glucose and oxygen. Many variables, including light intensity and wavelenght, CO_2 concentration, temperature and nutrition availability affect the rate of photosynthesis. The obtained results of the measurements have been statistically processed. It was used the descriptive statistical analysis.

RESULTS AND DISCUSSIONS

Because the researches until now have been carried out in orchards, not in nurseries, the specialized literature is incomplete in this regard. The authors considered it useful to obtain information, through the present research, regarding the necessity and efficiency of applying localized irrigation to the culture of fruit trees in the nursery, against the background of different fertilization treatments. It can be observed that both cultivars and the irrigation or fertilization had a real and statistically ensured influence on the rate of photosynthesis in the seedlings from 2022 under the conditions of a homogeneity of the environmental conditions at the level of experience (Table 1).

Table 1. Analysis of variance regarding the effect of cultivar, irrigation, and fertilization on photosynthetic rate

Source of variation	SP SS	GL DF	S^2 MS	F test
Entire	127.53	159		
Repetitions	0.18	4	0.05	0.41
Irrigation	39.68	3	13.23	120.55**
Irrigation error	1.32	12	0.11	
Cultivar	1.44	1	1.44	8.80**
Irrigation x Cultivar	5.70	3	1.90	11.57**
Cultivar error	2.63	16	0.16	
Fertilization	43.58	3	14.53	203.46**
Irrigation x Fertilization	16.37	9	1.82	25.48**
Source of variation	SP SS	GL DF	S^2 MS	F test
Cultivar x Fertilization	2.68	3	0.89	12.53**
Irrigation x Cultivar x Fertilization	7.10	9	0.79	11.05**
Fertilization error	6.85	96	0.07	

Fertilization showed the highest contribution to the variability of the photosynthesis rate (47.26%), followed by irrigation (28%), both effects being significantly superior to the cultivar effect (2.04%) Also the single or double interactions between the factors showed significant influences on this character, with a higher contribution in the case of the combination of irrigation and fertilization, but considerably less than their separate effects.

The results obtained at the level of experience regarding the rate of photosynthesis of seedlings were influenced to a degree of approximately 8.6% by other uncontrollable sources of variation.

Regarding the unilateral effect of irrigation, the average rate of photosynthesis showed an amplitude of variation of 1.32 µmol $CO_2/m^2/s$, with average values between 2.08 in the case of the non-irrigated variant and 3.40 µmol $CO_2/m^2/s$ in the case of applying the watering norm of 30 mm, under the conditions of a high variability of 21.52% between the four irrigation treatments (Table 2).

At the level of the whole experience in this year's climatic conditions, irrigation showed a significant effect on photosynthesis related to increases between 14.75 and 63.61 %. Increasing the watering rate from 10 to 20 mm significantly influenced this character on the background of an intensification of photosynthesis by 19.3%, while changing the watering rate from 10 to 30 mm, caused a significant increase by 42.6% of this process.

Table 2. Average photosynthetic rate under the effect of the different watering norms

Watering norm	Photosynthetic rate (µmol CO^2/m^2/s)		Relative values (%)	Difference/ Significance
0-10 mm	2.08	2.38	114.75	0.31**
0 -20 mm	2.04	2.84	136.87	0.77***
0-30 mm	2.08	3.40	163.61	1.32***
10-20 mm	2.38	2.84	119.28	0.46***
10-30 mm	2.38	3.40	142.59	1.01***
20-30 mm	2.84	3.40	119.54	0.56***

DL (LSD)$_{5\%}$=0.16 DL (LSD)$_{1\%}$=0.23
DL (LSD)$_{0,1\%}$=0.32

Considering the cumulative effect of the cultivar this year average values of the photosynthesis rate were found with limits from 2.61 µmol CO$_2$/m^2/s in the case of the 'Stanley' cultivar to 2.74 µmol CO$_2$/m^2/s in the case of the 'Cacanska Lepotica'. As such, in general the seedlings of the 'Cacanska Lepotica' presented a more intense photosynthesis by approximately 5.1%, without the respective difference reaching the level of significance (Table 3).

Table 3. Average photosynthetic rate of the two cultivars

Cultivar	Photosynthetic rate (µmol CO$_2$/m^2/s)		Relative values (%)	Difference/ Significance
'Cacanska Lepotica' - 'Stanley'	2.74	2.61	105.14	0.13

DL (LSD)$_{5\%}$=0.14; DL (LSD)$_{1\%}$=0.19; DL (LSD)$_{0,1\%}$=0.26.

The average photosynthesis rate values of the seedling leaves under the effect of different doses of NPK showed an amplitude of 1.44 µmol CO$_2$/m^2/s, with limits from 1.99 in the case of unfertilized agricultural fund to 3.44 µmol CO$_2$/m^2/s for the treatment with 24 kg of NPK, against the background of high variability between treatments (Table 4).

Table 4. Average photosynthetic rate under the effect of the different fertilization

NPK dose	Photosynthetic rate (µmol/m^2/s)		Relative values (%)	Difference/ Significance
$N_0P_0K_0$ - $N_8P_8K_8$	1.99	2.49	124.80	0.49***
$N_0P_0K_0$ -$N_{16}P_{16}K_{16}$	1.99	2.78	139.41	0.79***
$N_0P_0K_0$ -$N_{24}P_{24}K_{24}$	1.99	3.44	172.44	1.44***
$N_8P_8K_8$ -$N_{16}P_{16}K_{16}$	2.49	2.78	111.71	0.29***
$N_8P_8K_8$ -$N_{24}P_{24}K_{24}$	2.49	3.44	138.17	0.95***
$N_{16}P_{16}K_{16}$ -$N_{24}P_{24}K_{24}$	2.78	3.44	123.69	0.66***

DL (LSD)$_{5\%}$=0.12; DL (LSD)$_{1\%}$=0.16; DL (LSD)$_{0,1\%}$=0.20

Compared to the non-fertilized version, it is found that the application of different doses of NPK allowed a significant intensification of photosynthesis by 2.4-4.0%. The addition of fertilization from 8 to 16 kg favoured a significant increase of 11.7% in this process, while the change in the dose from 16 to 24 kg had a significant positive effect of 23.7%.

Regarding the interaction between cultivars and irrigation, in both cultivars, irrigation showed significantly positive influences on the rate of photosynthesis, against the background of higher effects on the 'Cacanska Lepotica' cultivar (Table 5).

Table 5. The effect of cultivar and irrigation on photosynthetic rate

Cultivar	Watering norm					
	0 mm	**10 mm**	**20 mm**	**30 mm**	$\overline{x} \pm s_{\overline{x}}$	S$_{\%}$
'Stanley'	z 2.07 a	y 2.44 a	y 2.55 b	x 3.36 a	2.61$\pm$0.08	28.56
'Cacanska Lepotica'	u 2.08 a	z 2.32 a	y 3.13 a	x 3.43 a	2.74$\pm$0.10	31.58
$\overline{x} \pm s_{\overline{x}}$	2.08$\pm$0.11	2.38$\pm$0.08	2.84$\pm$0.07	3.40$\pm$0.13	2.67$\pm$0.06	
S$_{\%}$	32.18	20.85	17.06	24.86	30.20	

Cultivar – DL (LSD)$_{5\%}$=0.24; DL (LSD)$_{1\%}$=0.32; DL (LSD)$_{0,1\%}$=0.43; (a,b)
Irrigation – DL (LSD)$_{5\%}$=0.27; DL (LSD)$_{1\%}$=0.37; DL (LSD)$_{0,1\%}$=0.51; (x,y,z,u)

Considering the effect of irrigation on the rate of photosynthesis in each cultivar it is observed that at 'Stanley' the values were between 2.07 µmol CO$_2$/m^2/s for the non-irrigated version and 3.56 µmol CO$_2$/m^2/s in the case of applying the norm of watering of 30 mm. Compared to the non-irrigated version, the application of the watering rules significantly influenced this process to a high extent of 17.86-62.02% (Table 6).

Table 6. The effect of irrigation on photosynthetic rate on the two cultivars

Watering norm	Photosynthetic rate (μmol $CO_2/m^2/s$)		Relative values (%)	Difference/ Significance
‘Stanley’				
0-10 mm	2.07	2.44	117.86	0.37**
0-20 mm	2.07	2.55	123.07	0.48***
0-30 mm	2.07	3.36	162.02	1.29***
10-20 mm	2.44	2.55	104.42	0.11
10-30 mm	2.44	3.36	137.47	0.92***
20-30 mm	2.55	3.36	131.65	0.81***
‘Cacanska Lepotica’				
0-10 mm	2.08	2.32	111.70	0.24*
0-20 mm	2.08	3.13	150.70	1.05***
0-30 mm	2.08	3.43	165.24	1.36***
10-20 mm	2.32	3.13	134.91	0.81***
10-30 mm	2.32	3.43	147.93	1.11***
20-30 mm	3,13	3,43	109.65	0.30*

DL $(LSD)_{5\%}$=0.24; DL $(LSD)_{1\%}$=0.32; DL $(LSD)_{0,1\%}$=0.43

Changing the watering rate from 10 to 20 mm was associated with a slight increase in the rate of photosynthesis by only 4.4%. Instead, the increase in the watering rate from 20 to 30 mm generated a significant increase of 31.65%.

In the case of seedlings of the ‘Cacanska Lepotica’, the variability between the effects of irrigation was associated with an amplitude of 1.36 μmol $CO_2/m^2/s$, ranging between 2.08 μmol $CO_2/m^2/s$ in the absence of watering and 3.43 μmol $CO_2/m^2/s$ for the norm of 30 mm. The three watering norms generated significant increases in photosynthesis rate associated with increases of 11.7-65.2%. The addition of irrigation from 10 to 20 mm determined a significant increase of 34.9% of this process, while the change of dose from 20 to 30 mm showed a significantly positive influence of 9.6%.

Considering the effect of the cultivar on the rate of photosynthesis on different watering rates, amplitudes are found from 0.01 μmol $CO_2/m^2/s$ for the non-irrigated variant to 0.58 μmol $CO_2/m^2/s$ for the variant related to the watering norm with 30 mm. Against the background of the application of the norm of 20 mm, the seedlings of the ‘Cacanska Lepotica’ showed a significantly higher intensity of this process by 22.75%, while the seedlings of the ‘Stanley’ showed a higher value by 5 % under the conditions of irrigation with 10 mm. Under the aspect of the intensity of photosynthesis, the seedlings of the two cultivars capitalized at a similar level the conditions of the non-irrigated agricultural fund and the one related to the 30 mm norm. Based on the exponential regression, it can be observed that in the case of the ‘Cacanska Lepotica’ the rate of photosynthesis showed an average growth rate of 0.045 μmol $CO_2/m^2/s$ for each mm of watering. The respective estimates have a precision of 95%, under conditions of increases of approximately 2.05 μmol $CO_2/m^2/s$ in the absence of irrigation (Figure 1).

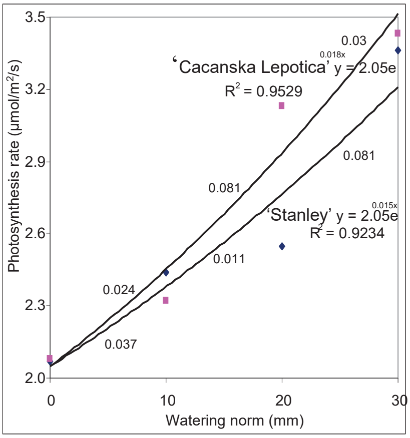

Figure 1. Variation of photosynthetic rate for the two cultivars under the effect of different watering norms

For the ‘Stanley’ cultivar, the effect of irrigation showed an average photosynthesis growth rate equivalent to 0.043 μmol $CO_2/m^2/s$ per mm, against the background of a lower variation (0.011) for the first two watering rates and a high variation (0.081) between the norms of 20 and 30 mm. The predictability of the logarithmic regression between the watering rate and the rate of photosynthesis in the Stanley cultivar is92.3%, based on a similar initial value in the absence of irrigation.

Considering the combined effect of irrigation and fertilization on the intensity of photosynthesis it is found that in the absence of watering, fertilization had the least influence on this process, while in the variant related to the watering norm of 30 mm, fertilization with different doses had a considerably higher influence (Table 7). In the conditions of the non-fertilized agricultural fund a variation of this character can be observed from 1.26 μmol $CO_2/m^2/s$ for the non-irrigated version to 2.62 CO_2μmol/m^2/s for the watering rate of 30 mm.

Table 7. The effect of irrigation and fertilization on photosynthetic rate

Watering norm	NPK dose					
	$N_0P_0K_0$	$N_8P_8K_8$	$N_{16}P_{16}K_{16}$	$N_{24}P_{24}K_{24}$	$\bar{x} \pm s_{\bar{x}}$	S%
0 mm	u 1.26 d	z 1.91 c	y 2.17 d	x 2.97 c	2.08±0.11	32.18
10 mm	z 1.80 c	y 2.31 b	y 2.54 c	x 2.88 c	2.38±0.08	20.85
20 mm	z 2.30 b	y 2.94 a	y 2.89 b	x 3.23 b	2.84±0.07	17.06
30 mm	z 2.62 a	z 2.79 a	y 3.52 a	x 4.66 a	3.40±0.13	24.86
$\bar{x} \pm s_{\bar{x}}$	1.99±0.10	2.49±0.07	2.78±0.09	3.44±0.12	2.67±0.06	
S%	31.48	18.50	20.59	22.68	30.20	

Irrigation – DL $(LSD)_{5\%}$=0.25; DL $(LSD)_{1\%}$=0.34; DL $(LSD)_{0,1\%}$=0.44; (a,b,c)
Fertilization – DL $(LSD)_{5\%}$=0.24; DL $(LSD)_{1\%}$=0.31; DL $(LSD)_{0,1\%}$=0.41; (x,y,z,u)

On this farmland, irrigation generated significant increases in the photosynthesis rate of 43.43-108.37% compared to the non-irrigated version. Changing the watering norm by 10-20 mm determined a significant variation of 0.32-0.5 µmol $CO_2/m^2/s$ of this process (Table 8).

Under the effect of applying the treatment with 8 kg of NPK, the rate of photosynthesis was between 1.91 and 2.94 µmol $CO_2/m^2/s$. As such, in this case the watering norms had a significant effect, associated with increases of 0.4-1.03 µmol $CO_2/m^2/s$ on the intensity of this process. Only supplementing irrigation by changing the watering rate from 10 to 20 mm generated a significant 27.3% increase in photosynthesis. Against the background of fertilization with 16 kg of NPK, the application of irrigation showed considerable and significant effects of 17.1-62.6% related to variations of 0.37-1.36 µmol $CO_2/m^2/s$. Increasing the watering norms by 10 mm allowed a significant increase of this character by 14-21.8%.

Under the conditions of the agricultural fund fertilized with 24 kg of NPK, the same trends are manifested, but the irrigation effect is less, so that only the application of the 20-30 mm norms produced increases of 8.75-56.9% compared to the non-irrigated version. The addition of irrigation from 10 to 20-30 mm determined significant increases of 12.15-62.81 in the rate of photosynthesis.

Based on the exponential regression, it can be observed that in the case of the non-irrigated version, the rate of photosynthesis showed an average growth rate of 0.071 µmol $CO_2/m^2/s$ for each kg of NPK, with limits from 0.03 0.1. The respective estimates have a precision of 96.23 %, under the conditions of a value of 1.03 µmol $CO_2/m^2/s$ in the absence of fertilization (Figure 2).

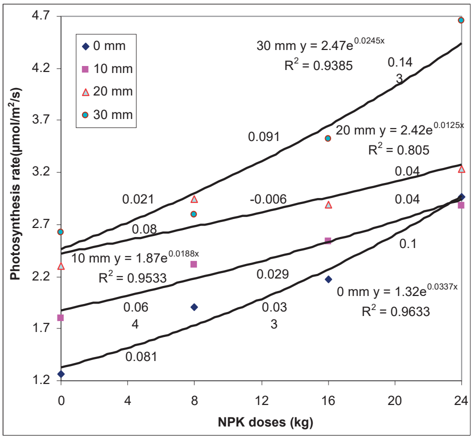

Figure 2. Variation of photosynthetic rate under the effect of different watering norms and fertilizations

For the watering norm of 10 mm, the effect of fertilization on the intensity of photosynthesis is expressed by a linear regression that is based on a coefficient of determination of 95.33% and indicates a smaller variation of this process between the doses of 8-16 kg NPK.

Under the effect of the watering norm of 20 mm, fertilization showed an influence of 80.5 % on the rate of photosynthesis, against the background of a value of 2.42 µmol $CO_2/m^2/s$ in the non-fertilized version and a small variation between doses of 8 and 16 kg NPK.

In the conditions of irrigation with 30 mm, there is an intensification of photosynthesis proportional to the dose of NPK, associated with an average rate of 0.085 µmol $CO_2/m^2/s$ per kg of NPK, in the conditions of a value of 2.47 µmol $CO_2/m^2/s$ in the absence of fertilization.

Regarding the effect of the interaction between cultivars and fertilization on the rate of photosynthesis, in the case of the ‘Stanley’ cultivar, the treatment with NPK was associated with a significant intensification of this process compared to the unfertilized variant and smaller variations between doses (Table 8).

Table 8. The effect of cultivar and fertilization on photosynthetic rate

Cultivar	NPK dose					
	$N_0P_0K_0$	$N_8P_8K_8$	$N_{16}P_{16}K_{16}$	$N_{24}P_{24}K_{24}$	$\overline{x} \pm s_{\overline{x}}$	$S_{\%}$
‘Stanley’	z 2.01 a	y 2.52 a	y 2.59 b	x 3.31 b	2.61±0.08	28.56
‘Cacanska Lepotica’	u 1.98 a	z 2.46 a	y 2.96 a	x 3.56 a	2.74±0.10	31.58
$\overline{x} \pm s_{\overline{x}}$	1.99±0.10	2.49±0.07	2.78±0.09	3.44±0.12	2.67±0.06	
$S_{\%}$	31.48	18.50	20.59	22.68	30.20	

Cultivar – DL $(LSD)_{5\%}$=0.19; DL $(LSD)_{1\%}$=0.26; DL $(LSD)_{0,1\%}$=0.33; (a,b)
Fertilization – DL $(LSD)_{5\%}$=0.17; DL $(LSD)_{1\%}$=0.22; DL $(LSD)_{0,1\%}$=0.29; (x,y,z)

Also, the ‘Cacanska Lepotica’ effectively capitalized on the NPK treatments that determined significant increases in terms of the intensity of photosynthesis compared to the unfertilized variant, against the background of significant differences between the treatments as well.

Considering the information, it is found that in the case of ‘Stanley’, the effect of fertilization on photosynthesis can be estimated by means of an exponential regression, with a precision of 92.98%. As such, the rate of photosynthesis increased proportionally with the dose of NPK with rates between 0.009-0.09 µmol $CO_2/m^2/s$ per kg NPK.

The relationship between the dose of NPK and the rate of photosynthesis in seedlings of the ‘Cacanska Lepotica’ is highlighted with a precision of approximately 99.8 % by means of an exponential function. Thus, against a value of 1.99 µmol $CO_2/m^2/s$ in the absence of fertilization, the average growth rate of this process was 0.066 µmol $CO_2/m^2/s$ per kg NPK applied, with different values from one dose to another of 0.063-0.075 µmol $CO_2/m^2/s$ per kg NPK. Following the comparison of the photosynthesis rate of the two cultivars on different fertilization treatments, it is found that on the unfertilized agro-fund and under the effect of the dose of 8 kg of NPK, the variation was very low and not statistically ensured. The seedlings of the ‘Cacanska Lepotica’ utilized the fertilization with 16 and 24 kg NPK at a significantly higher level, achieving a photosynthesis rate increases by 7.55-14.29 % (Table 9).

Table 9. The effect of cultivar on photosynthetic rate under different fertilizations

Cultivar x NPK	Photosynthetic rate (µmol $CO_2/m^2/s$		Relative values (%)	Difference/ Significance
$N_0P_0K_0$				
‘Cacanska Lepotica’ - ‘Stanley’	1.98	2.01	98.51	-0.03
$N_8P_8K_8$				
‘Cacanska Lepotica‘ - ‘Stanley‘	2.46	2.52	97.62	-0.06
$N_{16}P_{16}K_{16}$				
‘Cacanska Lepotica‘ - ‘Stanley‘	2.96	2.59	114.29	0.37***
$N_{24}P_{24}K_{24}$				
‘Cacanska Lepotica‘ - ‘Stanley‘	3.56	3.31	107.55	0.25*

DL $(LSD)_{5\%}$=0.19; DL $(LSD)_{1\%}$=0.26; DL $(LSD)_{0,1\%}$=0.33

Considering the interaction between fertilization and the rate of photosynthesis for the ‘Stanley’ cultivar, it is observed that NPK fertilization generated significant increases (25.37-64.68%) in the intensity of this process. Also, only the dose changes from 8 and 16 to 24 kg NPK was associated with a significant increase in the rate of photosynthesis by 27.80-31.35% (Table 10).

Under the effect of different fertilization treatments, seedlings of the ‘Cacanska Lepotica’ cultivar recorded a rate of photosynthesis with limits from 1.98 µmol $CO_2/m^2/s$ in the case of the unfertilized variant, up to 3.56 µmol $CO_2/m^2/s$ for the variant with 24 kg NPK, against the background of a variability between treatments of 31.58%.

Compared to the non-fertilized agricultural fund, NPK treatments had a significantly higher efficiency materialized by increases of 24.24-79.80%. Changing the dose of NPK from 8 to 16 and 24 kg, respectively, was associated with significant increases of 20.33-44.72% in the intensity of photosynthesis.

Table 10. The effect of fertilization on photosynthetic rate of the two cultivars

NPK dose x Cultivars	Photosynthetic rate (μmol $CO_2/m^2/s$)		Relative values (%)	Difference/Significance
'Stalney'				
$N_8P_8K_8 – N_0P_0K_0$	2.52	2.01	125.37	0.51***
$N_{16}P_{16}K_{16}– N_0P_0K_0$	2.59	2.01	128.86	0.58***
$N_{24}P_{24}K_{24} – N_0P_0K_0$	3.31	2.01	164.68	1.30***
$N_{16}P_{16}K_{16} – N_8P_8K_8$	2.59	2.52	102.78	0.07
$N_{24}P_{24}K_{24} – N_8P_8K_8$	3.31	2.52	131.35	0.79***
$N_{24}P_{24}K_{24} – N_{16}P_{16}K_{16}$	3.31	2.59	127.80	0.72***
'Cacanska Lepotica'				
$N_8P_8K_8 – N_0P_0K_0$	2.46	1.98	124.24	0.48***
$N_{16}P_{16}K_{16}– N_0P_0K_0$	2.96	1.98	149.49	0.98***
$N_{24}P_{24}K_{24} – N_0P_0K_0$	3.56	1.98	179.80	1.58***
$N_{16}P_{16}K_{16} – N_8P_8K_8$	2.96	2.46	120.33	0..50***
$N_{24}P_{24}K_{24} – N_8P_8K_8$	3.56	2.46	144.72	1.10***
$N_{24}P_{24}K_{24} – N_{16}P_{16}K_{16}$	3.56	2.96	120.27	0.60***

DL (LSD)$_{5\%}$=0.17; DL (LSD)$_{1\%}$=0.22; DL (LSD)$_{0,1\%}$=0.29

Regarding the combined effect of the three factors, in the absence of irrigation in the case of the 'Stanley' cultivar, fertilization showed a significant influence on the rate of photosynthesis associated with increases of 0.68-1.32 μmol $CO_2/m^2/$ s (Table 11).

Table 11. The effect of irrigation and fertilization on photosynthetic rate of the two cultivars

Specification	Watering norm			
	0 mm			
	NPK dose			
Cultivar	**$N_0P_0K_0$**	**$N_8P_8K_8$**	**$N_{16}P_{16}K_{16}$**	**$N_{24}P_{24}K_{24}$**
'Stanley'	z 1.37 a	y 2.05 a	y 2.18 a	x 2.69 b
'Cacanska Lepotica'	u 1.14 a	z 1.77 a	y 2.15 a	x 3.25 a
	10 mm			
	NPK dose			
Cultivar	**$N_0P_0K_0$**	**$N_8P_8K_8$**	**$N_{16}P_{16}K_{16}$**	**$N_{24}P_{24}K_{24}$**
'Stanley'	y 2.18 a	y 2.44 a	y 2.34 b	x 2.81 a
'Cacanska Lepotica'	z 1.42 b	y 2.18 a	x 2.73 a	x 2.95 a
	20 mm			
	NPK dose			
Cultivar	**$N_0P_0K_0$**	**$N_8P_8K_8$**	**$N_{16}P_{16}K_{16}$**	**$N_{24}P_{24}K_{24}$**
'Stanley'	y 1.85 b	x 2.84 b	x 2.63 b	x 2.88 b
'Cacanska Lepotica'	z 2.75 a	y 3.04 a	y 3.15 a	x 3.58 a
	30 mm			
	NPK dose			
Cultivar	**$N_0P_0K_0$**	**$N_8P_8K_8$**	**$N_{16}P_{16}K_{16}$**	**$N_{24}P_{24}K_{24}$**
'Stanley'	z 2.62 a	z 2.74 a	y 3.22 b	x 4.85 a
'Cacanska Lepotica'	z 2.61 a	z 2.83 a	y 3.82 a	x 4.47 b

Cultivar – DL (LSD)$_{5\%}$=0.39; DL (LSD)$_{1\%}$=0.52; DL (LSD)$_{0,1\%}$=0.67; (a, b)
Fertilization - DL$_{5\%}$=0.34; DL$_{1\%}$=0.44; DL$_{0,1\%}$=0.57; (x, y)
DL (LSD)$_{5\%}$=0.37; DL (LSD)$_{1\%}$=0.49; DL (LSD)$_{0,1\%}$=0.63

For cultivar 'Cacanska Lepotica, the effect of fertilization is more obvious, associated with significant variations (0.63-2.11 μmol $CO_2/m^2/s$) both compared to the unfertilized variant and between treatments. Seedlings of the 'Cacanska Lepotica' showed a significantly higher intensity of photosynthesis compared to the 'Stanley' cultivar, under the effect of fertilization with 24 kg of NPK.

In the case of the agricultural fund where 10 mm irrigation was applied, only fertilization with 24 kg of NPK favoured a significant 28.9% increase in the photosynthesis of the 'Stanley' cultivar compared to the non-fertilized version. The rate of photosynthesis in seedlings of the 'Cacanska Lepotica' under these irrigation conditions was significantly influenced by the fertilization treatment against the background of variations of 53.52-107.8%. In the absence of fertilization, the rate of photosynthesis in the seedlings of the 'Stanley' was significantly higher, while under the effect of fertilization with 16 kg of NPK, the seedlings of the 'Cacanska Lepotica' showed significantly higher values. The two cultivars utilized fertilization with 8 and 24 kg of NPK to the same extent. On the agricultural fund irrigated with 20 mm, fertilization with 8-24 kg of NPK of the 'Stanley' determined a significant increase in the intensity of photosynthesis by 0.99-1.03 μmol $CO_2/m^2/s$, while in the seedlings of the 'Cacanska Lepotica' the fertilization had a lower influence associated with significant increases only in the case of doses of 16-24 kg. The seedlings of the 'Cacanska Lepotica' showed a significantly higher intensity of photosynthesis compared to the 'Stanley', both in the absence of irrigation and under the effect of NPK fertilization.

In the case of applying the 30 mm norm, the varieties capitalized to the same extent on the conditions of the unfertilized agro-fund and the treatment with 8 kg of NPK. Under the effect of fertilization with 16 kg of NPK, seedlings of the 'Cacanska Lepotica' recorded a significantly higher value, while on the agricultural fund fertilized with 24 kg of NPK, significantly higher values of the photosynthesis rate were observed in the seedlings of the 'Stanley' cultivar. It is also found that fertilization had similar effects on the photosynthesis rate of the two cultivars.

CONCLUSIONS

Fertilization showed the highest contribution to the variability of the photosynthesis rate (47.26%), followed by irrigation (28%), both effects being significantly superior to the effect of the cultivar (2.04%), considering that in general the fruit trees cultivar 'Cacanska Lepotica' showed a more intense photosynthesis by about 5.1%. The application of irrigation had a significant effect on photosynthesis related to increases between 14.75 and 63.61%. Increasing the watering rate from 10 to 20 mm significantly influenced this character on the background of an intensification of photosynthesis by 19.3%, while changing the watering rate from 10 to 30 mm, caused a significant increase by 42.6% of this process. Compared to the non-fertilized version, it was found that the application of different doses of NPK allowed a significant intensification of photosynthesis by 24.872-4%. Supplementing fertilization from 8 to 16 kg favoured a significant increase of 11.7 % in this process, while changing the dose from 16 to 24 kg had a significant positive effect of 23.7%. Based on the application of the norm of 20 mm, the seedlings of 'Cacanska Lepotica' showed a significantly higher intensity of photosynthesis by 22.75%, while the seedlings of 'Stanley' showed a higher value by 5% under the conditions of irrigation with 10 mm. The fruit trees of 'Cacanska Lepotica' utilized the fertilization with 16 and 24 kg of NPK at a significantly higher level, achieving increases in the photosynthesis rate of 7.55-14.29 %. In the case of 'Stanley', the treatment with NPK was associated with a significant intensification of this process compared to the unfertilized variant and smaller variations between doses.

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