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The Effect of Irrigation and Fertilization on the Qualitative Indices of the Planting Material, for Some Plum Species, with the Aim of Obtaining a Sustainable Fruit Trees Production, in the Pedo-Climatic Conditions of Romania

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Abstract: The aim of the present research was to obtain information about the necessity and efficiency of the application of localized irrigation to some qualitative indices of plum trees in the nursery, against the background of different fertilization treatments. The expected results to be obtained by applying differentiated rules of irrigation and fertilization will consist in obtaining a healthy, vigorous fruit tree planting material, increasing production in the nursery. 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. The fruit nursery where the research was carried out is located on a land with fertile soil. But, considering the demand of young plants for nutritional conditions, their relatively high density per surface unit, the need for their intensive growth in a relatively short time, the rational application of fertilizers becomes a very important factor for increasing yield and the quality of the planting material. The two varieties of plum studied were Stanley and Cacanska Lepotica, two valuable varieties for the quality of the fruit. During the research, the fertilization treatments had the highest contribution (34.50 %) on the stem diameter, compared to irrigation (20.67 %) and respectively the variety (5.63 %), considering that the variety did not significantly influence the increase in diameter of the grafted trees.

Keywords: fruit trees nursery; planting material; fertilization; irrigation; variety; stem diameter

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1. Introduction

Fruit growing must become one of the main sectors of Romanian horticulture in the next stage. Fruit production will have to cover not only domestic consumption but also a large part of the demand on the foreign market. Having sufficient ecological, material, and human resources, fruit growing must make a greater contribution to the increase of the national income [1]. Obtaining tree planting material with high biological value and with favorable economics requires a careful concern for the rootstocks used in the nursery [2]. In Romania, in the past, generative rootstocks of high vigor were used, especially for classical orchards. Lately, due to the intensification of fruit trees plantations, rootstocks with vegetative propagation are being sought more and more. Romania is currently among the European countries with good achievements in the field of improving vegetative rootstocks, which are requested for testing in many European nurseries. The interest in the use of rootstocks has increased in line with the development of fruit growing as a commercial activity, a development that requires the production of many trees in specialized nurseries. In the culture of fruit trees and shrubs, the planting material becomes necessary to replace cleared orchard areas through the replacement rate, to expand the orchard heritage by establishing new plantations, to

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restore the density of existing plantations by filling in gaps, to promote the production of varieties recommended for each area and culture area in part, the multiplication and promotion in culture of valuable genotypes such as varieties newly created in our country or introduced from abroad, newly selected clones and in general material with high biological value [3]. A worrying phenomenon that Romania is facing in recent years is the drought. In horticulture, drought stimulates the senescence of the leaves at the base of the plants, their fall and thereby the reduction of leaf surface and total transpiration. In the case of a greater water deficit, the characteristic symptoms of plants consist of the loss of cell turgor, the cessation of growth, the reduction of gas exchange and the intensification of the respiration process, which exceeds the intensity of photosynthesis. [4]. The lack of soil water for relatively short periods of time depending on the species, does not have drastic consequences on plants, due to the redistribution of water from their tissues [5]. The water from the roots of the plants is transported to the aerial organs, and the water from the apoplast penetrates through endosmosis into the cells of the leaves, where it restores the turgor pressure and ensures the normal conditions for the development of metabolic processes [6]. The increase in the thickness of the cuticle, the decrease in the number of stomata, the accumulation in the cell walls of hemicelluloses in the form of a gel that retains water, are other ways by which plants avoid massive water losses, during periods of water stress [7]. Prolonging the period of water stress causes the synthesis of ethylene, which is also considered as a stress hormone [8]. Ethylene stimulates the ripening process of plants and the synthesis of pectic enzymes and cellulases, which catalyze the hydrolysis of these compounds in the abscission zone of the leaf petiole [9].

Cells in this area break off easily, causing the leaves to drop. This causes the reduction of the leaf surface, which is one of the ways by which plants reduce their water losses from the tissues, preventing dehydration and cell death [10]. Plant growth is the result of the process of cell division, as well as increasing their volume, size, and mass [11]. Thermal stress can directly influence plant growth through the effect it has on the development of this process, but also indirectly, through the action it has on the development of other physiological processes (photosynthesis, transpiration, respiration, etc.), growth being the cumulative result of the metabolism of the entire plant [12]. Water stress has the effect of the synthesis of abscisic acid which causes the hydro active closing of the stomata, and the removal of water from the leaves through the transpiration process contributes to the decrease of the water potential of the cells in the leaves to values lower than -1.2 - 1.3 MPa [13], which causes the hydro passive closing of the stomata. This process has the effect of blocking the main way for carbon dioxide to enter the leaves, which contributes to the decrease in the intensity of the photosynthesis process [14].

Economy is mainly dependent on agriculture and climate change can have dramatic effects on it [15]. More than that, through agriculture, it is necessary to provide food for all mankind [16]. 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 [17]. Plants have adapted to specific environmental conditions, which allow them to carry out their vital processes in optimal conditions and ensure the perpetuation of their species [18]. The change in climatic factors can affect plant metabolism and thereby its production and quality, as well as the possibilities of providing the population with plant-based food resources [19]. Plants respond differently to the action of stress factors depending on the characteristics of the species, variety, etc., from this point of view there are species or varieties resistant or sensitive to the action of a stress factor [20]. Long dry periods, the reduction of river flow, the level of lakes and the lowering of the water table have important economic consequences, including in the field of agriculture [21]. Precipitation provides the water needed for agricultural crops on more than 80% of the globe's surface, but much of this surface is exposed to drought stress [22]. Of the total cultivated area on the globe, only about 18% is irrigated. The action of stress factors can result in losses reaching up to 40-50% of production [23]. Current climate changes are increasing water requirements for irrigating horticultural crops and intensifying the competition between agricultural and non-agricultural water needs. For these reasons, it is necessary to identify new ways to improve water efficiency use by plants [24]. The rational use of water in agriculture implies a prioritization of water consumption in

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critical situations, the adoption of technologies with reduced water consumption, the adoption of measures that require the application of reference models, the application of innovative solutions to reduce water losses, the quality control of water to reduce environmental pollution [25]. Also, improving irrigation technology and promoting drip irrigation are important ways to improve the efficiency of water resource use [26].

Like other branches of agricultural production, modern fruit growing cannot be conceived without ensuring a water regime corresponding to the requirements of the cultivated species and the culture system used [27]. 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 favorable results even in areas with a lower rainfall regime or when plantations are located on sloping land and on dry sands, where water is retained more difficult [28]. 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 plantations becomes a necessary, if not indispensable measure [29]. Through irrigation, an optimal water supply level of 65-75% of the soil's total holding capacity must be ensured, without creating excess moisture (> 80%) [30]. The root system develops most intensively towards the end of the first half of the vegetation period, when the plants are young and when the moisture regime in the soil most influences the intensity of root growth and their distribution [31]. With shallow rooting, the layer occupied by the roots has a reduced thickness, and after a watering, the water available for the plants is consumed in a very short period. With the entry into the summer months, with maximum water consumption for evaporation from the soil surface and plant transpiration, the layer occupied by the roots dries at a faster rate.

Romania, due to its geographical location at the confluence of the continental and Mediterranean climates, generally offers favorable 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 centers in typically dry areas, on zonal soils and on sands, irrigation must be a concern of prime importance for the fruit-growing sector in our country, but which must to manifest differently, depending on the pedoclimatic zone, type of rootstock, etc. [32].

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 [33]. 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 [34]. Water enters the composition of the various organs of the tree in the proportion of 75-85% and sometimes even more, of their total weight [35]. 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 [36]. 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 [37].

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, variety/rootstock associations in relation to age and vegetation phases of plants [38].

Among the main elements of the fertilization system in the modern fruit tree nursery are: the accumulation of organic matter in the soil through rotations and the incorporation of special plant residues for green fertilizers; administration of mineral fertilizers with nitrogen, phosphorus, and

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potassium [39]. 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 [40]. In horticultural crops, in practice, the limiting factor is rarely the insufficiency of nutritional elements, but rather the nutritional imbalance, produced by the excess in some elements, as well as insufficient water supply or excess water. Insufficient water supply creates excessive salinity conditions that inhibits both the absorption of nutrients and water [41]. Excess water, on the one hand, washes nutrients out of the rhizosphere and, on the other hand, worsens the oxygen supply of the roots and thereby leads to a poorer absorption of nutrients [42]. This interdependence between water supply and mineral nutrition highlights the role of the simultaneous and balanced supply of water and fertilizers, which in practice has led to fertilizing irrigation. [43]. The quantitative and qualitative knowledge of the nutrients extracted by fruit plants from the surface unit is very important for the rational application of fertilizers. This understanding requires prior information, based on chemical laboratory analyses, on the qualitative and quantitative presence of different nutrients in the soil [44]. In the nursery, the lack of basic elements - nitrogen, phosphorus, potassium - causes serious deficiencies in the growth process of seedlings [45]. The annual consumption of nutrients from the soil is determined by the different conditions of research: climatic and edaphic factors, the system of maintenance and tillage of the soil, the vigor of the planting material [46]. Practicing intensive horticulture requires significant investment, which is why production can neither be mediocre nor fluctuating. This requires more professional competence and a permanent supervision and control of the vegetation factors, among which the nutritional ones have a predominant role. The fertilizer application system comprises a set of principles and measures that relate to the establishment of fertilizer doses, the order in which they are applied annually and on a full rotation (or off-rotation for non-rotating species), organic fertilizers and those minerals, coordinated with the biological particularities of each species, with the properties of the soil, the technological measures and the economic conditions, highlighting the methods of administration of fertilizers for each individual crop [47]. The fertilizer application system in nurseries needs to address issues such as replenishing the soil's reserve of readily assimilated nutrients in a balanced ratio to meet the needs of seedlings and rootstocks, as each harvest removes a certain amount of mineral and organic matter from the soil [48], without this, higher plants will compete with it for mineral nutrition; in addition to these, fertilizers provide soil microflora with organic matter [49]. Most microorganisms in the arable layer are heterotrophs, meaning they require organic matter that has previously been created by other species to obtain the energy required for feeding [50]. The application of fertilizer assists in controlling the ionic soil composition and, in accordance with the biological needs of seedlings and rootstocks, adjust the alkaline or acidic reaction [51]. Applying chemical fertilizers in addition to naturally occurring organic ones is the most effective way to replenish the nutrients lost in the soil after harvest and provide organic matter to the microflora. The following features need to be considered when designing the nursery fertilizer application system: the soil's hydro-physical characteristics; the differences in nutrients between rootstocks; species, variety, stage of vegetation, harvest level; weather (temperature, rainfall, light intensity), the unique technological characteristics of every species; the agrochemical properties and content of the applied fertilizers; the optimal selection of the technique for determining fertilizer dosage and managing the condition of nutrient delivery; putting in place the proper administrative and financial frameworks for the usage, storage, and supply of fertilizers [52–54]. Fertilizers are used to optimize the nutritional conditions for increasing the synthesis of organic matter and achieving large, economical productions with superior quality indices, without weakening the plants' resistance to the attack of diseases and pests and without polluting the environment [55]. Fertilizers bring their optimal contribution to increasing production only to the extent that they are included in a system of well-ranked technological measures, and the doses used are correlated with the plant, soil, climatic factors, culture technology [56]. Due to the interdependence between these factors, it is not easy to find the most appropriate dose of fertilizers in the overall time development of growth, development, and nutrition processes. The rational use of fertilizers requires thorough knowledge of the principles of mineral nutrition of horticultural plants, of the laws that govern the processes of growth and development, in conjunction with soil conditions and environmental factors [57]. The factors that condition plant growth and development are on the one hand numerous, and on the other hand variable and some unpredictable, which makes it difficult to simultaneously determine the influence they exert on nutrition, growth, and development [58]. 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 [59].

Nitrogen is considered an essential and indispensable element for plant growth and development, with functions and presence in plant tissues noted over three centuries ago. [60]. Nitrogen is considered a main component of proteins which are a constituent part of the enzymes involved in energy and synthesis transformations in the plant. Nitrogen participates in building the molecular architecture of the substances that make up the genetic code of the body, in the growth processes and where growth takes place, protein substances are formed [61].

Phosphorus is present in plants in all cells. It participates in building the molecular architecture of nucleic acids, which make up the genetic code of cells. It has a crucial part in the procedures of phosphorylation, generating energy-rich compounds such as adenosine triphosphoric acid, which through enzymatically controlled biochemical reactions release the energy needed for metabolic processes. Phosphorus intervenes in chlorophyll functions, participating in the synthesis of carbohydrates, as well as some fats and lipids. It favorably influences the processes of fruiting, transport, and deposition of carbohydrates in fruits, roots, tubers. It accelerates maturity and stimulates the development of the root system [62].

Potassium, along with nitrogen and phosphorus, is one of the primary macro elements with an essential role in plant nutrition, with distinct and known physiological and metabolic functions. Potassium is required for plant growth and development and is found in all cells, tissues and organs of living plants, growth zones, cambial tissue, seeds [63].

The advantages of drip irrigation consist in the saving of water and the possibility of obtaining rich harvests thanks to the particularly favorable conditions created in the soil in terms of the humidity regime, the aeration process, etc. [64]. 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 [65]. At the same time, losses through evaporation and infiltration are almost entirely reduced. Drip irrigation also contributes to the transport of harmful salts to the surface of the soil, below the root zone. 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 [66]. Other advantages of localized irrigation are that it allows the free movement of machinery for all maintenance work, thus avoiding soil settlement, it reduces treatments to combat weeds, it requires much less energy consumption compared to sprinkling (1 bar at the end irrigation pipe) [67]. Also compared to the traditional sprinkler irrigation method, the drip irrigation method has the advantage of being able to adjust the humidity ceiling and reduces the number of treatments against diseases [68].

Water-saving spot irrigation methods, like drip irrigation, that provide water directly to the root zone have grown in popularity because they minimize evaporation, surface runoff, and deep percolation [69]. The drip irrigation method appeared within the global framework of the water and energy resource economies, the protection of the environment, the increase of labor productivity and the achievement of large and stable productions regardless of the rainfall regime [70]. Drip irrigation creates conditions for permanently maintaining optimal humidity in the root system development area. Through the other methods during the watering period, an over wetting occurs and between waterings a relative drying of the soil, while with drip irrigation, an optimal regime of not only water, but also air and nutrients is permanently maintained in the soil. In addition, water is distributed much more evenly. The drip irrigation method allows the application of soluble fertilizers [71–73]. All these elements specific to the method lead to obtaining higher productions than in the case of the other methods and to improving their quality. The drip irrigation method does not require leveling work and allows fertilizers to be applied together with the irrigation water [74]. Due to the very high efficiency of water application, no increase in the groundwater level was observed and no danger of

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secondary salinization of the soil appeared, therefore there is usually no need for drainage on drip irrigated land. The extremely low distributed flow ensures the prevention of soil erosion and crust formation. From the research carried out so far, it is found that watering only along the rows of trees does not harm the development of the root system. In such conditions, the roots are grouped in a narrower space, but without reducing too much of the total length, so that the absorption capacity is practically not hindered [75–78]. Another advantage related to the drip irrigation method is related to the possibility of using mineralized irrigation water, because it was found that the salts move from the supply point to the limits of the wetting zone, so in the root system development zone the most quantities are found small amounts of salts [79]. On the other hand, due to the maintenance of a high humidity throughout the irrigation period, the concentration of salts in the moistened root zone is kept lower and thus the plants find better conditions for development even on salinized soils [80]. The danger of salinization when using mineralized water is also reduced since a smaller volume of water is used per hectare than in the case of other irrigation methods The listed advantages justify the efforts being made to expand irrigation facilities, but it must be remembered that these are potential advantages, that they can become realities only if rational irrigation is applied, depending on the requirements of the plants and the physical properties of the soil [81,82]. The need to irrigate crops stands out if comparisons are made, on the one hand, between the quantity of water that is useful and how much water the plants use from precipitation and groundwater intake, and, on the other hand, between the productions obtained in slightly rainier years than normal and dry years or in irrigated and non-irrigated crop [83]. In addition to precipitation, to assess the need for irrigation, one must know the course of temperature, relative air humidity, the frequency and intensity of winds, because the destructive effects of drought are amplified in dry periods accompanied by high temperatures, low relative air humidity, hot and dry winds. In such cases, the soil drought is also accompanied by an atmospheric drought [84].

Given the weather in 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. It is, in fact, a means used to correct a natural factor, which, as it appears, results in large fluctuations in harvest from one year to another. Using irrigation, the aim is to obtain as stable productions as possible, close to the productive potential of the plants in the given pedo-climatic conditions. This, of course, more since, during the research carried out in our country, it was found that there are years in which, due to insufficient rainfall in certain periods, harvests are greatly reduced, going as far as total compromise [85].

2. Materials and Methods

The research was completed in Girișu de Criș, Bihor County, Romania, in a private nursery.

The Girișu de Criș commune is in the Crisurilor Plain, in its low area. The low plain is the result of the process of accumulation and erosion by drifting of the hydrographic networks that descend from the higher region of Bihor County.

In the Girișu de Criș area, predominates the relief of the plain, which determines a uniform distribution of meteorological values during the year. The rivers that drain the plain have shallow beds and are not accompanied by terraces.

The average altitude within the Crișurilor Plain in the low area is 110 m.

The amount of annual precipitation was higher (636 mm) in 2020 and lower (498 mm) in 2021, given that during the three years the annual precipitation was lower than the multi-year average. In 2020, the monthly precipitation showed an amplitude of 114.9 mm with limits from 12.7 mm in October to 127.6 m in July. For the year 2021, the level of precipitation registered an amplitude (110.6 mm) close to the previous year, against the background of high precipitation of 119.3 mm in June and very low of only 8.7 mm in February. The amplitude of variation of monthly precipitation in 2022 was higher (119.7 mm) than in the previous period, with limits between 13.5 mm in January and 133.2 mm in July. The amount of precipitation from the April-September vegetation period recorded values between 337.5 mm in 2020 and 370.1 mm in 2022.

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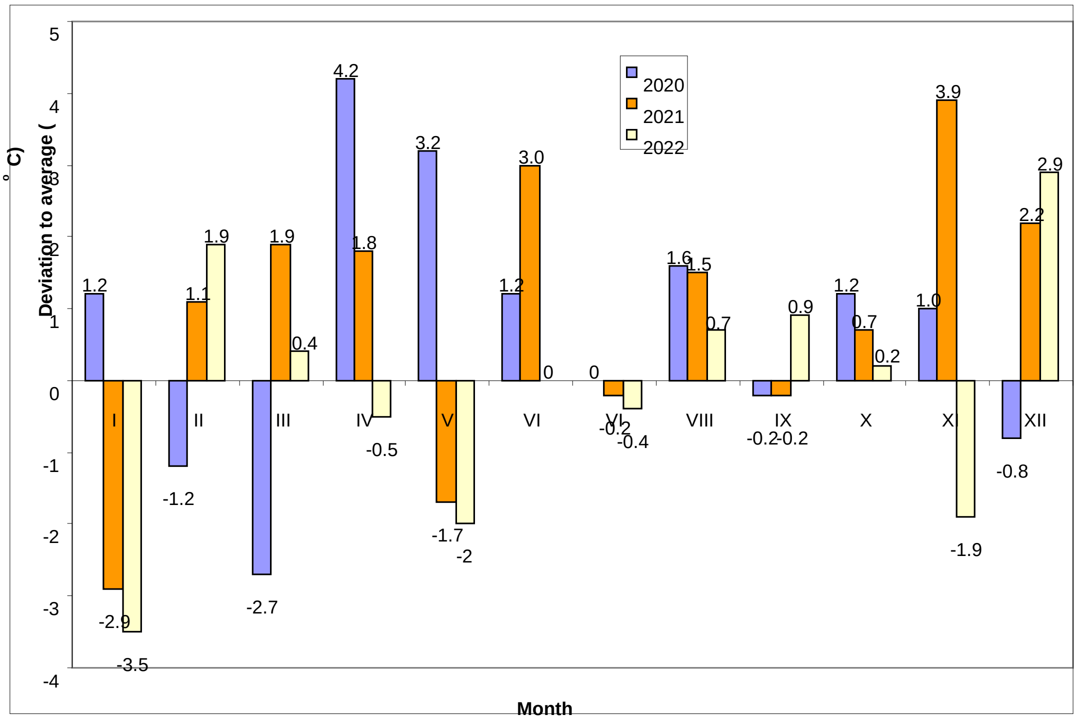

Figure 1. Deviations of monthly average rainfall from 2020 – 2022 compared to multiannual average monthly temperatures from Girişu de Criş.

With a view to a complex characterization of the climate conditions during the research period, different aridity indices were used (Table 1). According to the UNEP aridity index (IAU), the three years had average values for the vegetation period between 0.52 in 2020 and 0.59 in 2021, placing the area from Girişu de Criş in the dry-subhumid climate class. Based on this index, it is considered that in 2020 and 2022 the driest months were August-September, respectively July-August in 2021.

Table 1. Hydroclimatic characterization of conditions from Girişu de Criş during 2020-2022.

Year	Month							
	Index	IV	V	VI	VII	VIII	IX	Average
2020	IAU	0,50	0,48	0,63	1,00	0,25	0,26	0,52
IATH = 46,16	IADM	17,88	23,27	32,15	47,85	12,99	9,54	23,95
2021	IAU	0,74	1,00	0,94	0,16	0,08	0,39	0,55
IATH = 39,55	IADM	23,69	51,19	43,38	8,26	4,06	14,24	24,14
2022	IAU	0,32	0,75	0,96	0,97	0,21	0,34	0,59
IATH = 33,41	IADM	8,80	29,39	40,60	50,58	10,48	12,87	25,45

IAU- UNEP Aridity Index; IADM- Martonne aridity index; Bh- Water balance; IATH - Thornthwaite Aridity Index.

According to the Martonne index (IADM), the values of the three years (23.95-25.45) characterize the climate of Girişu de Criş as semi-humid. Thus, during the 2020 vegetation period, July (IADM = 47.85) was considered the wettest and September (IADM = 9.54) the driest. Under the conditions of 2021, May and June (IADM = 43.38-51.19) were the wettest and July and August (IADM = 4.06-8.26) were the driest. In 2022, the respective index had values between 8.8 for April and 50.58 for July.

According to the Thornthwaite aridity index (IATH), the climate at Girişu de Criş in 2021 and 2022 with values between 20 and 40 is considered semi-arid, while the climate in 2020 with a value of 46.16 is considered arid.

Following the analyses, the soil taxonomic unit identified was weakly glaciated, loamy clay, on fluvial deposits, arable, having the profile: Ap-A0-AC-Cg. The depth of the groundwater is 2-3 m.

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The research 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 (a1- non-irrigated, a2- irrigated with 10 mm, a3- irrigated with 20 mm, a4- irrigated with 30 mm), the variety as a secondary factor (b1- Stanley, b2- Cacansla Lepotica) and fertilization as a tertiary factor (c1- $N_0P_0K_0$, c2- $N_8P_8K_8$, c3- N_{16} P_{16} K_{16}, c4- $N_{24}P_{24}K_{24}$). The PAST 4.10 program was used for statistical interpretation.

To obtain the doses of 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 $N_{24}P_{24}K_{24}$.

To characterize the climatic conditions during the study period, different aridity indices were calculated:

- UNEP aridity index (1992):

$IA_U = P / FTE;$ [1.]

where:

P - precipitation (mm);

ETP-potential evapotranspiration (mm).

According to it, the climate varies from hyperarid ($IA_U < 0.03$) to humid ($IA_U > 65$);

- Martonne aridity index:

annually: $AIDM = P / (T + 10);$ [2.]

monthly: $AIDM= 12p / (t + 10);$ [3.]

where:

T-average annual temperature (oC);

t-mean monthly temperature (oC).

It allows determining the degree of aridity of a region for certain periods (a year or a month), with climate variations from hyper arid (IADM = 0-5) to humid (IADM > 30);

- Thornthwaite aridity index:

$IATH =100 \times \Sigma(P – ETP) / \Sigma ETP;$ [4.]

It characterizes a climate as arid at values above 40 and respectively semi-temperate at values of 0-10.

To determine water consumption directly, the soil water balance was established according to the soil water reserve at the beginning and end of each month from April to September. Soil moisture was determined by the gravimetric method, in this sense soil samples were collected from the field at the beginning and middle of each month, they were weighed before and after drying in the oven. Soil moisture was calculated based on the difference between the two weighing, with the formula:

$W=100 \times (B – A) / A;$ [5.]

Where:

W-soil moisture (%);

A-mass of the sample with wet soil (g);

B- mass of the sample with dry soil.

The soil water reserve (R) was established with the formula:

$R=100 \times DA \times H \times W;$ [6.]

where:

DA-apparent density (t/m3);

H- the depth of the active soil layer (m);

W-soil moisture (%);

To establish the moment when it is necessary to supply the soil with water through irrigation, the minimum ceiling was determined, which represents the lower limit of the humidity that is easily accessible to the plants. In the case of medium soils, which also includes the soil from the experimental land, the minimum ceiling (%) was calculated with the formula:

$Pmin = CO + ½(CC-CO);$ [7.]

where:

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CO-withering coefficient (%);
CC-field capacity for water (%).
The minimum volumetric ceiling (m3/ha) was calculated with the formula:
Pmin.vol.=100 x DA x H x Pmin. [8.]

Figure 2. Watering control in the nursery.

The moment of application of irrigation was established depending on reaching the minimum ceiling in the version watered with the norm of 10 mm. In this sense, in some months, several waterings were applied with the three norms taken into study.

To indirectly determine water consumption, potential evapotranspiration was estimated using the Thornthwaite method. This method estimates potential evapotranspiration as a function of air temperature using the formula

$$ETP = 160\left(\frac{10 \cdot t}{I}\right)^{a} \cdot K \qquad [9.]$$

where:
ETP-potential monthly evapotranspiration (m^3);
tn-average monthly temperature for which ETP is calculated (^{0} C);
I-annual thermal index;

$$I = \sum_{n=1}^{n=12} i = \sum_{n=1}^{n=12} \left(\frac{t_n}{5} \right)^{1,514}$$ [10.]

a-empirical coefficient that is determined with the relationship:

a=0.000000675 I^2 – 0.000077 I +0.01279211 I +0.49239; [11.]

K – brightness coefficient depending on the latitude of the land (for the period April-September: 1.135, 1.3, 1.32, 1.133, 1.225, 1.045).

The effective precipitation (Pe) during the vegetation months was calculated according to the total precipitation (Pt) that fell in that month, using the USBR method:

Pe = Pt (125 - 0.2 P) / 125, when Pt < 250 mm; [12.]

Pe = Pt (125 + 0.1 Pt) / 125 when Pt > 250 mm; [13.]

For each combination of the three factors (irrigation x variety x fertilization) determinations were made regarding the following morphological characters regarding the stem diameter (cm).

The growth rate for different characters under the effect of different watering norms and fertilization doses was determined based on an exponential function represented by the equation:

$$y = \alpha \cdot e^{\beta x};$$ [14.]

where:

α - initial value;

x – time;

y - growth rate.

The accuracy of the respective estimates was evaluated by means of the coefficient of determination R^2.

Regarding the applied technology, to establish the first field of the nursery, the land was prepared by a deep plowing of 35 cm carried out in August 2020, followed by the leveling work by discus and harrowing in October.

The planting of rootstocks in field I was carried out in the fall of 2020. In 2021, two mechanical slings were applied between the rows in field I and two manual slings per row. Phytosanitary treatments with the fungicide Dithane (0.2%) and the insecticide Decis (0.02%) were also applied. Fertilization treatments with the complex fertilizer 16:16:16 (Azomureş) were applied simultaneously with the mechanical nets, 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 $N_{24}P_{24}K_{24}$. To ensure the moisture requirement in the soil, one watering was applied in July and three waterings in August with norms related to the three experimental variants, respectively 100 m^3/ha, 200 m^3/ha and 300 m^3/ha. In August 2021, took place the grafting.

In the second field of the nursery, in the spring of 2022, the work of cutting the cone was carried out, followed by two mechanical harrows between the rows and four manual harrows per row. Also, four works of weeding the wild and 2 works of pinching the side growths were carried out.

To combat diseases and pests, three treatments were applied with the fungicide Dithane (0.2%) and the insecticide Fastak (0.02%). In August, the soil water deficit was completed by applying three irrigations with norms related to the three experimental variants, namely 100 m^3/ha, 200 m^3/ha and 300 m^3/ha.

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Figure 3. Second field of the nursery.

Figure 4. Second field of the nursery.

3. Results

The studied factors showed considerable influences, statistically ensured on the stem diameter. Fertilization treatments had the highest contribution (34.50 %) on this character, compared to irrigation (20.67 %) and respectively the variety (5.63 %). Also, the combined effects of the three factors showed significant influences on the stem diameter, but considerably less than their separate effects. The interaction between variety and fertilization was highlighted by a major effect of 5.03%, followed by the irrigation x variety interaction. At the level of experience, the obtained results were influenced to a degree of 16.6% by other sources of variation not included in the experimental device (Table 2).

Table 2. Analysis of variance with relation to the outcome of variety, irrigation, and fertilization on stem diameter.

Source of Variation	SP	GL	S²	F test
Entire	684,12	159		
Repetitions	6,55	4	1,64	1,24
Irrigation	126,46	3	42,15	31,99**
Irrigare error	15,82	12	1,32	
Variety	10,53	1	10,53	8,71**
Irrigation x Variety	21,66	3	7,22	5,97**
Variety error	19,34	16	1,21	
Fertilization	233,99	3	78,00	53,37**
Irrigation x Fertilization	35,68	9	3,96	2,71**
Variety x Fertilization	34,13	3	11,38	7,78**
Irrigation x Variety x Fertilization	39,66	9	4,41	3,01**
Fertilization error	140,30	96	1,46	

Considering the unilateral effect of irrigation, it is observed that the stem diameter registered an amplitude of 2.46 cm with values between 7.09 cm in the non-irrigated version and 9.55 cm in the situation where 30 mm of watering is used (Table 3).

Table 3. Average stem diameter under the effect of the different watering norms.

Watering Norm	Stem Diameter (cm)		Relative Values (%)	Difference/ Significance
10 mm – 0 mm	7,98	7,09	112,59	0,89**
20 mm – 0 mm	8,47	7,09	119,53	1,38***
30 mm – 0 mm	9,55	7,09	134,75	2,46***
20 mm – 10 mm	8,47	7,98	106,17	0,49
30 mm – 10 mm	9,55	7,98	119,68	1,57***
30 mm – 20 mm	9,55	8,47	112,73	1,08**

DL (LSD)5%=0,56 cm DL (LSD)1%=0,78 cm DL (LSD)0,1%=1,11 cm.

As such, the three watering norms showed major and strongly statistically assured influences, determining progressive increases in the diameter of the stem between 12.59 and 34.75%.

Changing the watering norm from 10 to 20 mm had a negligible impact linked to an increase in diameter of only 6.17%, instead the addition of irrigation from 20 to 30 mm determined a significant increase of this character of 12.73%.

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Regarding the individual effect of the varieties, the stem diameter registered an amplitude (0.36 cm) and low variability, with limits from 8.09 cm in the case of Stanley seedlings to 8.45 cm in the case of Cacanska Lepotica (Table 4).

Table 4. Average stem diameter of the two varieties.

Variety	Stem diameter (cm)		Relative values (%)	Difference/ Significance
Cacanska Lepotica - Stanley	8,45	8,09	104,49	0,36

DL (LSD)5%=0,37 cm; DL (LSD)1%=0,51 cm; DL (LSD)0,1%=0,70 cm.

Thus, at the level of the entire experience, it is confirmed that against the background of the climatic conditions of 2020, the variety did not significantly influence the growth in diameter of the seedlings.

Considering the many fertilization techniques, the stem diameter showed a variation amplitude of 3.24 cm, with values between 6.51 cm on the unfertilized agricultural background and 9.74 cm in the case of applying the 24 kg NPK dose, under the conditions of a variability of 8.49% between treatments (Table 5).

Table 5. Average stem diameter due to the various fertilizing methods.

NPK Dose	Stem Diameter (cm)		Relative Values (%)	Difference/ Significance
$N_8P_8K_8 - N_0P_0K_0$	7,90	6,51	121,51	1,40***
$N_{16}P_{16}K_{16} - N_0P_0K_0$	8,93	6,51	137,20	2,42***
$N_{24}P_{24}K_{24} - N_0P_0K_0$	9,74	6,51	149,79	3,24***
$N_{16}P_{16}K_{16} - N_8P_8K_8$	8,93	7,90	112,92	1,02***
$N_{24}P_{24}K_{24} - N_8P_8K_8$	9,74	7,90	123,28	1,84***
$N_{24}P_{24}K_{24} - N_{16}P_{16}K_{16}$	9,74	8,93	109,18	0,82**

DL (LSD)5%=0,54 cm; DL (LSD)1%=0,71 cm; DL (LSD)0,1%=0,92 cm.

The application of NPK fertilization variants led to the recording of significant increases in the growth of this character by 21.51-49.79% compared to the non-fertilized agricultural background. The seedlings successfully used the additional fertilizer, which increased from 8 to 16 kg and from 16 to 24 kg, respectively, to produce notable gains of 9.18-12.92%.

In the case of the Cacanska Lepotica variety, it appears that the three watering norms did not produce substantial changes compared to the non-irrigated variant, taking into account the influence of the interaction between the varieties and irrigation on the stem diameter of the seedlings. Only the norms of 20 and 30 mm were effectively used by the Stanley variety's seedlings to identify substantial increases; the influence of the 10 mm norm was negligible and smaller than that of the Cacanska Lepotica variety. Considering the interaction between irrigation and the diameter of the plot in the seedlings of the Stanley variety, it is observed that only irrigations with 20-30 mm allowed a significant variation of 12.26-27.45 %, while the 10 mm watering norm's impact was smaller and insignificant. Also, only increasing the watering rate from 20 to 30 mm determined a significant increase of 13.53% in the growth in diameter in the seedlings of this variety (Table 6).

Table 6. The effect of variety and irrigation on stem diameter.

Variety	Watering Norm 0 mm	10 mm	20 mm	30 mm	$\bar{x} \pm s_{\bar{x}}$	S%
Stanley	z 7,20 a	yz 7,91 a	y 8,08 b	x 9,17 b	8,45+0,20	21,66
Cacanska Lepotica	u 6,98 a	z 8,04 a	y 8,86 a	x 9,93 a	8,09+0,18	20,53
$\bar{x} \pm s_{\bar{x}}$	7,09+0,24	7,09+0,21	8,47+0,26	9,55+0,25	8,27+0,14	
S%	21,87	16,43	19,02	16,54	21,13	

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Variety – DL (LSD)5%=0,73 cm; DL (LSD)1%=0,98 cm; DL (LSD)0,1%=1,31 cm; (a,b).

Irrigation – DL (LSD)5%=0,74 cm; DL (LSD)1%=1,02 cm; DL (LSD)0,1%=1,40 cm; (x, y,z)

Under the effect of different watering norms, the seedlings of the Cacanska Lepotica variety recorded a stem diameter with the limits from 6.98 cm in the case of the non-irrigated variant, up to 9.93 cm in the 30 mm variant, against the background of a variability between treatments of 20, 53% (Table 7).

Table 7. The effect of irrigation on stem diameter on the two variaties.

Watering Norm x Variaties	Stem Diameter (cm)		Relative Values (%)	Difference/ Significance
		Stanley		
10 mm – 0 mm	7,91	7,20	109,94	0,72
20 mm – 0 mm	8,08	7,20	112,26	0,88*
30 mm – 0 mm	9,17	7,20	127,45	1,98***
20 mm – 10 mm	8,08	7,91	102,11	0,17
30 mm – 10 mm	9,17	7,91	115,93	1,26**
30 mm – 20 mm	9,17	8,08	113,53	1,09**
		Cacanska Lepotica		
10 mm – 0 mm	8,04	6,98	115,33	1,07**
20 mm – 0 mm	8,86	6,98	127,03	1,89***
30 mm – 0 mm	9,93	6,98	142,29	2,95***
20 mm – 10 mm	8,86	8,04	110,14	0,82*
30 mm – 10 mm	9,93	8,04	123,38	1,88***
30 mm – 20 mm	9,93	8,86	112,02	1,07**

DL (LSD)5%=0,73 cm; DL (LSD)1%=0,98 cm; DL (LSD)0,1%=1,31 cm.

In contrast to the unirrigated agricultural background, the saplings of this variety effectively capitalized on all three watering norms, achieving significant increases of 15.33-42.29%. The gradual adjustment of the irrigation standard by 10 mm generated significant variations of this character of 10.14-12.02 %.

After comparing the stem diameter of the two varieties on different watering rates, it is found that on the agricultural backgrounds where 20-30 mm were applied, the Stanley variety showed a superior behavior realized by a growth spurt of this character of 8.23-9.69 % (Table 8).

Table 8. The effect of variety on stem diameter under different watering norms.

Varieties x Watering norm	Stem Diameter (cm)		Relative Values (%)	Difference/ Significance
		0 mm		
Cacanska Lepotica - Stanley	6,98	7,20	96,94	-0,22
		10 mm		
Cacanska Lepotica - Stanley	8,04	7,91	101,69	0,13
		20 mm		
Cacanska Lepotica - Stanley	8,86	8,08	109,69	0,78*
		30 mm		
Cacanska Lepotica - Stanley	9,93	9,17	108,23	0,76*

DL (LSD)5%=0,74 cm; DL (LSD)1%=1,02 cm; DL (LSD)0,1%=1,40 cm.

In the absence of irrigation, the stem diameter of the Cacanska Lepotica variety was reduced by approximately 3%, without the respective difference reaching the level of statistical significance. The two seedlings' types benefited from irrigation to comparable degrees, with the typical norm of 10 mm.

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Regarding the Stanley type, the impact of watering on the growth of seedlings can be estimated by means of an exponential regression, with a precision of 93.78%.

As such, against the background of a diameter of 7.2 cm regarding the non-irrigated kind, the value grew at an average rate of 0.07 cm/mm of watering, having values between 0.02 and 0.11 cm/mm of watering. The relationship between the watering rate and the growth of the stem diameter in the seedlings of the Cacanska Lepotica variety is highlighted with a precision of approximately 99.5% by means of an exponential function.

Thus, against the background of average values of 7.05 cm in the absence of irrigation, the average rate of growth of this character was 0.1 cm/mm of watering, with different values from one norm to another (0.08-0,11 cm/mm of watering). It has been noted that the Cacanska Lepotica variety capitalized on the irrigation at a higher level (Figure 5).

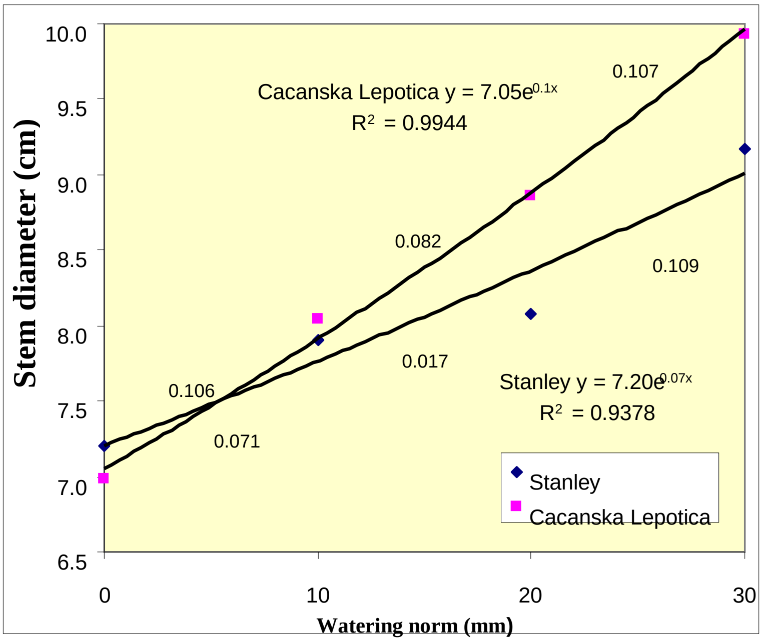

Figure 5. Variation of stem diameter for the two varieties under the effect of different watering norms.

When considering how fertilization affects the diameter increase attained at a given watering rate, it is evident that the non-irrigated variety had the largest variation amplitude, whilst the 30 mm norm showed the lowest variation amplitude. There was a reduced amplitude between NPK dosages (Table 9).

Table 9. The effect of irrigation and fertilization on stem diameter.

	NPK Dose					
Watering Norm	$N_0P_0K_0$	$N_8P_8K_8$	$N_{16}P_{16}K_{16}$	$N_{24}P_{24}K_{24}$	$\bar{x} \pm s_{\bar{x}}$	S%
0 mm	z 4,92 c	y 6,84 c	x 8,13 b	x 8,46 c	7,09+0,24	21,87
10 mm	z 6,53 b	yz 7,45 bc	y 8,42 b	x 9,52 b	7,09+0,21	16,43
20 mm	z 6,65 b	y 8,44 ab	y 8,62 b	x 10,18 ab	8,47+0,26	19,02
30 mm	y 7,93 a	y 8,90 a	x 10,54 a	x 10,83 a	9,55+0,25	16,54
$\bar{x} \pm s_{\bar{x}}$	6,51+0,24	7,90+0,17	8,93+0,19	9,74+0,20	8,27+0,14	
S%	23,23	13,83	13,48	12,67	21,13	

Irrigation – DL (LSD)5%=1,06 cm; DL (LSD)1%=1,40 cm; DL (LSD)0,1%=1,81 cm; (a,b,c). Fertilization – DL (LSD)5%=1,07 cm; DL (LSD)1%=1,42 cm; DL (LSD)0,1%=1,84 cm; (x, y).

The three watering norms allowed the realization in these conditions of very significant increases for the growth of seedlings with values between 32.76 and 61.34%, as opposed to the version that is not irrigated. Changing watering norms from 10 to 20 mm did not generate significant increases, while supplementing irrigation from 20 to 30 mm was connected to a notable rise in stem diameter by 19.25%.

In the absence of fertilization, the watering norms studied allowed to obtain stem diameter values between 4.92 cm for the non-irrigated agricultural background and 7.93 cm for the 30 mm norm and a variability of 21.87% between the watering norms (Table 10).

Table 10. The effect of irrigation on stem diameter under different fertilizations.

Watering Norm x NPK	Stem Diameter (cm)		Relative Values (%)	Difference/ Significance
		$N_0P_0K_0$		
10 mm – 0 mm	6,53	4,92	132,76	1,61**
20 mm – 0 mm	6,65	4,92	135,30	1,74**
30 mm – 0 mm	7,93	4,92	161,34	3,02***
20 mm – 10 mm	6,65	6,53	101,92	0,13
30 mm – 10 mm	7,93	6,53	121,53	1,41**
30 mm – 20 mm	7,93	6,65	119,25	1,28*
		$N_8P_8K_8$		
10 mm – 0 mm	7,45	6,84	108,97	0,61
20 mm – 0 mm	8,44	6,84	123,41	1,60**
30 mm – 0 mm	8,90	6,84	130,21	2,07***
20 mm – 10 mm	8,44	7,45	113,25	0,99
30 mm – 10 mm	8,90	7,45	119,50	1,45**
30 mm – 20 mm	8,90	8,44	105,51	0,47
		$N_{16}P_{16}K_{16}$		
10 mm – 0 mm	8,42	8,13	103,57	0,29
20 mm – 0 mm	8,62	8,13	105,97	0,48
30 mm – 0 mm	10,54	8,13	129,58	2,41***
20 mm – 10 mm	8,62	8,42	102,32	0,20
30 mm – 10 mm	10,54	8,42	125,12	2,12***
30 mm – 20 mm	10,54	8,62	122,29	1,92***
		$N_{24}P_{24}K_{24}$		
10 mm – 0 mm	9,52	8,46	112,47	1,06*
20 mm – 0 mm	10,18	8,46	120,27	1,72**
30 mm – 0 mm	10,83	8,46	127,96	2,37***
20 mm – 10 mm	10,18	9,52	106,94	0,66
30 mm – 10 mm	10,83	9,52	113,77	1,31*
30 mm – 20 mm	10,83	10,18	106,39	0,65

DL (LSD)5%=1,06 cm; DL (LSD)1%=1,40 cm; DL (LSD)0,1%=1,81 cm.

This character can be seen to vary under 8 kg of NPK fertilization, ranging from 6.84 cm for the non-irrigated variety to 8.9 cm for the 30 mm watering norm. Only the watering norms of 20 and 30 mm on this agricultural area demonstrated statistically significant increases of 23.41-30.21% as compared to the non-irrigated alternative.

Also, changing the watering rate by 10 mm had an insignificant effect, so only the increase in the watering rate from 10 to 30 mm determined a significant variation of 19.50% of the stem diameter.

As a result of applying the treatment with 16 kg of NPK, the stem diameter was between 8.13 and 10.54 cm. As such, in this case only the watering norm of 30 mm showed a significant positive effect of 29.58% on the growth in thickness of the seedlings, compared to the non-irrigated version. Instead, the addition of irrigation from 20 to 30 mm allowed a significant increase of 22.29% of the stem diameter.

In light of the fertilization process with 24 kg of NPK, the application of irrigation with the three watering norms favored a significant increase of this character by 12.47-27.96%. In the case of this agricultural fund, the differences between the watering norms were small and insignificant, only the increase in the watering norm from 10 to 30 mm showed a high efficiency materialized by a 13.77% increase in diameter.

In the case of the non-irrigated version, the exponential regression indicates that the growth of the stem diameter revealed a mean rate of 0.15 cm for each kg of NPK applied, with limits from 0.04 between doses of 16 and 24 kg to at 0.24 cm/kg NPK between the unfertilized version and the 8 kg dose (Figure 6).

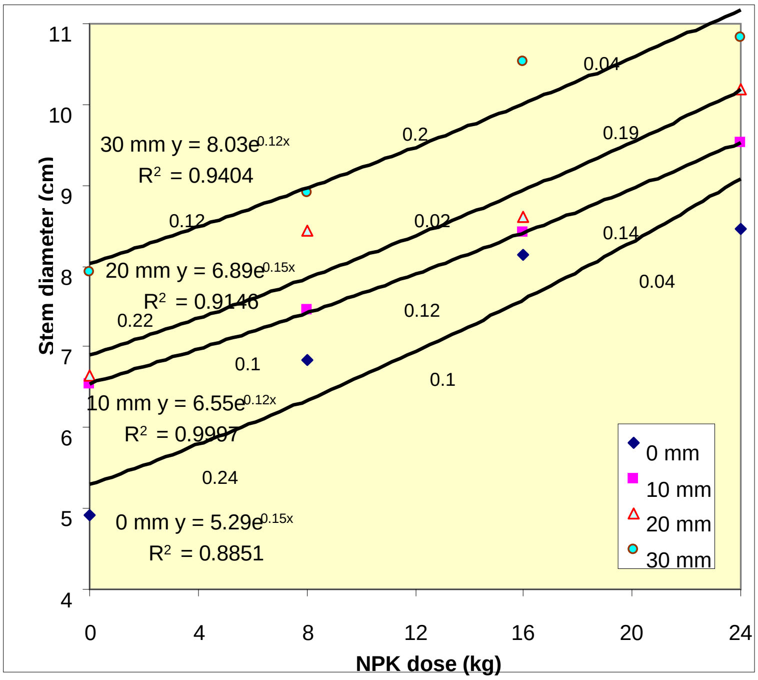

Figure 6. Variation of stem diameter under the effect of different watering norms and fertilizations.

The respective estimates have a precision of 88.5%, under the conditions of a stem diameter of approximately 5.3 cm in the absence of fertilization.

For the watering rate of 10 mm, the result of fertilization on the thickness of the seedlings is expressed by a regression that is based on a precision of 99.97% and indicates an average increase of this character with a relatively constant rate of 0.12 cm/kg NPK.

Under the conditions of irrigation with 20 mm, a variation of the stem diameter associated with an average rate of 0.15 cm/kg NPK is found, against the background of a coefficient of determination of 91.5% and an initial value of this character of 6.89 cm per non-irrigated agricultural land.

Against the background of irrigation with 30 mm, the average rate of growth in diameter was 0.12 cm/kg NPK applied, with different values from one dose to another (0.04-0.2 cm/kg NPK), under the conditions an estimation accuracy of 94%.

Considering the result of fertilization on the stem diameter in seedlings on different watering rates, it is observed that in the absence of irrigation, the seedlings recorded values with limits from 4.92 cm regarding the unfertilized variant, up to 8.46 cm in the variant with 24 kg of NPK, against the background of a variability between treatments of 21.87%. Compared to the non-fertilized agricultural background, the applied treatments had a significantly higher efficiency materialized by increases of this character of 39.02-71.95%. Only the change in the dose of NPK from 8 to 16 kg was associated with significant effects of 18.86% on the growth in thickness of the seedlings.

Against the backdrop of irrigation with the norm of 10 mm, the applied fertilization options allowed obtaining stem diameters between 6.53 cm for the unfertilized agricultural background and 9.52 cm for the dose of 24 kg of NPK, with an amplitude of variation of 2.99 cm and a variability of 16.43% between treatments.

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In these soil moisture conditions, only the application of 16-24 kg of NPK generated significant increases in seedling diameter of 28.94-45.79% compared to the unfertilized version. Also, the treatment with 24 kg of NPK had a significantly higher effect on the stem diameter than the doses of 8-16 kg of NPK, associated with increases between 13.06 and 27.79%.

Under the effect of irrigation with 20 mm, fertilization with NPK showed a significant efficiency on the increase in diameter of seedlings, associated with increases of 26.92-53.08 %. Supplementation of fertilization from 8 to 16 kg of NPK had a small and insignificant effect, but the application of 24 kg of NPK generated significant increases of 18.1-20.62% in the thickness of seedlings, compared to the other two doses (Table 11).

Table 11. The effect of fertilization on stem diameter under different watering norms.

NPK dose x Watering norm	**Stem Diameter (cm)**		**Relative Values (%)**	**Difference/ Significance**
		0 mm		
$N_8P_8K_8 - N_0P_0K_0$	6,84	4,92	139,02	1,92***
$N_{16}P_{16}K_{16} - N_0P_0K_0$	8,13	4,92	165,24	3,21***
$N_{24}P_{24}K_{24} - N_0P_0K_0$	8,46	4,92	171,95	3,54***
$N_{16}P_{16}K_{16} - N_8P_8K_8$	8,13	6,84	118,86	1,29*
$N_{24}P_{24}K_{24} - N_8P_8K_8$	8,46	6,84	123,68	1,62**
$N_{24}P_{24}K_{24} - N_{16}P_{16}K_{16}$	8,46	8,13	104,06	0,33
		10 mm		
$N_8P_8K_8 - N_0P_0K_0$	7,45	6,53	114,09	0,92
$N_{16}P_{16}K_{16} - N_0P_0K_0$	8,42	6,53	128,94	1,89***
$N_{24}P_{24}K_{24} - N_0P_0K_0$	9,52	6,53	145,79	2,99***
$N_{16}P_{16}K_{16} - N_8P_8K_8$	8,42	7,45	113,02	0,97
$N_{24}P_{24}K_{24} - N_8P_8K_8$	9,52	7,45	127,79	2,07***
$N_{24}P_{24}K_{24} - N_{16}P_{16}K_{16}$	9,52	8,42	113,06	1,10*
		20 mm		
$N_8P_8K_8 - N_0P_0K_0$	8,44	6,65	126,92	1,79**
$N_{16}P_{16}K_{16} - N_0P_0K_0$	8,62	6,65	129,62	1,97***
$N_{24}P_{24}K_{24} - N_0P_0K_0$	10,18	6,65	153,08	3,53***
$N_{16}P_{16}K_{16} - N_8P_8K_8$	8,62	8,44	102,13	0,18
$N_{24}P_{24}K_{24} - N_8P_8K_8$	10,18	8,44	120,62	1,74**
$N_{24}P_{24}K_{24} - N_{16}P_{16}K_{16}$	10,18	8,62	118,10	1,56**
		30 mm		
$N_8P_8K_8 - N_0P_0K_0$	8,90	7,93	112,23	0,97
$N_{16}P_{16}K_{16} - N_0P_0K_0$	10,54	7,93	132,91	2,61***
$N_{24}P_{24}K_{24} - N_0P_0K_0$	10,83	7,93	136,57	2,90***
$N_{16}P_{16}K_{16} - N_8P_8K_8$	10,54	8,90	118,43	1,64**
$N_{24}P_{24}K_{24} - N_8P_8K_8$	10,83	8,90	121,69	1,93***
$N_{24}P_{24}K_{24} - N_{16}P_{16}K_{16}$	10,83	10,54	102,75	0,29

DL (LSD)5%=1,07 cm; DL (LSD)1%=1,42 cm; DL (LSD)0,1%=1,84 cm.

Under the conditions of the application of the 30 mm watering norm, the seedlings recorded stem diameter values from 7.93 cm regarding the unfertilized variant, up to 10.83 cm in the variant with 240 kg of NPK, against the background of a variability between treatments of 16, 54%.

Compared to the unfertilized agricultural background, only the application of 16-24 kg of NPK had a significantly higher efficiency materialized through increases of 32.91-36.57%. The progressive modification of the dose of NPK from 8 to 16 and 24 kg, respectively, was associated with significant effects of 18.43-21.69% on the thickness of seedlings. Supplementation of fertilization from 16 to 24 kg NPK had a reduced and insignificant influence on the stem diameter.

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Concerning the impact of fertilization and variation on the diameter of the stem, only in the Stanley variety the treatments with NPK showed significantly positive influences, against the background of small variations between the treatments. In the case of seedlings of the Cacanska Lepotica variety, fertilization did not significantly influence the diameter of the stem (Table 12).

Table 12. The effect of variety and fertilization on stem diameter.

Variety	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%
Stanley	z 5,81 b	y 7,86 a	x 9,13 a	x 9,56 a	8,45+0,20	21,66
Cacanska Lepotica	z 7,20 a	z 7,95 a	y 8,73 a	x 9,93 a	8,09+0,18	20,53
$\bar{x} \pm s_{\bar{x}}$	6,51+0,24	7,90+0,17	8,93+0,19	9,74+0,20	8,27+0,14	
S%	23,23	13,83	13,48	12,67	21,13	

Variety – DL (LSD)5%=0,74 cm; DL (LSD)1%=0,98 cm; DL (LSD)0,1%=1,27 cm; (a,b). Fertilization – DL (LSD)5%=0,76 cm; DL (LSD)1%=1,00 cm; DL (LSD)0,1%=1,30 cm; (x,y,z).

According to the results of the exponential regression, the Cacanska Lepotica variety's diameter variation varied at an average rate of 0.11 cm for every kg of NPK, with limits of 0.09 cm/kg NPK for initial doses and up to 0.15 cm/kg NPK for the 24 kg dose.

The respective estimates have a precision of 99.5%, under the conditions of a stem diameter of approximately 7.16 cm when there is not fertilized.

The Stanley variety showed a stronger response to fertilization in terms of increased seedling diameter, with an average growth rate of 0.16 cm/kg NPK, against the background of variations from 0.05 cm/kg NPK between the last two treatments and respectively 0.25 cm/kg NPK between the 8 kg doses and the unfertilized version.

Based on an initial value of 6.21 cm on the unfertilized soil, the logarithmic regression between the fertilization dosage and the rise in seedling thickness in the Stanley variety has 89.1% predictability. The difference between the way of capitalizing the fertilization between the varieties can also be seen from the slope of the regression lines, which is higher for the Stanley variety (Figure 7).

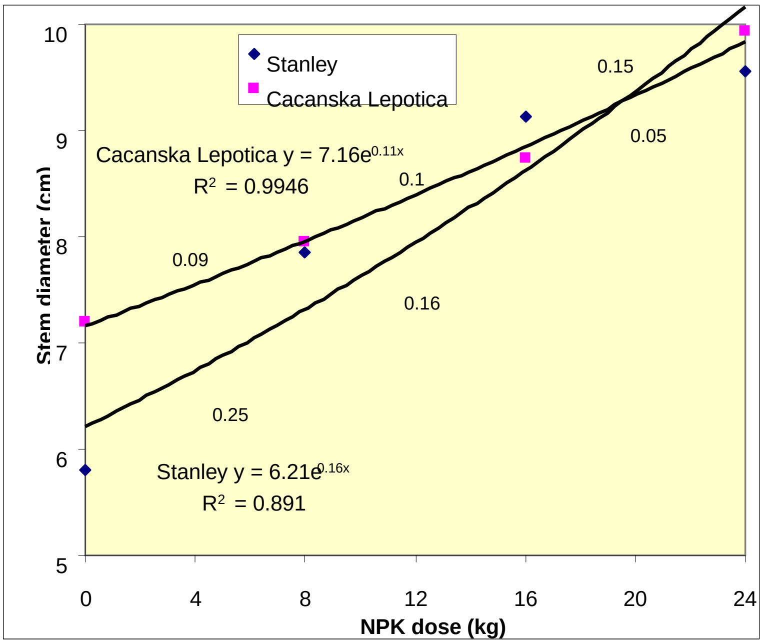

Figure 7. Variation of stem diameter under the effect of different fertilizations.

Considering, the impact of variant on stem diameter under various fertilizing methods, there are amplitudes from 0.09 cm at the dose of 8 kg NPK to 1.39 cm for the unfertilized variant (Table 13).

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Table 13. The effect of variety on stem diameter under different fertilizations.

Varieties x NPK	Stem Diameter (cm)		Relative Values (%)	Difference/ Significance
		$N_0P_0K_0$		
Cacanska Lepotica - Stanley	7,20	5,81	123,92	1,39***
		$N_8P_8K_8$		
Cacanska Lepotica - Stanley	7,95	7,86	101,15	0,09
		$N_{16}P_{16}K_{16}$		
Cacanska Lepotica - Stanley	8,73	9,13	95,62	-0,40
		$N_{23}P_{24}K_{24}$		
Cacanska Lepotica - Stanley	9,93	9,56	103,87	0,37

DL (LSD)5%=0,74 cm; DL (LSD)1%=0,98 cm; DL (LSD)0,1%=1,27 cm.

Considering these variations, the non-fertilized variant of the variety Cacanska Lepotica grew at a substantially higher rate, accounting for 23.92% of the seedling diameter. The two types' seedlings benefited from comparable levels of fertilization, with the Stanley variety experiencing greater gains in diameter on agricultural backgrounds with 16–24 kg NPK. However, the differences between the two varieties were not statistically guaranteed.

In terms of how fertilization affects each variety's increased stem diameter, at Stanley, the results ranged from 5.81 cm for the unfertilized version to 9.56 cm when 24 kg of NPK was applied. (Table 14).

Table 14. The effect of fertilization on stem diameter of the two plum varieties.

NPK Dose x Variaties	Stem Diameter (cm)		Relative Values (%)	Difference/ Significance
		Stanley		
$N_8P_8K_8 – N_0P_0K_0$	7,86	5,81	135,28	2,05***
$N_{16}P_{16}K_{16}– N_0P_0K_0$	9,13	5,81	157,14	3,32***
$N_{24}P_{24}K_{24} – N_0P_0K_0$	9,56	5,81	164,54	3,75***
$N_{16}P_{16}K_{16} – N_8P_8K_8$	9,13	7,86	116,16	1,27**
$N_{24}P_{24}K_{24} – N_8P_8K_8$	9,56	7,86	121,63	1,70***
$N_{24}P_{24}K_{24} – N_{16}P_{16}K_{16}$	9,56	9,13	104,71	0,43
		Cacanska Lepotica		
$N_8P_8K_8 – N_0P_0K_0$	7,95	7,20	110,42	0,75
$N_{16}P_{16}K_{16}– N_0P_0K_0$	8,73	7,20	121,25	1,53***
$N_{24}P_{24}K_{24} – N_0P_0K_0$	9,93	7,20	137,92	2,73***
$N_{16}P_{16}K_{16} – N_8P_8K_8$	8,73	7,95	109,81	0,78*
$N_{24}P_{24}K_{24} – N_8P_8K_8$	9,93	7,95	124,91	1,98***
$N_{24}P_{24}K_{24} – N_{16}P_{16}K_{16}$	9,93	8,73	113,75	1,20**

DL (LSD)5%=0,76 cm; DL (LSD)1%=1,00 cm; DL (LSD)0,1%=1,30 cm.

The three treatments significantly affected this property by 35.28–64.54% as compared to the unfertilized varient. Additionally, it was discovered that a notable rise in the thickness of the seedlings by 16.16–21.63% related to the gradual increase in dose from 8 to 16 and 24 kg. Supplementation of fertilization from 16 to 24 kg NPK did not significantly influence the diameter of the stem of this variety.

The variation in the Cacanska Lepotica variety seedlings' diameter was less correlated with the effects of fertilization, with an amplitude of 2.73 cm, ranging from 7.2 cm on the unfertilized agricultural background to 9.93 cm for the dosage of 24 kg NPK. The dose of 8 kg of NPK showed a small and insignificant influence of 0.75 cm on the growth of seedlings in diameter, instead the other two treatments generated significant increases of 21.25-37.92%. The addition of fertilization by

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progressively increasing the doses determined a significant increase of 9.81-13.75% in the development of seedlings of the Cacanska Lepotica variety. Considering the combined effect of the three factors, fertilization had a more pronounced effect on the diameter of seedlings of the Cacanska Lepotica variety, especially on non-irrigated farmland, compared to the seedlings of the Stanley variety (Table 15).

Table 15. The impact of fertilizer and irrigation on stem diameter of the two varieties.

Watering Norm: 0 mm				
		NPK Dose		
Variety	$N_0P_0K_0$	$N_8P_8K_8$	$N_{16}P_{16}K_{16}$	$N_{24}P_{24}K_{24}$
Stanley	y 4,63 a	x 7,27 a	x 8,76 a	x 8,12 a
Cacanska Lepotica	z 5,20 a	yz 6,40 a	xy 7,50 a	x 8,80 a
Watering Norm: 10 mm				
		NPK Dose		
Variety	$N_0P_0K_0$	$N_8P_8K_8$	$N_{16}P_{16}K_{16}$	$N_{24}P_{24}K_{24}$
Stanley	z 6,25 a	yz 7,42 a	y 8,14 a	x 9,83 a
Cacanska Lepotica	z 6,80 a	yz 7,48 a	xy 8,70 a	x 9,20 a
Watering Norm: 20 mm				
		NPK Dose		
Variety	$N_0P_0K_0$	$N_8P_8K_8$	$N_{16}P_{16}K_{16}$	$N_{24}P_{24}K_{24}$
Stanley	y 5,10 b	x 8,63 a	x 8,73 a	x 9,85 a
Cacanska Lepotica	y 8,20 a	y 8,24 a	y 8,50 a	x 10,50 a
Watering Norm: 30 mm				
		NPK Dose		
Variety	$N_0P_0K_0$	$N_8P_8K_8$	$N_{16}P_{16}K_{16}$	$N_{24}P_{24}K_{24}$
Stanley	y 7,26 a	y 8,10 b	x 10,87 a	x 10,45 a
Cacanska Lepotica	y 8,60 a	xy 9,70 a	x 10,20 a	x 11,20 a

Variety – DL (LSD)5%=1,48 cm; DL (LSD)1%=1,96 cm; DL (LSD)0,1%=2,53 cm; (a,b). Fertilization - DL5%=1,52 cm; DL1%=2,01 cm; DL0,1%=2,60 cm; (x,y). DL (LSD)5%=1,49; DL (LSD)1%=1,97; DL (LSD)0,1%=2,53.

Fertilization resulted in a notable increase in the diameter of the Stanley variety seedlings on the non-irrigated farmland by 2.64–4.13 cm, with negligible differences between the three doses administered.

When 10 mm of irrigation is used, the diameter of seedlings fertilized with 24 kg of NPK grows significantly more than those fertilized with 8 kg of NPK or the untreated variety. Fertilization had a smaller impact on the diameter of the seedlings when irrigation with a 20 mm stream was used. This was accompanied by considerable increments of 3.53–4.75 cm in comparison to the non-fertilized version, as well as negligible variations between the three doses. Under the conditions of the application of the 30 mm norm, it is observed that. Comparing the treatments with 16–24 kg of NPK to the other two fertilization methods, there was a noticeable increase in the stem diameter. As 16–24 kg of NPK fertilizer were applied to the Cacanska Lepotica variety's non-irrigated seedlings, the diameter of the stem increased significantly by 2.3–3.6 cm as compared to the untreated form. Also, it is discovered that the 24 kg dose has a far higher efficiency than the 8 kg NPK dose.

In comparison to the other variations, the seedlings of this variety demonstrated a notable rise in stem diameter under the influence of 10 mm irrigation, demonstrating an excellent utilization of the 16-24 kg of NPK treatments. Only 24 kg of NPK fertilization, against a background of minor differences between the three dosages, enabled for a considerable rise in the stem diameter by 2.3 cm, against the background of 20 mm irrigation. Under the conditions of irrigation with 30 mm, the seedlings efficiently capitalized on the fertilization by 16-24 kg, registering significant increases of this character by 1.6-2.6 cm compared to the non-fertilized version.

On the non-fertilized agricultural background, the seedlings of the Cacanska Lepotica variety made more efficient use of irrigation by 20 mm, registering a notable rise in the stem diameter

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compared to the Stanley variety. Also, in the case of the agricultural background fertilized with 8 kg of NPK and irrigated with 30 mm, the diameter of the stem in the seedlings of the Cacanska Lepotica variety had a significantly higher value by 1.6 cm compared to the seedlings of the Stanley variety. For the other combinations between fertilization and irrigation, no significant variations are observed between the two varieties for this character.

4. Discussion

The fertilization treatments had the highest contribution (34.50 %) on the stem diameter, compared to irrigation (20.67 %) and respectively the variety (5.63 %), considering that the variety did not significantly influence the increase in diameter in grafted trees. The different watering norms had considerable influences, determining progressive increases in the diameter of the stem between 12.59 and 34.75%. Changing the watering norm from 10 to 20 mm had a minor impact linked to a mere 6.17% rise in diameter; in contrast, the inclusion of irrigation from 20 to 30 mm resulted in a noteworthy 12.73% increase in this characteristic. The diameter of the stem increased significantly by 21.51–49.79% as compared to the non-fertilized agricultural background after various doses of NPK were administered. The seedlings successfully utilized the additional fertilizer from 8 to 16 kg and, correspondingly, from 16 to 24 kg, resulting in notable increases of 9.18–12.92 percent. Only the norms of 20 and 30 mm were effectively used by the Stanley variety of trees, resulting in notable increases in stem diameter; the impact of the 10 mm norm was negligible and less than that of the Cacanska Lepotica variety. The variety Cacanska Lepotica showed a significantly higher growth by 23.92% of the seedling diameter in the non-fertilized version. The young plants of both types capitalized at a similar level of fertilization with NPK, against the background of close values of the stem diameter.

To obtain high and sustainable productions of grafted trees and efficient from an economic perspective, the combined application of irrigation and fertilization with NPK is recommended. Ensuring a proper growth and development of the trees requires a monitoring of the soil's water reserve and the application of irrigation in periods of water deficit when the water consumption of the trees is high.

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