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Original paper

Influence of irrigation methods on the microbiological activity in the soil and on the physiological status of vines

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Abstract The work has been carried out during 2016-2017 period, in a vineyard located in Valea Calugareasca viticultural center, planted with Tamaioasa romaneasca variety, aiming to determine the influence of two irrigation systems (with pluvial collectors located between the vines supplemented with a system based on dripping and irrigation system based only on dripping) on the biological process at the soil level and on the physiological processes in the plant, on the quality of the grape harvest. The obtained results highlight the positive effect of the two irrigation systems on the microbiological activity in the soil. The positive effects on plants is referring to the stimulation of the physiological processes in the plant, ensuring an optimal growth and yielding ratio, increasing the grape production by 17-20% and providing a sugar content of the grape juice that allows the obtaining of wines with good quality.

Keywords Collector pluvial, humidity sensor, water stress, grapevine.

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Introduction

Over the last two decades, there has been a lot of progress on agricultural crop irrigation techniques, which have led to the reduction of water consumption and the increasing of the efficiency in the water use. However, this problem remains particularly open in very rough areas with low water sources (MEDRANO [1]; MORISON, 2008 [2]).

The vine is easily adapted to the conditions of drought (possessing a well-developed deep root system with a high absorption capacity) and can use the soil moisture to values close to the wilting coefficient. However, the lack of water in the soil can induce critical period in terms of physiological point of view, which can be reflected not only on the production of that year, but also on the future evolution of crops. Taking into account the high water consumption required for irrigation of vineyards in the years of excessive drought, it has become a necessity to use new methods of vine irrigation in order to provide a higher coefficient of utilization of irrigation water compared to that obtained by using traditional irrigation methods and which do not adversely affect the quality of grape production (PIRCALABU [3]; OJEDA [4]).

Starting from these considerations, the research carried out at ICDVV Valea Calugareasca aimed at developing a "smart" and "automated" irrigation system for vine, which allows the use of both rain and irrigation water with maximum efficiency, when the pluviometric water can not satisfy the water needs of the grapevine.

The researches were carried out within a demonstration polygon with the Tămâioasa românească variety and aimed to determine the influence of two irrigation systems (with pluvial collectors located between the vineyards + drip irrigation and drip irrigation) on the microbiological activity in the soil, on physiological processes of vine growth and on the grape quality.

Materials and Methods

In the year 2016 an experimental plot was arranged in a plantation, three years aged, with Tamaioasa Romaneasca variety grafted on rootstock SO4-4. This variety is recognized for quality aromatic wines, recommended for Valea Calugareasca viticultural center.

The experience was monofactorial, the factor studied being the irrigation system with graduations: a_1 = drip irrigation and pluvial collector; a_2 = drip irrigation and a_3 = non-irrigated. The soil in the experimental polygon is reddish preluvosol which is part of the luvisol class.

The electricity for the functioning of the irrigation system with low water consumption has been assured by a solar generation of electricity.

The pluvial collectors have been placed between the vines, and were integrated into the automated drip irrigation system.

The collectors includes a storage vessel provided with a cover, which decreases in the rate of evaporation of water accumulated.

The geometry of the cover ensures efficient capture of rainwater that is slowly ceded to the vine through cotton wicks.

The monitoring of the humidity threshold value at the level of the vine roots was done by means of 8 sensors, conceived by INCDMTM Bucharest, evenly distributed on the experimental plot, and by 3 humidity transducers.

Irrigation was started on the August 2nd when soil humidity reached the ceiling of 17%, considered as the minimum threshold from which it must be triggered and was stopped on August 26, although the soil moisture level fell below the minimum threshold, given that the grapes were in the water in the veraison.

The following parameters were used for the characterization of the ecoclimatic conditions during the experimental period: average annual temperature, sum of the active temperature, sum of the useful temperature grades, the sum of the monthly precipitation and the number of days with precipitation.

Observations and determinations of the main physical properties (apparent density, hygroscopicity coefficient, coefficient of wilting, field capacity, active humidity range) and microbiological observations (determining the viable germ load, determining the structure of microbial communities) were made.

Determinations concerning the myobiological soil activity in the two irrigation systems in comparison with non-irrigated control variant, appreciated by the load of microorganisms in the soil on depths of 0-30 cm and 30-60 cm were made.

The total number of soil viable microorganisms was achieved by inoculation on solid culture media using the method of serial dilution. A 10 g of each soil samples were collected and mixed with 90 ml of sterile distilled water. The suspensions were stirred for 3 to 5 minutes for homogenization. 1 ml of the previous dilution is added to 9 ml of distilled water, using sterile pipettes for each dilution. This protocol was repeated in order to obtain the most favorable number of colonies (30 to 300). Each serial dilution was inoculated in three Petri dishes.

In order to identify microbial colonies, selective culture media for each systematic group of microorganisms were used: Potato dextrose agar medium for bacteria, Glycerol yeast agar for Actinomycetes, Sabouraud dextrose agar with streptomicin for fungi and yeasts and Ashby mannitol agar to determine the number of nitrogen-binding bacteria of the genera *Azotobacter* and *Clostridium.*

Determinations regarding the main physiological processes in plant (photosynthetic rate, respiration, transpiration), were made by using a LCA-4 automated analyzer.

In order to estimate leaf water potential in the leaves during the veraison phenophase a Scholander Pressure Chamber was used.

The grape production (Kg/vine) was determined by weighing the grapes individually harvested in comparison with the control.

The mechanical composition of the grapes was determined by calculating the berry technological indices (grape structure index, berry index and yield index).

The composition of the grape juice has been evaluated on the basis of the following parameters: sugar (g/l) and total acidity.

Results and Discussions

The ecoclimatic conditions specific to 2017 year were characterized by a high heliothermic regime of rich water resources in July and relatively low in August (Table 1).

Table 1. The ecoclimatic conditions recorded during the experimental period (Valea Calugareasca, 2017 year)

Month	Sum of active temperature	Sum of useful temperature	Monthly average temperature	Rainfalls	Number of days with rainfall
January	0	0	-3.3	7.3	2
February	20.7	0.7	1.3	32.9	3
March	145.6	25.6	9.2	9.8	5
April	226.7	56.7	10.9	97.4	9
May	571.0	261.0	18.4	56.4	9
June	636.9	336.9	21.2	82.3	6
July	710.4	400.4	22.9	86.6	11
August	748.5	438.5	24.1	36.4	6
The growing season	2893.5	1493.5	19.5	359.1	41
TOTAL	3059.8	1519.8	13.1	409.1	51

The hydro physical soil (CO, CC) indices from the experimental polygon on June 2017 highlight that the soil can store a volume of water (CU) of 1048 cubic meters/hectare. In that moment, water reserve in the soil was 2932 cubic meters/hectare, resulting in a surplus of 1164 cubic meters/hectare.

The harvest period 2016-2017 was normal from hydric point of view, water stress being moderate at the beginning of August and very high at the end of August and in early September. Irrigation was needed only between August 2 and August 26.

The amount of water accumulated from precipitation inside a rainwater collector was 51.76 l (25.88 l/vine), resulting in an amount of 129.4 cubic meters/hectare. The irrigation norm used to supplement the deficit was 231.25 cubic meters/hectare for variant 1-drip irrigation and pluvial collector and 360.65 cubic meters/hectare for the variant 2- drip irrigation. The analysis of the data obtained in case of the two irrigated and non-irrigated variants showed a significant increase of soil micro-biological activity in case of irrigated variants at the sampling horizon of 0-30 and 30-60 centimeters (Table 2).

Table 2. The microbial load of soil in irrigated and non-irrigated variants (Valea Calugareasca, 2017 year)

Variants	Depth cm	Total number of live microorga-nisms / g soil	Other Bacteria %	Actinomycete %	Yeasts + Fungus %	Nitrogen fixative bacteria %
V1 – drip irrigation and pluvial collector	0-30	2673200	67.34	1.68	30.86	0.12
	30-60	3448000	92.81	0.84	6.09	0.26
V1 – drip irrigation	0-30	2906500	75.69	0.83	23.40	0.09
	30-60	5979000	91.99	0.20	7.69	0.12
V3 – non irrigated	0-30	460000	84.78	4.35	6.52	4.35
	30-60	919200	84.86	1.22	10.01	3.92

The most numerous group of microorganisms in case of the two systems was that of bacteria which represented 67.34-92.81% from the total number of viable micro-organisms.

In case of non-irrigated variant there was observed a reduction of the total number of microorganisms with 17.21-26.66%, in case of the soil profile 0-30 cm and with 15.37-15.83% in case of the soil profile of 30-60 cm.

Regarding Actinomycetes group, there was noticed a reduction with 55.56-16.66% for the soil profile 0-30 cm and of 75-53.33% for the soil profile of 30-60 cm, compared to the irrigated variants.

The group of fungus was represented by 23.40%-30.86% for the total number of microorganisms, in case of the irrigated variants, for the soil profile 0-30 cm, and in area percent, less than 10% for the other variants.

Fungus belonging to the genus *Penicillium*, *Aspergillus*, *Fusarium*, *Alternaria*, *Cladosporium*, *Mucor*, *Verticillium*, *Phoma*, *Trichoderma and Gliocladium*, were identified (Figure 1; 2; 3).

The most representative genus for irrigated variants were *Penicillium*, *Cladosporium* and *Aspergillus*.

Under non-irrigation conditions, more numerous, with approx. 30% were the genera *Tricoderma* and *Alternaria*.

The Fungi/Bacteria ratio, which is an indicator of the good functionality of microbial activity in the soil, had higher values for the two irrigation systems compared to the non-irrigated control. These results can be explained by the fact that, for these variants, the soil moisture was higher during the vegetation period of the vine, especially in the 0-30 cm horizon, which led to the creation of optimal conditions for the development of soil microorganisms.

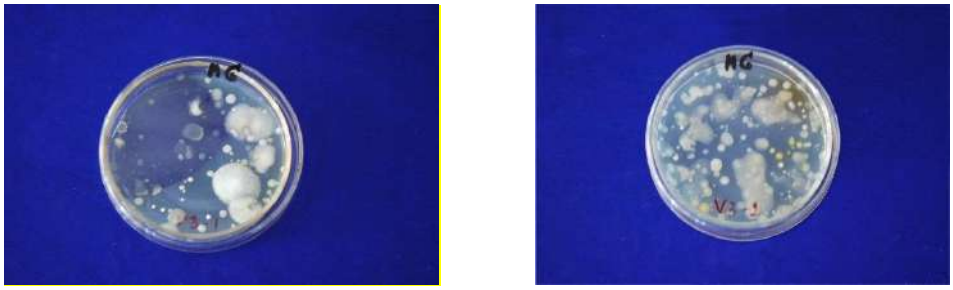

Figure 1. Gram positive and Gram negative bacteria (including Actinomycete) and fungi.

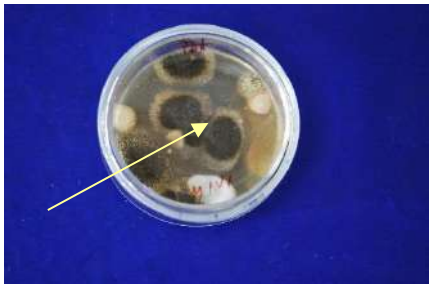

Figure 2. *Aspergillius niger*

Figure 3. *Fusarium sp.*

The irrigation systems used in the study also have an important influence on the physiological processes in the plant.

The intensity of the photosynthesis was higher during the ripeness of the grapes phenophase, in case of both irrigated variant having values of 26.44 µmol $CO_2/m^2/s$ in case of pluvial collector + drip irrigation and 25.81 µmol $CO_2/m^2/s$ in the drip irrigation variant (Figure 4).

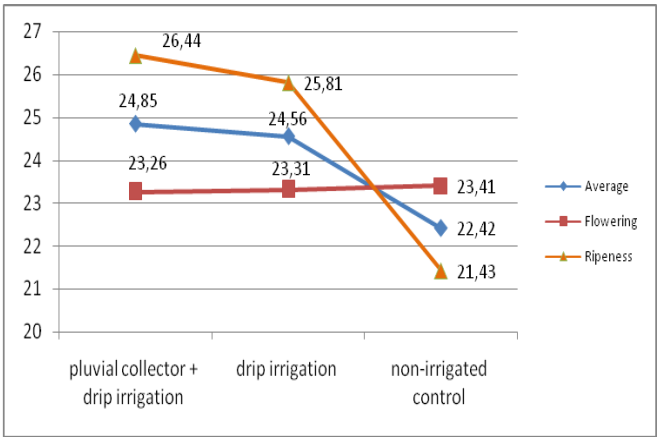

Figure 4. Influence of the irrigation systems on the intensity of the photosynthesis.

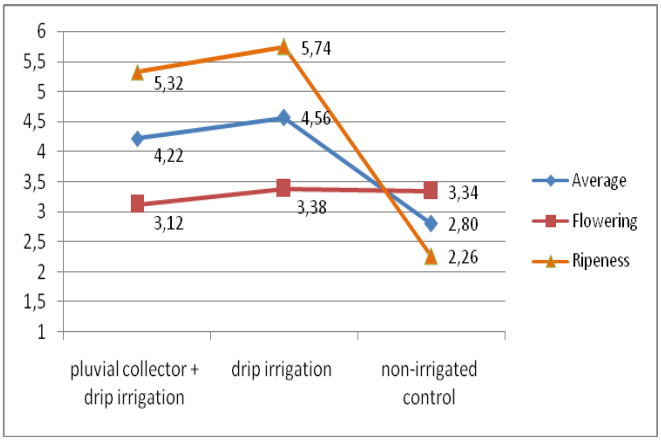

Figure 5. Influence of the irrigation systems on the intensity of the transpiration process.

During flowering phenophase there were no significant differences between variants, since in this phenophase there was sufficient water in the soil, and the irrigation was not requiring. As with the photosynthesis process, the intensity of the perspiration process was higher during the ripeness of the grapes (5.32 µmol $CO_2/m^2/s$ in the pluvial collector + drip irrigation and 5.74 µmol $CO_2/m^2/s$ in the drip irrigation variant) (Figure 5).

During flowering phenophase there were no significant differences between variants.

The intensity of the respiration process varied within relatively small limits during flowering phenophase. The highest values of the intensity of this process were recorded during the ripeness of the grapes in case of irrigated variants (Figure 6).

The leaf water potential showed values of -3.3-3.4 bar in case of irrigated variants, representing a medium level of water stress. For the non-irrigated control, the value was -6.5 Bar, representing a strong hydric stress level (Figure 7).

The influence of two irrigation systems compared to the non-irrigated control on grape production and quality is shown in Table 4.

Irrigation systems have influenced the technological characteristics of grapes in the sense of increasing the values of the grain index and the yield index, which put into evidence that the grapes obtained by using the irrigation systems are richer in the wort, ensuring a higher vinification yield, compared to the non-irrigated control variant.

Regarding the influence of the two irrigation systems on the grape yield, the variance analysis emphasized a positive effect as compared with the non-irrigated control.

The must sugar concentration depended to a lesser extent on the influence of the irrigation systems.

Based on the data obtained from the mechanical analysis of the grapes, the main uvological indices characterizing the technological abilities of the grapes were calculated (Table 5).

The higher values of the mechanical composition indices of the grapes both in terms of the mechanical composition and the quality of the berry, allowing to obtaining wines with good quality were obtained in case of irrigated variants.

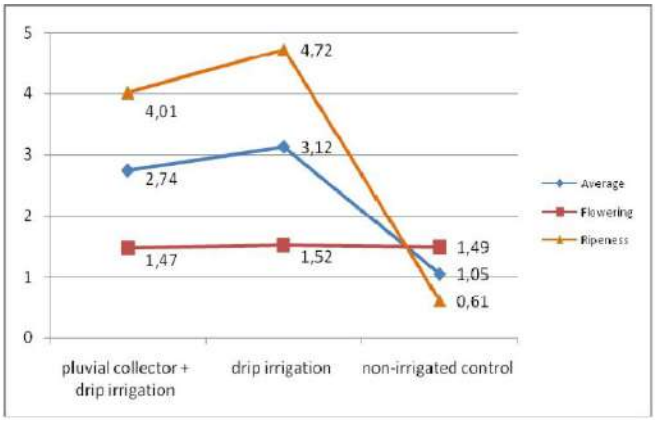

Figure 6. Influence of the irrigation systems on the intensity of the respiration process.

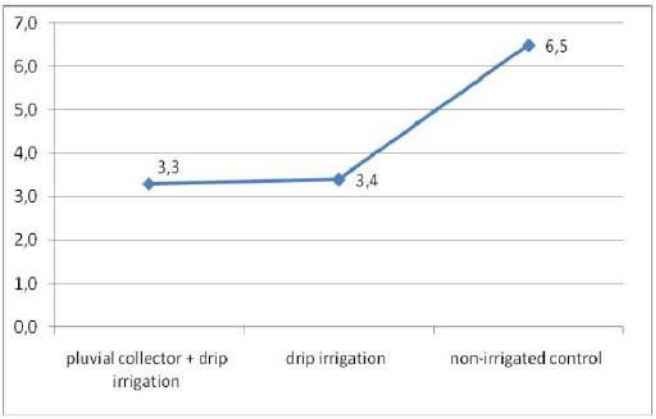

Figure 7. Leaf water potential before the grapes harvesting.

Table 4. The influence of experienced technological factors on the quality of grapes

Variants	The average weight of a grape g	Number of grapes	The production Kg/ha	The sugar g/l	Total acidity g/l tartaric acid
V1- drip irrigation and pluvial collector	204	6.9	1.408*	209,0	8.1
V2- drip irrigation	202	6.8	1.374*	209,0	8.1
V3- non-irigated	168	7.0	1.177	201,0	8.5
			DL 5% 0.18	DL 1% 0.25	DL 0.1% 0.31

Table 5. Variation of the values of mechanical berry composition indices depending on the irrigation system

Variants	Grape harvesting index	Berry index	Composition index berry	Yield index
V1- drip irrigation and pluvial collector	77.9	57.8	7.5	7.5
V2- drip irrigation	74.2	55.5	7.4	7.4
V3-non-irigated	73.4	52.6	7.4	6.7

Conclusions

The using of different system of irrigation are positive effects on plants, in terms of the stimulation of the physiological processes in the plant, the increasing of soil microbiological activity and the ensuring an optimal growth and yielding ratio.

The obtained results put into evidence the positive influence of irrigation, both upon the grape yield and its quality, no matters what irrigation method was used. The increasing yields of the grapes were obtained in comparison with the not irrigated control, averagely ranging in between the limits of 19-20%, on the background of a better accumulation of sugars in grapes which will allow the obtaining of quality wines.

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