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The Impact of Various Types of Tillage on the Soil Water Availability

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Abstract

The present study is focused on the role that various ways of soil tillage may have on the increase of soil water availability to the plant roots. The research was carried out in Tirana, Albania, and the experiment was established in a vineyard field. The soil was cultivated in three different ways (three treatments): conventional (plowing plus surface cultivation), conservative (subsoiling plus surface cultivation), conservative (chisel plowing plus surface cultivation). In order to quantify the available soil water to plants, the pF-soil moisture curves were determined. The determined pF-soil moisture curves belong to two layers: 0-25 cm and 25-50 cm, taken into consideration for each treatment. The soil water content between the field capacity (FWC) and the permanent wilting point (PWP) was considered as potentially available to plant roots. The results showed clearly that the way the tillage was applied has a significant effect on soil water capacity potentially available to plant roots. Loosening the soil by breaking up the impermeable layers, the conservative tillage makes possible the increase of the amount of water held by soil particles in the range between FWC and PWP, in comparison with the conventional tillage. This increase of available soil water capacity is due to the soil loosening in deeper layers of soil profile as well, which leads to the situation where the plant roots can penetrate deeper and occupy more space, consequently, drawing more water to meet their needs. Within the conservative tillage versions, sub soiling seems to be more effective in the increase of available soil water capacity comparing with the chisel plowing. The study contributes, as well, to the determination of the pF-soil moisture curves in a way that is theoretically well based. The founded curves fit with the exponential form of functions and the coefficients of determinations, for each case under study, are significant in high probability levels.

Keywords: conventional tillage, conservative tillage, chisel plough, pF-soil moisture curves**,** available soil water**,** FWC, PWP.

1. Introduction

The studies about soil tillage and its effect on soil water have been frequently focused in a better understanding of the role of tillage to the increase of infiltration and consequently, to the decrease of negative effect of erosion. This study is rather focused on the role that various types of soil tillage can have to the increase of soil water capacity, which would lead to a decrease in the water flow on soil surface, consequently, to a decrease of erosion on one side and also, to an increase of amount of soil water available to the plant roots on the other side. This focus in our research is of a great importance for Albania, which receives enough water from the rainfall over a given year, but, because of its uneven distribution, the summer is characterized by dry conditions. It is the uneven distribution of the rainfall which makes irrigation a very important mean to reduce the drought and make the plant production possible. In this context, the soil tillage was considered as a tool by which the soil can get more loosen, the impermeable layers developed in the soil profile can get broken down helping the root system getting spread more easily and because of this, receiving more water from a greater space occupied by it. The soil tillage is considered to be the very basic operation by which a farmer can restore the soil moisture in soil and have it as a reservoir to the plant roots over the summer time, so, over that period of time in which the field doesn't receive rain. Therefore, the main focus of our study is to find out which type of soil tillage would restore more water in soil after the winter period, for being used in summer time during the cultivation of a vineyard.

2. Material and Methods

2.1 General

The study was based on the field experiments carried out in the field of Kamza, Experimental Centre

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of the Agricultural University of Tirana, Albania. The experiment was organized into three treatments, each of them repeated four times, as it is foreseen in a randomized block. The experimental plot was 1.96 ha, with a west orientation and the distances among the grape trees were 2 x 1.5m, which means that there were 6533 plants/ha. The vineyard was 11 years old and the cultivar was "Sheshi i Zi", an well known cultivar in Albania. The three treatments showed on the Tb.1 are in fact the treatments applied in the third year of the experimental study. The whole experimental field was kept under the traditional treatment T_1 for the first two years and the two other treatments, T_2 and T_3 were introduced after, in the third year, to see the differences among the soil water holding capacities in two different soil layers for each treatment. We believe that the treatment T_1 can be considered as a conventional treatment, because the tillage operations are performed as it used to be traditionally. The treatments T_2 and T_3 can be considered as conservative treatment, (conservation tillage), because more than a minimum of 30% residue cover on the soil surface was maintained after tillage (ASAE, 2004), ASAE standards. Clearly, the treatment T_1 doesn't have a till deeper than 25 cm, which has caused a soil compaction under this depth over the years. The tillage in the treatments T_2 and T_3 goes deeper than 25 cm, which makes possible a better soil environment for the plant roots and also, as we will see, it will increase the soil capacity to hold available water to plants. In the treatment T_3, the subsoiling by using a mole plough goes deeper than the subsoiling in the treatment T_2, in which a chisel plough was used.

Table 1. Three treatments applied on the vineyard experimental field over three years of the experimental study

Treatments		
	Year 1	
$\mathbf{T_1}$ (traditional)	$\mathbf{T_1}$(traditional)	$\mathbf{T_1}$(traditional)
	Year 2	
$\mathbf{T_1}$ (traditional)	$\mathbf{T_1}$(traditional)	$\mathbf{T_1}$(traditional)
	Year 3	
$\mathbf{T_1}$ (traditional)	$\mathbf{T_2}$(chisel plowing)	$\mathbf{T_3}$(subsoiling)
Autumn plowing by mould board plough depth=21-25 cm November	Autumn chisel plowing depth=28-35 cm November	Autumn subsoiling by using the mole plough depth=45-50 cm November
Spring plowing depth=21-25 cm March	Autumn plowing by mould board plough depth=21-25 cm November	Autumn plowing by mould board plough depth=21-25 cm November
Summer plowing depth=17-20 cm June	Spring chisel plowing depth=25-30 cm April-May	Spring chisel plowing depth=25-30 cm April-May
rotator, cultivator, disc harrow depth=8-10cm July-August	rotator, cultivator, disc harrow depth=8-10cm July-August	rotator, cultivator, disc harrow depth=8-10cm July-August

2.2 Determination of pF-soil moisture curves

In order to find out the impact of the above treatments on the soil water capacity potentially available to plants, the pF-soil moisture curves were determined for each treatment and for each respective depth: 0-25 cm and 25-50 cm for covering the most space occupied by the plant roots. The pF curves were determined by applying different methods for different stages of the curves.

2.2.1 Determination of the experimental points located within the range between 0-100 cm soil water suction.

To determine the experimental points within the range 0 – 100 cm of soil suction, the soil column method was applied, which is described as one of the first work done by E. Buckingham in soil physics (Buckingham, E., 1907).

The mentioned experimental points can be determined if the soil moisture distribution in a soil column situated vertically above a free water surface, in the conditions of prevention of the evaporation, has been reached the equilibrium. For making this determination possible, six soil columns of 1 m height were taken: two of them for each treatment and in each treatment, one for each depth, respectively 0-25 cm and 25-50 cm. The soil columns were taken horizontally for each mentioned depth. After the equilibrium of soil moisture was reached throughout the soil column located vertically on the free water surface in the conditions of the evaporation prevention, we were sure that the soil water suction at a any given point is numerically the same as the height of that point above the water surface. The analysis is done first by Buckingham and shortly, for methodical purposes, can be presented here:

The general form of the equation that can describe the water flow vertically up from the free water surface towards the top of the soil column is:

$q = K(H_m)[dH_m - H_g)/dz$, or,

or

$q = K(H_m)(dH_m/dz - 1)$ (1);

where q is the water flux flowing vertically up from the free water surface towards the top of the soil column, H_m is the soil water suction height, H_g is the soil water gravitational height, z is the height of soil column. When the equilibrium is reached (Buckingham, E., 1907, Gjongecaj B. 2009b, Hillel, D. 1971a, Hillel, D. 1982b), the soil water flow vertically up has stopped, which means that the water flux is become zero, so q=0. The flux can become zero only when $dH_m/dz = 1$; or after integration, in the conditions when H_m=z. In this case, the constant of integration is zero, because H_m becomes zero when the height z is zero, at the bottom of soil column. The equity H_m=z taken when the equilibrium of soil moisture is reached throughout the soil column in the conditions of no evaporation, shows clearly that the soil water content in a given height of the column has the same suction as the height is. The results taken are presented in the following tables and graphs.

2.2.2 Determination of the experimental points located within the range between 100-1000cm (0.1atm to 1atm) soil water suction.

Tensiometers were used to determine the experimental points that occur in the range between 100-1000cm. By using them it became possible to measure the soil water content that get adsorbed by soil particles by the suction of 450cm, 590cm, and 800cm. The technique was simple and it was carried out by using the same soil columns described above. The tensiometers were placed in the column, in two different ones, and the measurements were done when the above suctions were reached. In this case, the soil column wasn’t covered, so the evaporation was proceeding. These experimental points played an important role to fill the long range between the soil suctions measured by the soil column and soil suctions measured by the sulfuric acid method, in the absence of the pressure membrane apparatus.

2.2.3 Determination of the experimental points of pF-soil moisture curves having the ordinates: pF=4.62; pF=5.28; pF=5.6; pF=6.16.

Determination of the above mentioned experimental points was done based on the principle that if a soil sample has reached the equilibrium with the atmosphere of a given amount of sulfuric acid whose concentration is known, then the further increase of its concentration will lead to a situation in which more water will be extracted from the soil sample to the atmosphere as a vapor. It means that the increase of acid sulfuric concentration will lower the soil sample water content, or will increase the soil water suction of the sample. Therefore, the theory of this experimental finding relies on:

$H_m = RT \ln e/e_o$ (2);

where R is the universal constant of gaseous, T is the temperature of the environment and e/e_o is the relative humidity of the air.

Theoretically, the relationship between the acid sulfuric concentration and its ability to adsorb the water content of the soil sample as a vapor in order to decrease its own concentration, is known. So, the sulfuric acid concentrations of 20%, 30%, 40% dhe 50%, will be in the conditions of equilibrium with the soil sample if the soil water suction correspond respectively with the pF as 4.62, 5.28, 5.6, and 6.16. Such experiments were carried out in the laboratory conditions and the respective soil water contents were found for each treatment and for each depth under consideration of a given treatment.

3. Results and Discussion

The results of the experiments are going to be presented in sections.

3.1. The results of the relationship $H_m=f(\theta)$ for the layer 0-25cm taken from the soil column situated above a free water surface.

Table 2. Soil water content on volume basis in various depths of the soil column.

Height of the point in the soil column starting from the free water table, H_m in cm	Soil water content, θ, cm water/cm soil		
	Treatment 1	Treatment 2	Treatment 3
0	0.409	0.493	0.456
5	0.45	0.487	0.475
10	0.39	0.468	0.44
20	0.385	0.405	0.415
30	0.361	0.4	0.38
40	0.355	0.376	0.368
50	0.343	0.355	0.365
60	0.32	0.335	0.345
70	0.295	0.31	0.325
80	0.29	0.29	0.306
90	0.286	0.32	0.3
100	0.285	0.3	0.3

The data of the above table are plotted in a graph in order to get a more realistic impression about the relationship between the soil water content and its respective soil suction. The regression analysis was done and the coefficients of determination are calculated. The results of the regression analysis are presented in the following figure and in the following table.

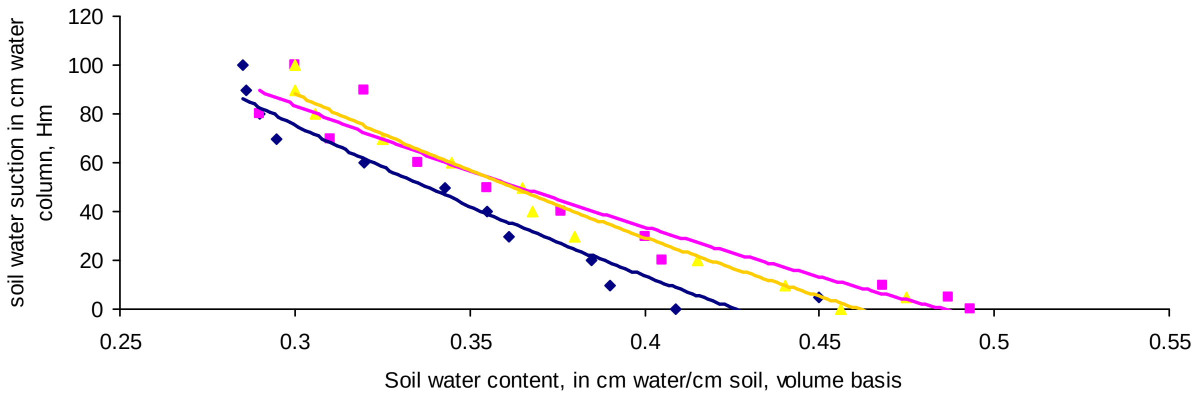

Figure 1 The lines representing the function $H_m=f(\theta)$, so the function of soil water suction, Hm, from the soil water content, θ, for the three treatments belonging to the depth 0-25 cm. The first treatment is presented by the blue color, the second one by the purple color and the third one by the yellow color.

Table 3. The equations of regressions and its respective coefficients of determination belonging to the lines given in the Figure 1.

Equations Hm = f(θ)		
Treatment 1	Treatment 2	Treatment 3
$Hm = -214.97\ln\theta - 183.37$ $R^2=0.94$	$Hm = -173.46\ln\theta - 125.27$ $R^2=0.92$	$Hm = -204.98\ln\theta - 158.49$ $R^2=0.97$

Clearly, the lines presented in the figure 1 are too close to each other and it is impossible to see a significant distance to each other. It clearly means that in the three treatments, the relationship between the soil water suction and soil water content is almost the same, or, which is the same thing, this relationship is not affected by the treatment itself. It can be explained by the fact that the three treatments present almost the same interference on the upper layer of soil. However, the results show that for each treatment there is a relationship between soil water content and soil suction, which is represented by a logarithmic function and characterized by strong coefficients of determinations.

3.2. The results of the relationship $H_m=f(\theta)$ for the layer 25-50cm taken from the soil column situated above a free water surface.

Table 4. Soil water content on volume basis in various depths of the soil column.

Height of the point in the soil column starting from the free water table, H_m in cm	Soil water content, θ, cm water/cm soil		
	Treatment 1	Treatment 2	Treatment 3
0	0.405	0.633	0.673
5	0.389	0.596	0.651
10	0.376	0.56	0.576
20	0.34	0.503	0.571
30	0.33	0.457	0.521
40	0.325	0.455	0.51
50	0.333	0.447	0.501
60	0.3	0.441	0.471
70	0.29	0.378	0.44
80	0.32	0.333	0.435
90	0.3	0.305	0.423
100	0.28	0.345	0.411

The data of the above table are plotted in a graph in order to get a more realistic impression about the relationship between the soil water content and its respective soil suction. The regression analysis was done and the coefficients of determination are calculated. The results of the regression analysis are presented in the following figure and in the following table.

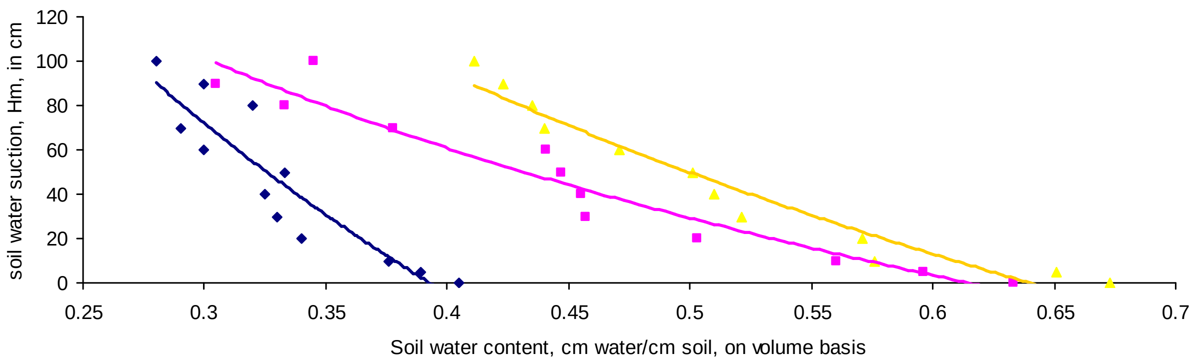

Figure 2 The lines representing the function $H_m=f(\theta)$, so the function of soil water suction, Hm, from the soil water content, θ, for the three treatments belonging to the depth 25-50 cm. The relationship belonging to the first treatment is presented by the blue color, the second one by the purple color and the third one by the yellow color.

Table 5. The equations of regressions and its respective coefficients of determination belonging to the lines given in the figure 2.

Equations Hm = f(θ)		
Treatment 1	Treatment 2	Treatment 3
H_m=-267.01lnθ - 249.59 R^2 = 0.832	H_m=-141.52lnθ - 68.857 R^2 = 0.93	H_m=-201.62lnθ - 90.01 R^2 = 0.95

Clearly, the lines presented in the figure 2 show important differences. The values of soil water content at the soil saturation, Hm=0, are very different from one to another treatment. We see that the least value of soil saturation belongs to the soil in the first treatment and the highest value of soil saturation belongs to the third treatment. It means that because of the type of tillage, the capacity of soil at the saturation is increased. Conservative tillage, treatment 2 and 3, has increased the soil water capacity at saturation from about 0.39 cm water/cm soil, which is at the traditional tillage (conventional), to about 0.62cm water/cm soil, treatment 2, to about 0.64 cm water/cm soil, treatment 3. The same is noticed considering the water field capacity, which belongs to that soil water content having the soil suction 100 cm, or pF=2. In this case, the most significant difference can be seen in the treatment 3 comparing with the treatment 1, even with the treatment 2; 0.42 cm water/cm soil, (T3); 0.32 cm water/cm soil (T2); 0.28 cm water/cm soil (T1). The increase of field water capacity in the depth of 25-50 cm of soil clearly has happened due to the deep till in the treatment 3, by using the mould plough. The conservative tillage has increased dramatically the ability of soil to hold water between the field water capacity and saturation and also, which is very important, to hold more water at the field capacity, namely, to increase the magnitude of soil water that is readily available to plant roots. What remains the same in the layer 25-50 cm comparing with the layer 0-25 cm, is the fact that for each treatment there is a relationship between soil water content and soil suction, which is represented by a logarithmic function and characterized by strong coefficients of determinations.

3.3. The results of the relationship H_m=f(θ) for the layer 0-25 cm taken from the sulfuric acid trial.

Table 6. Soil water content on volume basis in various depths of the soil column.

pF	Soil water content, θ, cm water/cm soil		
	Treatment 1	Treatment 2	Treatment 3
4.62	0.108	0.109	0.111
5.28	0.089	0.09	0.091
5.6	0.075	0.069	0.071
6.16	0.052	0.058	0.055

The data of the above table are plotted in a graph in order to get a more realistic impression about the relationship between the soil water content and its respective soil suction. Instead of the logarithm of the height expressed in cm, as it is shown in the table 4, so, instead of pF values, the values of the soil water suction in cm water column are presented on the y axis. The regression analysis was done and the coefficients of determination are calculated. The results of the regression analysis are presented in the following figure and in the following table.

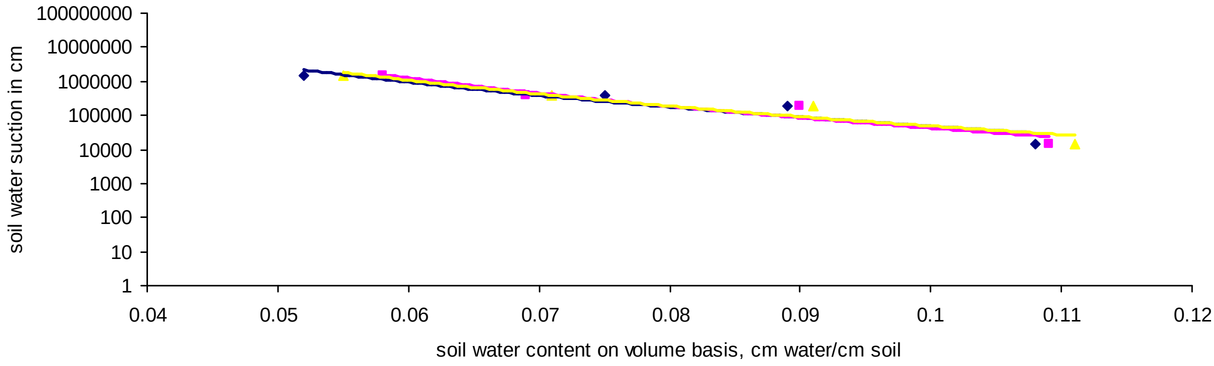

Figure 3 The lines representing the function $H_m=f(\theta)$, so the function of soil water suction, Hm, expressed as cm water column, from the soil water content, θ, for the three treatments belonging to the depth 0-25 cm. The relationship belonging to the first treatment is presented by the blue color, the second one by the purple color and the third one by the yellow color.

Table 7. The equations of regressions and its respective coefficients of determination belonging to the lines given in the figure 3.

Equations $H_m = f(\theta)$		
Treatment 1	Treatment 2	Treatment 3
$H_m = 0.068\theta^{-585}$ $R^2=0.86$	$H_m = 0.001\theta^{-6.64}$ $R^2=0.92$	$H_m = 0.041\theta^{-608}$ $R^2=0.91$

The lines presented in the figure 3 almost don't show any significant differences. They almost overlap each other, which means that the treatment have not affected the relationship $H_m=f(\theta)$ in the top layer, 0-25 cm. However, the relationship does exist and this time, the power function represents it as the best fit.

3.4. The results of the relationship $H_m=f(\theta)$ for the layer 25-50 cm taken from the sulfuric acid trial.

Table 8. Soil water content on volume basis in various depths of the soil column.

pF	Soil water content, θ, cm water/cm soil		
	Treatment 1	Treatment 2	Treatment 3
4.62	0.115	0.113	0.121
5.28	0.105	0.101	0.09
5.6	0.09	0.085	0.081
6.16	0.067	0.06	0.071

The data of the above table are plotted in a graph in order to get a more realistic impression about the relationship between the soil water content and its respective soil suction. Instead of the logarithm of the height expressed in cm, as it is shown in the table 4, so, instead of pF values, the values of the soil water suction in cm water column are presented on the y axis. The regression analysis was done and the coefficients of determination are calculated. The results of the regression analysis are presented in the following figure and in the following table.

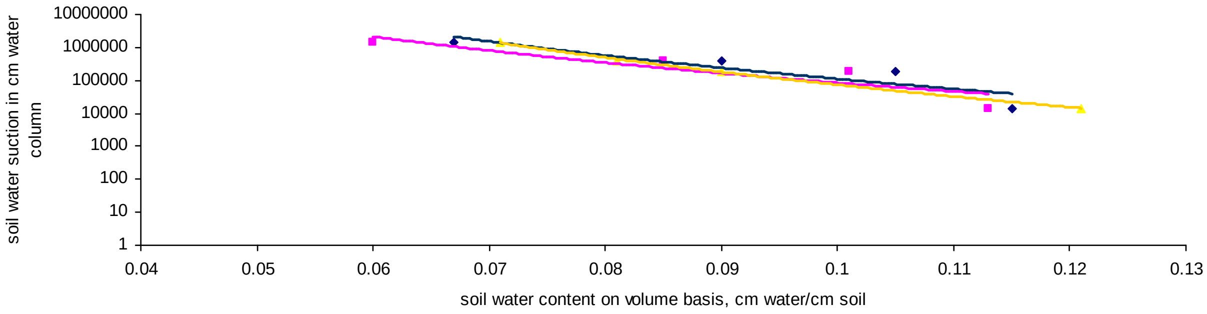

Figure 4 The lines representing the function $H_m=f(\theta)$, so the function of soil water suction, Hm, expressed as cm water column, from the soil water content, θ, for the three treatments belonging to the depth 25-50 cm. The relationship belonging to the first treatment is presented by the blue color, the second one by the purple color and the third one by the yellow color.

Table 9. The equations of regressions and its respective coefficients of determination belonging to the lines given in the figure 4.

Equations $H_m = f(\theta)$		
Treatment 1	Treatment 2	Treatment 3
$H_m = 0.00510\theta^{-7.34}$ R^2=0.83	$H_m = 0.042\theta^{-6.31}$ R^2=0.81	$H_m = 0.041\theta^{-8.55}$ R^2=0.99

The lines presented in the figure 4 almost don't show any significant differences. They almost overlap each other, which means that the treatment have not affected the relationship $H_m=f(\theta)$ in the layer 25-50 cm. However, the relationship does exist and this time, the power function represents it as the best fit.

It is the right time do make some comments about the results on the relationships Hm=f(θ) in the zone of very high soil water suction, as it is the case of this part of the experiment. Seemingly, the fact that the treatment, so, the way of soil tillage doesn't affect the relationship $H_m=f(\theta)$ shows that this relationship in the range of about pF4 - pF7 cannot be affected by soil structure or the degree of soil loosing, which basically are the impacts of the soil tillage. In the mentioned range, the relationship $H_m=f(\theta)$ is affected by something that is an intrinsic attribute of soil, that cannot be affected by something from outside, specifically by soil tillage. There are studies (Gjongecaj B. 1998a, Hillel, D. 1971a Hillel, D. 1982b, William A. Jury, Wilford R. Gardner, Walter H. Gardner, 1991,) which clearly indicate that in high levels of soil water suctions the relationship $H_m=f(\theta)$ will be affected by the clay content, which is basically what can be used to explained our case. The clay content remains the same no matter what type of tillage we apply, so the $H_m=f(\theta)$ relationship remains unaffected as well.

3.5. The results of the relationship pF=f(θ) for the entire range of the soil water suctions considered, layer 0-25cm.

The data of the following Table 10 are plotted in a graph in order to get a more realistic impression about the relationship between the soil water content and its respective soil suction. For a more understandable picture, on the y axis the values of pF are located ($pF=\log H_m$). The values of soil water suction greater than 100cm (pF=2), but lower than 800cm (pF=2.9), are measured by using tensiometers. The results of the regression analysis are presented in the following figure and in the Table 11.

Table 10. Soil water content on volume basis in various pF, the entire range of measurements, 0-25cm.

pF	Soil water content, θ, cm water/cm soil		
	Treatment 1	Treatment 2	Treatment 3
	0.409	0.493	0.456
0.69897	0.45	0.487	0.475
1	0.39	0.468	0.44
1.30103	0.385	0.405	0.415
1.47712	0.361	0.4	0.38
1.60206	0.355	0.376	0.368
1.69897	0.343	0.355	0.365
1.77815	0.32	0.335	0.345
1.8446	0.295	0.31	0.325
1.90308	0.29	0.29	0.306
1.95424	0.286	0.32	0.3
2	0.285	0.3	0.3
2.65321	0.21	0.221	0.211
2.77815	0.188	0.198	0.174
2.90309	0.154	0.151	0.141
4.16	0.108	0.109	0.111
5.28	0.089	0.09	0.091
5.5	0.075	0.069	0.071
6.16	0.052	0.058	0.055

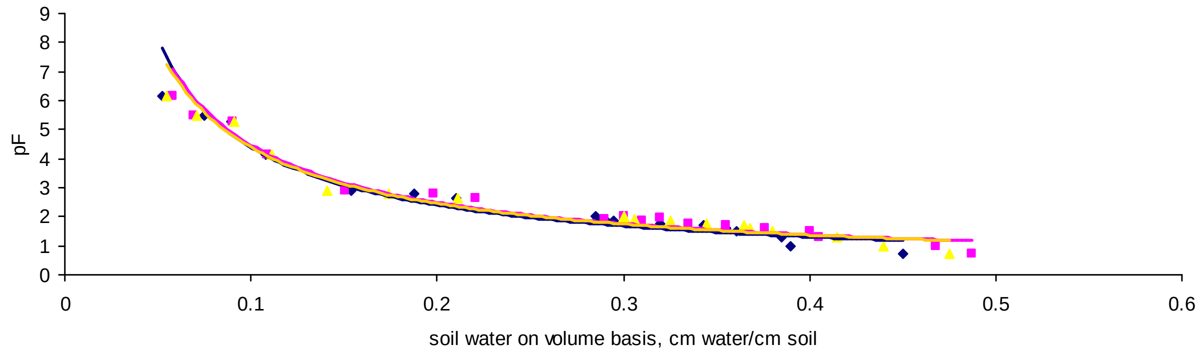

Figure 5 The lines representing the function pF=f(θ), for the three treatments belonging to the depth 0-25 cm. The relationship belonging to the first treatment is presented by the blue color, the second one by the purple color and the third one by the yellow color.

Table 11. The equations of regressions and its respective coefficients of determination belonging to the lines given in the figure 5.

Equations pF = f(θ)		
Treatment 1	Treatment 2	Treatment 3
$pF = 0.584\ \theta^{-0.876}$ R^2=0.91	$pF = 0.637\theta^{-0.85}$ R^2=0.92	$pF = 0.635\theta^{-0.84}$ R^2=0.91

The lines presented in the figure 5 almost don't show any significant differences. They almost overlap each other, which means that the treatment didn't affect the relationship pF=f(θ) in the layer 0-25 cm. However, the relationship does exist and the power function represents it as the best fit.

3.6. The results of the relationship pF=f(θ) for the entire range of the soil water suctions considered, layer 25-50cm.

Table 12. Soil water content on volume basis in various pF, the entire range of measurements, 25-50cm.

pF	Soil water content, θ, cm water/cm soil		
	Treatment 1	Treatment 2	Treatment 3
	0.405	0.633	0.673
0.69897	0.389	0.596	0.651
1	0.376	0.56	0.576
1.30103	0.34	0.503	0.571
1.47712	0.33	0.457	0.521
1.60206	0.325	0.455	0.51
1.69897	0.333	0.447	0.501
1.77815	0.3	0.441	0.471
1.8446	0.29	0.378	0.44
1.90308	0.32	0.333	0.435
1.95424	0.3	0.305	0.423
2	0.28	0.345	0.411
2.65321	0.182	0.221	0.265
2.77815	0.164	0.191	0.203
2.90309	0.145	0.155	0.159
4.16	0.115	0.113	0.121
5.28	0.105	0.101	0.09
5.5	0.09	0.085	0.081
6.16	0.067	0.06	0.071

The data of the above table are plotted in a graph in order to get a more realistic impression about the relationship between the soil water content and its respective soil suction. For a more understandable picture, on the y axis the values of pF are located ($pF=logH_m$). The values of soil water suction greater than 100cm (pF=2), but lower 800cm (pF=2.9), are measured by using tensiometers. The results of the regression analysis are presented in the following figure and in the following table.

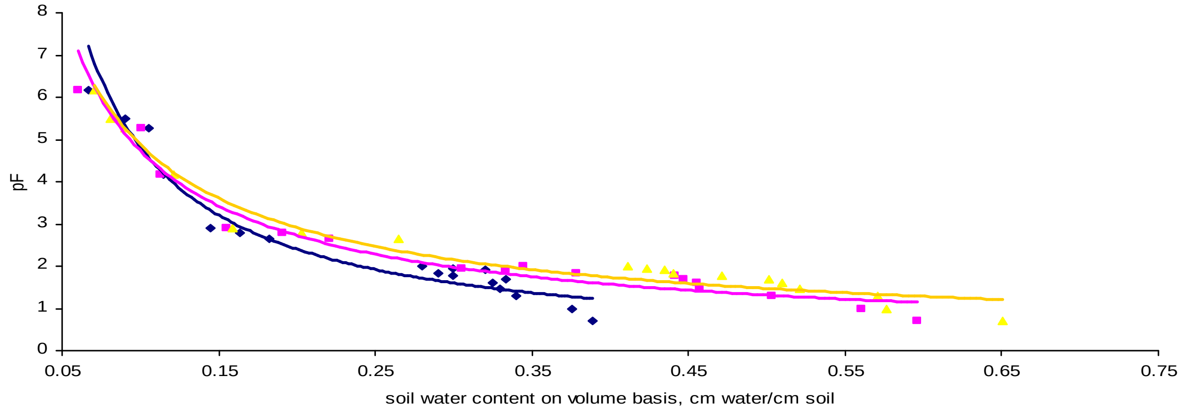

Figure 6 The lines representing the function pF=f(θ), for the three treatments belonging to the depth 25-50 cm. The relationship belonging to the first treatment is presented by the blue color, the second one by the purple color and the third one by the yellow color.

Table 13. The equations of regressions and its respective coefficients of determination belonging to the lines given in the figure 6.

Equations $H_m = f(\theta)$		
Treatment 1	Treatment 2	Treatment 3
$pF = 0.478\theta^{-1.003}$ $R^2=0.89$	$pF = 0.757\theta^{-0.796}$ $R^2=0.92$	$pF = 0.879\theta^{-0.744}$ $R^2=0.9$

The lines presented in the figure 6 show significant differences to each other. Even in this case, the power function represents the relationship as the best fit. In order to better understand the differences among treatments the following table will be presented.

Table 14. Soil water content on volume basis in as it is calculated by the formulas of the regressions found. The saturation is the only physical quantity which is not calculated, but taken from measurements.

Soil depth	Treatment	Saturation **cm/cm**	Field water capacity FWC, pF=2, **cm/cm**	Macroporosity volume, V_{po} 0<pF<2 **cm/cm**	Permanent wilting point, PWP pF=4.2 **cm/cm**	Soil water potentially available to plants, 2<pF<4.2 **cm/cm**
0-25 cm	1	0.409	0.245	0.164	0.105	0.14
	2	0.493	0.26	0.233	0.109	0.151
	3	0.456	0.255	0.201	0.105	0.15
25-50 cm	1	0.405	0.24	0.165	0.114	0.126
	2	0.633	0.295	0.338	0.116	0.18
	3	0.673	0.331	0.342	0.122	0.209

The Table 13 is meaningful in two directions in particular. Firstly, it shows that the treatment 3 and the treatment 2 have had a strong effect on the increase of the macro porosity, which is considered to be the porosity between saturation and the field water capacity. This statement can become understandable if the treatments 2 and 3 get compared with the traditional treatment, treatment1, according to the macro porosity volume in the 25-50cm soil layer. So, the macro porosity of the 25-50cm soil layer in the treatment 3 is twice as greater as the macro porosity of the same layer in the treatment 1, namely, 0.342 cm porosity/cm soil to 0.165 cm porosity/cm soil respectively. Secondly, we see from the table a significant increase of the soil water capacity available to plants in the soil depth of 25-50 cm, in particular in the treatment 3. The number 0.209 cm water/cm soil, at the end of the last column, shows a difference of about 0.083 cm water/cm soil in comparison with the treatment 1 of the same soil depth, which is 0.126 cm water/cm soil. If this difference would be converted into m^3 water/ha, then, just because of the type of tillage (treatment 3), the soil would have $200m^3$ water available to plants /ha more than the treatment 1, just in the depth 25-50 cm only.

4. Conclusions

1. The treatments showed no differences either in soil air capacity or in the soil water holding capacity in the top layer of soil: 0-25 cm.
2. In respect with the capability of soil to hold water, the treatments didn't show any significant difference in the high suction range, so above the suction corresponding with the permanent wilting point, pF=4.2. One more time, it is proved that in this range of suctions, the ability of soil to hold water doesn't depend on soil structure, consequently on the type of soil tillage that can affect it, but on the amount of clay only.
3. All the differences among the treatments were noticed in the soil under layer, 25-50 cm, which

indicates that the main effect of the conservative tillage is focused in this layer

4. The conservative tillage indicates that it has a very significant effect to increase the macro porosity of soil, which is going to create a better environment for the root system of vineyard to grow and develop

5. The conservative tillage indicates that it has a very significant effect to increase the magnitude of field water capacity (FWC) in deep soil layers, consequently, the amount of water that can be held by soil and become available to plant roots over time.

5. References

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