ORIGINAL PAPER

STUDIES CONCERNING THE ECOLOGICAL RECONSTRUCTION OF SOIL IN ORDER TO ENSURE A SUSTAINABLE RURAL DEVELOPMENT

CRISTIANA RADULESCU[1], ALEXANDRU SIDOR [2], CLARA STIRBU[1]

Manuscript received: 27.07.2013; Accepted paper: 30.08.2013;

Published online: 15.09.2013.

Abstract. *The present study aim to determine the effectiveness of the proposed ecological reconstruction method by using the perennial grasses (e.g. Festuca rubra, Poa Pratensis, Lolium perenne, and Medicago sativa) and dolomite (DEL-CA-MAG) as a soil amendment for a degraded soil (i.e. Valea Voievozilor area, Dambovita County, Romania), in order to improvements the quality indicators of analyzed soil. The physicochemical indicators of soil (e.g. pH, conductivity, salinity, TDS, redox potential, turbidity, humidity, carbonate, nitrate and nitrite concentration) were determined.*

Keywords: *soil, maize, perennial plant, dolomite, ecological reconstruction.*

1. INTRODUCTION

The ecological reconstruction requires a range of measures performed by humans through whom it restores the structure of biogeochemical, ecological and hydrological functions of diversity as well as the natural dynamics of degraded ecosystem. The main goal of the ecological reconstruction is to resume the natural functions held by an ecosystem and its evolution under natural conditions in order to the sustainable exploitation of the natural resources, thus improving the environmental and human life quality. The concept of ecological reconstruction is one of the actual in the context of biodiversity conservation and the development of environmental strategies that aim to stop the disappearance of plant and animal species phenomena, and to improve the environmental quality as well. In Romania, the assessment of soil degradation and their restoration is provided in H.G. no 1403/2007 from Romanian Regulation.

The main measure of ecological reconstruction is the application of amendments and fertilizers on degraded soil. The purpose of using the amendments is to correct the soil reaction, in order to improve its characteristics considering that mostly of cultivated plants requires a medium of reaction which range between a weak acid pH to neutral (i.e. pH 6.3 to 7) for a normal growth and development of plants.

The present study aim to determine the effectiveness of the proposed ecological reconstruction method by using the perennial grasses and dolomite (DEL-CA-MAG) as a soil amendment for a degraded soil (e.g. Valea Voievozilor - Razvad area), and the improvements the quality indicators of analyzed soil as well. Three years ago, the studied land area has been amended with the same amendment (DEL-CA-MAG), but in unknown concentration and without to study the soil properties. Therefore, this research aims to emphasize the necessity

[1] Valahia University of Targoviste, Faculty of Sciences and Arts, 130082 Targoviste, Romania.
E-mail: radulescucristiana@yahoo.com
[2] Valahia University of Targoviste, Faculty of Environmental Engineering and Food Science, 130082 Targoviste, Romania

to amend any degraded land with a known concentration of dolomite for the second time according with the recommended studies [1-4].

2. MATERIALS AND METHODS

The soil samples were collected from the Valea Voievozilor village, Dambovita County (Figs 1 and 2). This land was cultivated for over 25 years only with maize (i.e. *Zea mays L*) and it is well known that the soil is moderate salinized due to the presence by a fleet of crude oil storage and pumping near to the studied land. Three years ago, the owners observed a significant decrease of maize production due the increasing the soil acidity. Hence, they resorted to amend with dolomite the land without to assess the necessity of this intervention from agrochemical point of view.

Fig. 1. The investigated land on Romania map.

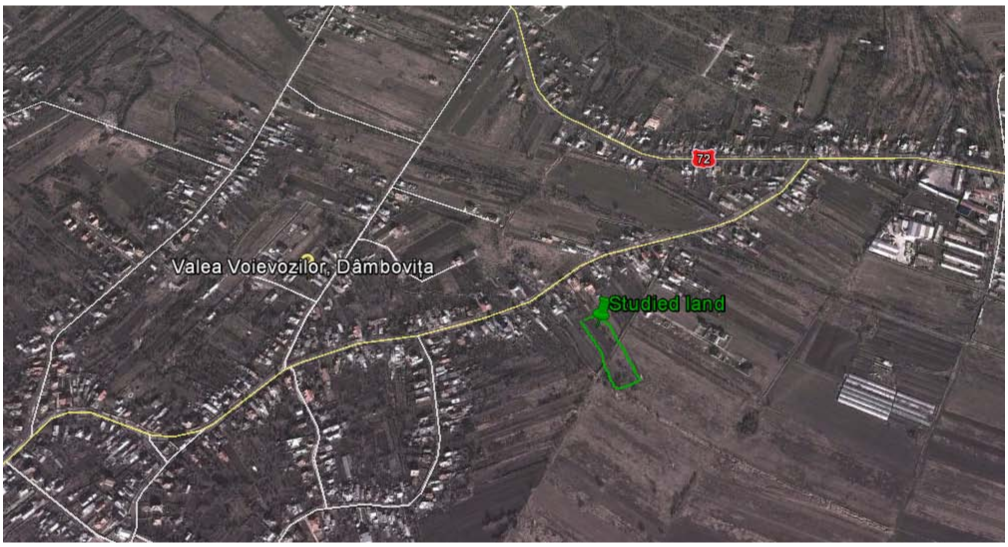

Fig. 2. The investigated land in Dambovita County, Valea Voievozilor respectively.

From investigated area were selected twenty well-established soil points according with [5]. The depth of sample for surface soils was 0 to 5 cm. From each point were collected approximately 5 soil samples which were mixed, finally being obtained a representative sample (25 kg) which was coded and treated according to data from Table 1.

The seeding of soil samples (Table 1) were carried out on November 18, 2012 for the perennial grasses (V2, V3, V4 and V5) and on December 19, 2012 for maize (V6 and V7) in flowerpot with the next dimensions: 18.5x14cm. During the vegetative period the seeded samples were monitored. Hence, was assured a constant temperature (i.e. 20^0C), light and water in climatic conditions. During the vegetative period was analyzed the evolution of perennial plants (e.g. size, density on pot, covering degree) and for maize samples (V6 and V7) were followed the sizes and growing season. The sampling was achieved in three stages: after the first sampling, the production for each flowerpot (g green weight/flowerpot) was determined; after the second sampling the production was calculated and then overseeding purposes with perennial plants (e.g. *Festuca rubra*-80%. *Poa Pratensis*-10% and *Lolium perenne*-10% as well as *Medicago sativa*, aproximatelly 16 g, on soil mixed with 100 g dolomite for V2, V3, V4 and V5 samples) was achieved. All this time, the possible modifications of quantity and quality indices were monitored.

Table 1. The amended samples.

Soil Code	Sample
P1	**V1** - Blank - Soil sample with the same characteristics with the soil of investigated land.
P2	**V2** - This sample was seeded with 30 g of a mixture of perennial grasses including *Festuca rubra* - 80%. *Poa pratensis* - 10% and *Lolium perenne* - 10%; after the second sampling the soil sample was seeded with the same mixture and was added *Medicago sativa* in an amount of 16 g.
P3	**V3** - This sample, which contains the soil from investigated land mixed with 100 g dolomite (DEL-CA-MAG), was seeded with 30 g of a mixture of perennial grasses including *Festuca rubra* - 80%. *Poa pratensis* - 10% and *Lolium perenne* - 10%; after the second sampling the soil sample was seeded with the same mixture and was added *Medicago sativa* in an amount of 16 g.
P4	**V4** - This sample which contains the soil from investigated land mixed with 200 g dolomite (DEL-CA-MAG), was seeded with 30 g of a mixture of perennial grasses including *Festuca rubra* - 80%. *Poa pratensis* - 10% and *Lolium perenne* - 10%; after the second sampling the soil sample was seeded with the same mixture and was added *Medicago sativa* in an amount of 16 g.
P5	**V5** - This sample which contains the soil from investigated land mixed with 300 g dolomite (DEL-CA-MAG), was seeded with 30 g of a mixture of perennial grasses including *Festuca rubra* - 80%. *Poa pratensis* - 10% and *Lolium perenne* - 10%; after the second sampling the soil sample was seeded with the same mixture and was added *Medicago sativa* in an amount of 16 g.
P6	**V6** - This sample contains only soil from investigated land which was seeded with maize
P7	**V7** - This sample contains the soil from investigated land mixed with 300 g dolomite (DEL-CA-MAG).

The soil sampling was accomplished at February 25, 2013. For each soil sample including P1-P7 the physicochemical indicators (e.g. pH, conductivity, salinity, TDS, redox potential, turbidity, humidity, carbonate, nitrate and nitrite concentration) were determined. Soil samples were air dried, ground, sieved to less than 2 mm diameter. The pH of soil was determined according with ISO 10390:2005. The conductivity, salinity and TDS were determined according with EPA 120.1., MSZ EN 27 888:1998 [6]. Redox potential of soil was determined according with [7] and SR 7184/12-88 [8]. The carbonate was determined in according with SR 7184/16-80 [9] and humidity in according with SR 7184/9-79 [10]. Dried soil was shaken with 2 M KCl using 1:10 soil: solution ratio and filtered through Whatman filter paper. Soil extracts were analyzed for NO_3^- and NO_2^- according with [11].

3. RESULTS AND DISCUSSION

The influence of the amendament including dolomite (DEL-CA-MAG) to the growing of perennial plants or maize crop can be investigated depending of the humidity of plant and weight as well. On the first sampling (Fig. 3) it can see that the sample V4 has a humidity by 83.33% and a dry weight by 16.66%. V2 sample present an equilibrate percent between humidity (i.e. 67.64%) and dry weight of plant (i.e. 32.35%) and this can be due to the fact that the soil is without amendament. V5 sample present the extreme values for both indicators, humidity and dry weight of plants.

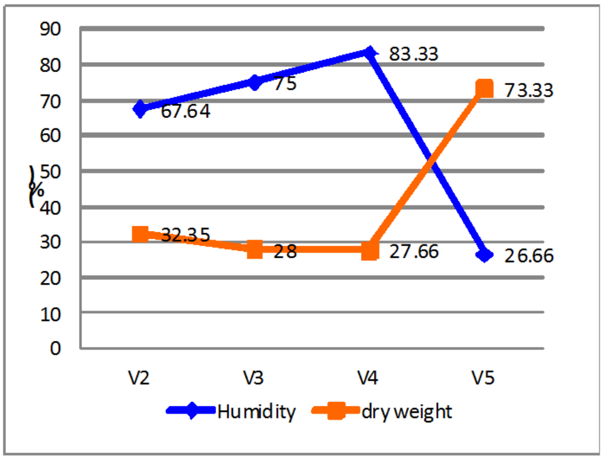

Fig.3. The correlation between humidity and dry weight of perennial plant at the first sampling.

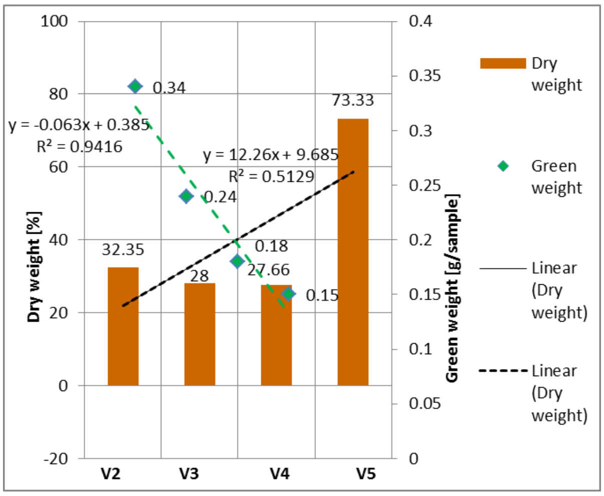

Fig. 4. Correlation between green weight and dry weight of perennial plants at the first sampling.

The high quantity of green weight of plant / sample was recorded at the second sample, V2 (Fig. 4) with 0.34 g green plant from which 32.35% was dry weight. The lower quantity of green plant (i.e. 0.15 g) was observed to the sample V5, which was amended with 300 g dolomite, and in this case 73.33% represent the dry weight.

To the second sampling (Fig. 5) it can observe a high humidity for all samples seeded with perennial plants (i.e. V2, V3, V4 and V5).

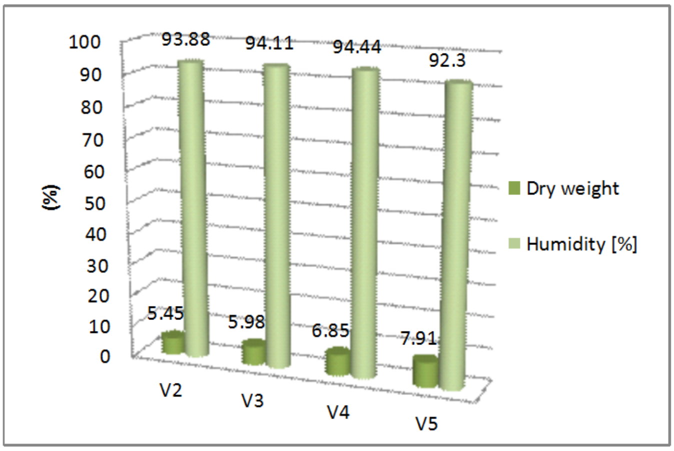

Fig. 5. Humidity and dry weight of perennial plants from the second sampling.

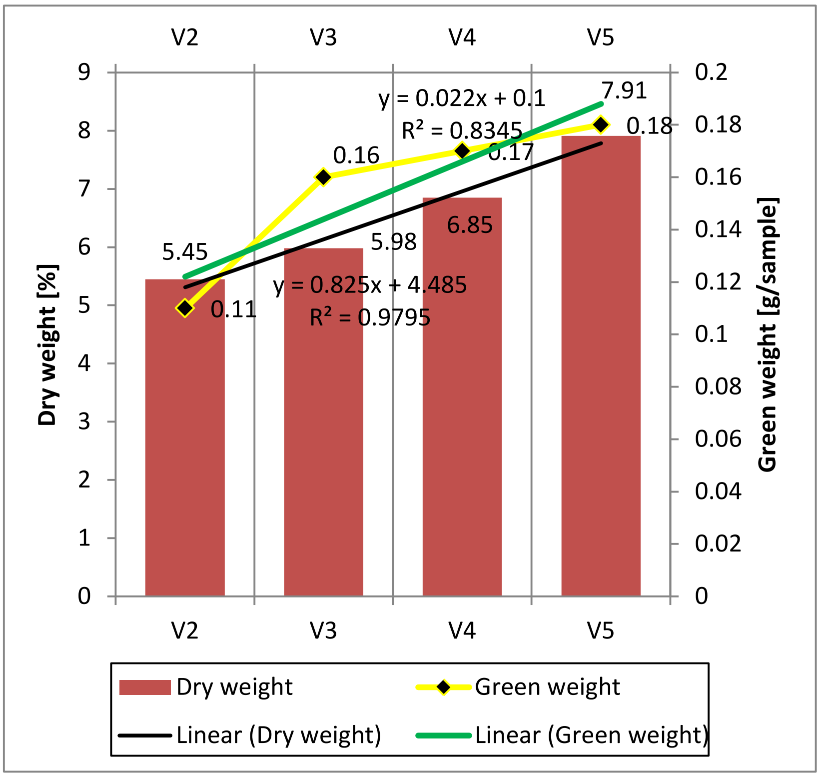

Fig. 6. Correlation between green weight and dry weight of perennial plants at the second sampling.

At the second sampling (Fig. 6) the recorded production has a similar values comparative with the first sampling (Fig. 4). A low quantity (i.e. 0.11 g) for the perennial plants was observed at the V2 sample and a high quantity (i.e. 0.18 g) was recorded a V5 sample, from which 7.91 represent the dry weight.

On the third sampling was observed a low values for humidity and dry weight for V3 and V4 samples (Fig. 7). A high value of humidity (i.e. 88.78%) was recorded for the V2 sample, followed by the value obtained for V3 sample (i.e. 85.71%).

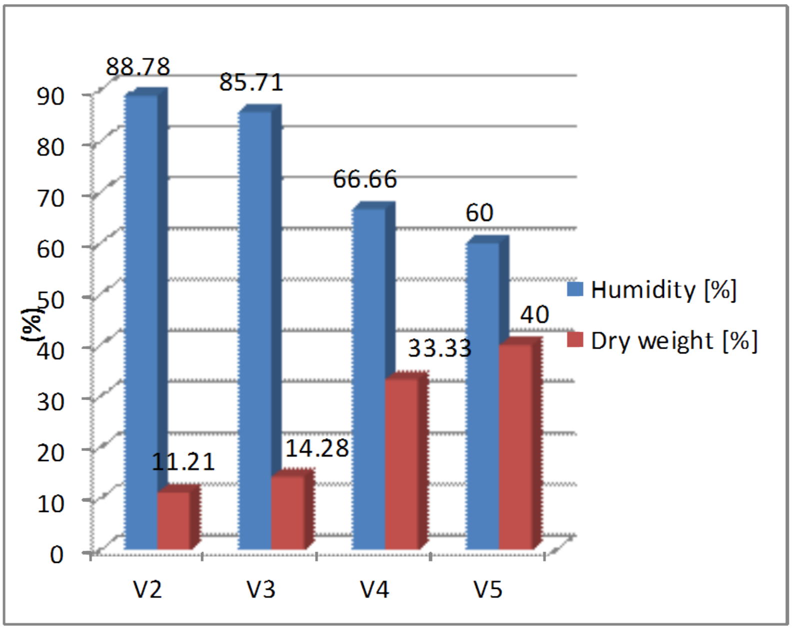

Fig. 5. Humidity and dry weight of perennial plants of the last sampling.

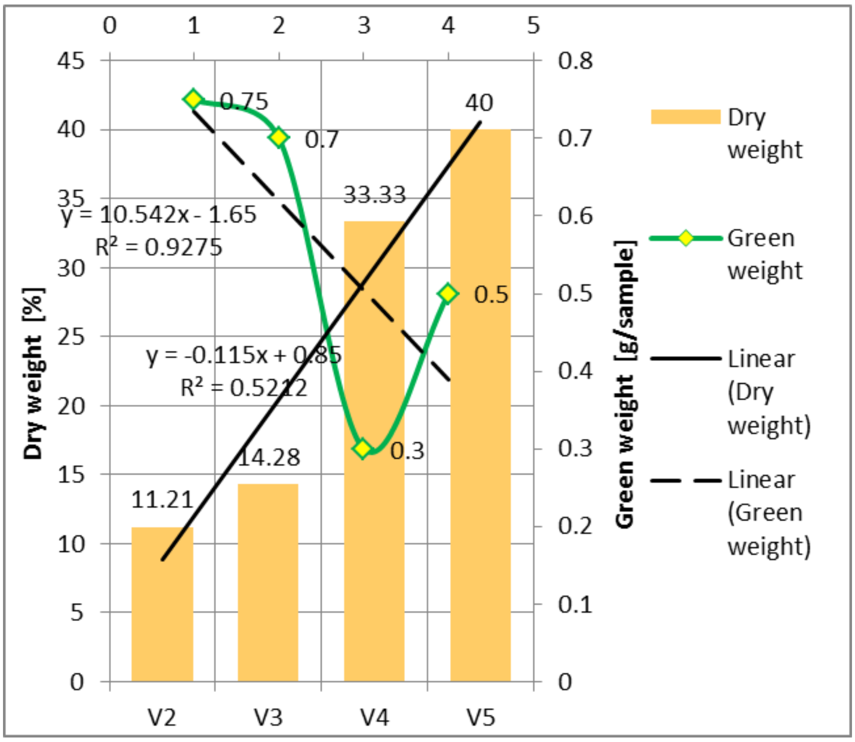

Fig. 8. Correlation between green weight and dry weight of perennial plants at the last sampling.

The las sampling of perennial plants was recorded an increase of green weight comparative with the other two productions due to the fact that was used the overseeding purposes variants (Fig. 8).

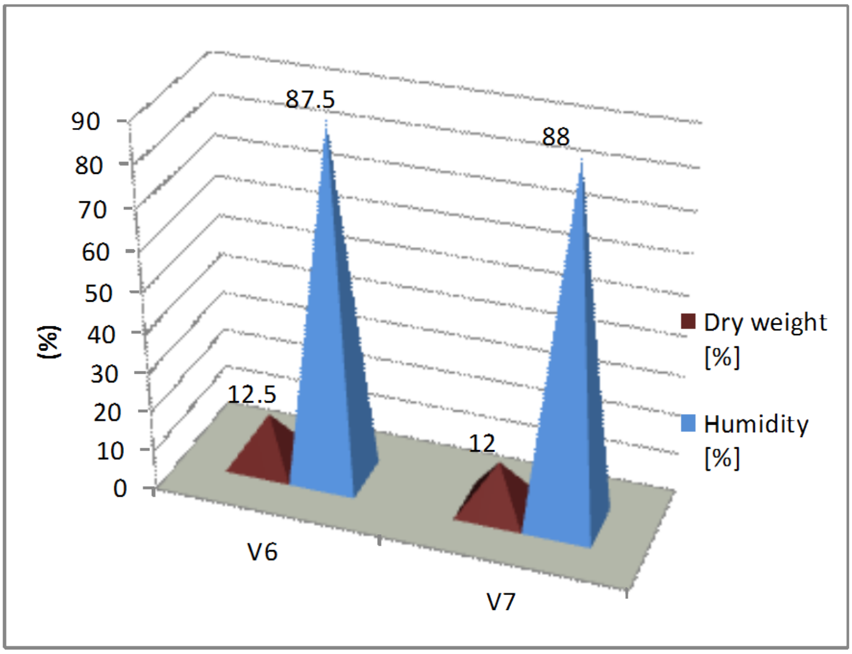

Fig. 9. Humidity and dry weight of maize (V6 and V7).

In the case of V6 and V7 samples (Fig. 9) it was observed a small diference between the humidity and dry weight of maize values. A slight increase of humidity value was recorded at V7 sample in which the soil was amended (i.e. 88%) comparative with the V6 sample without dolomite (87.5%).

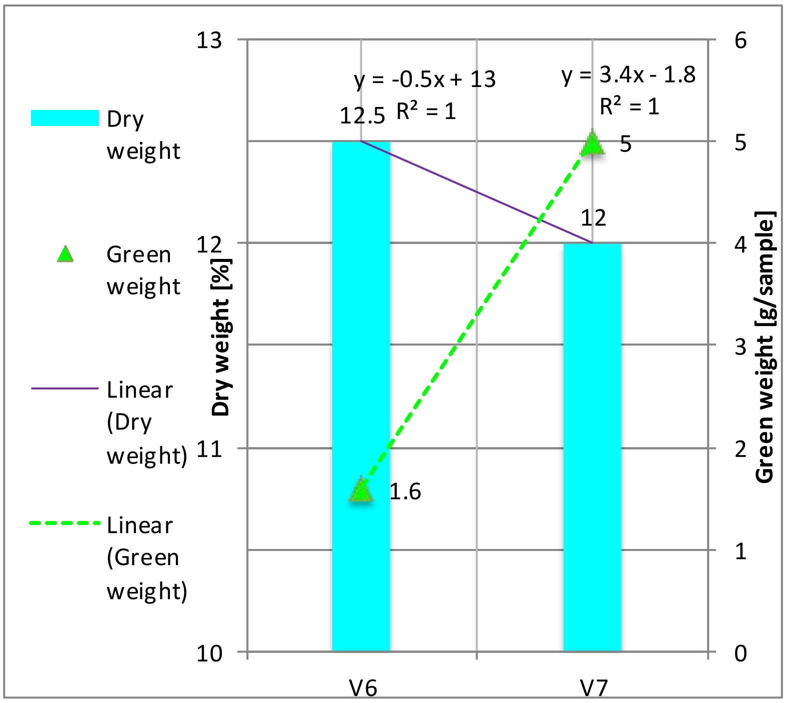

Fig. 10. Correlation between green weight and dry weight of maize for V6 and V7 samples.

Obviously, was recorded a significant increase of maize green weight (Fig. 10) at V7 sample (5 g), which was amended with 300 g dolomite, comparative with green production of maize from V6 sample (only 1.6 g) without dolomite.

Biometric measurements achieved throughout to the experiment were presented in Table 2.

Table 2. Biometric measurements

<table>
<tr><th>Sample</th><th>Density [cm^2]</th><th>Production (g vegetal weight /sample)</th><th>Period / Size [cm]</th><th>Root weight [g]</th><th>Growing energy Germination</th><th>Seed quantity [g]</th></tr>
<tr><td>V_1</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td rowspan="9">V_2</td><td rowspan="9">13 plant threats</td><td rowspan="3">0.34</td><td>After 10 days/13cm</td><td rowspan="9">1.2</td><td rowspan="9">4 days</td><td rowspan="9">30</td></tr>
<tr><td>After 20 days/13.5cm</td></tr>
<tr><td>After 30 days/15cm</td></tr>
<tr><td rowspan="3">0.11</td><td>After 40 days/3cm</td></tr>
<tr><td>After 50 days/3.5cm</td></tr>
<tr><td>After 60 days/4cm</td></tr>
<tr><td rowspan="3">0.50 + overseeding purposes</td><td>After 70 days/6cm</td></tr>
<tr><td>After 80 days/12cm</td></tr>
<tr><td>After 90 days/12.6cm</td></tr>
<tr><td rowspan="9">V_3</td><td rowspan="9">6 plant threats</td><td rowspan="3">0.04</td><td>After 10 days/9cm</td><td rowspan="9">1.3</td><td rowspan="9">6 days</td><td rowspan="9">30</td></tr>
<tr><td>After 20 days/10.5cm</td></tr>
<tr><td>After 30 days/11cm</td></tr>
<tr><td rowspan="3">0.17</td><td>After 40 days/4cm</td></tr>
<tr><td>After 50 days/4.5cm</td></tr>
<tr><td>After 60 days/5cm</td></tr>
<tr><td rowspan="3">0.70 + overseeding purposes</td><td>After 70 days/6.3cm</td></tr>
<tr><td>After 80 days/11.2cm</td></tr>
<tr><td>After 90 days/11.5cm</td></tr>
</table>

Sample	Density [cm^2]	Production (g vegetal weight /sample)	Period / Size [cm]	Root weight [g]	Growing energy Germination	Seed quantity [g]
V_4	8 plant threats	0.06	After 10 days/8cm	0.70	7 days	30
			After 20 days/11cm			
			After 30 days/12cm			
		0.18	After 40 days/5.5cm			
			After 50 days/6cm			
			After 60 days/6.2cm			
		0.30 + overseeding purposes	After 70 days/7cm			
			After 80 days/13.2cm			
			After 90 days/13.5cm			
V_5	12 plant threats	0.15	After 10 days/11cm	1.4	5 days	30
			After 20 days/13.5cm			
			After 30 days/14cm			
		0.13	After 40 days/6cm			
			After 50 days/6.5cm			
			After 60 days/6.8cm			
		0.50 + overseeding purposes	After 70 days/5.2cm			
			After 80 days/11.8cm			
			After 90 days/12.5cm			
V_6	1 maize threat	1.60	After 10 days/23cm	1.3	5 days	4
			After 20 days/30cm			
			After 30 days/35cm			
			After 40 days/38cm			
			After 50 days/38.4cm			
			After 60 days/39cm			
V_7	1 maize threat	5.00	After 10 days/24cm	4	5 days	4
			After 20 days/32cm			
			After 30 days/36cm			
			After 40 days/39cm			
			After 50 days/41cm			
			After 60 days/44cm			

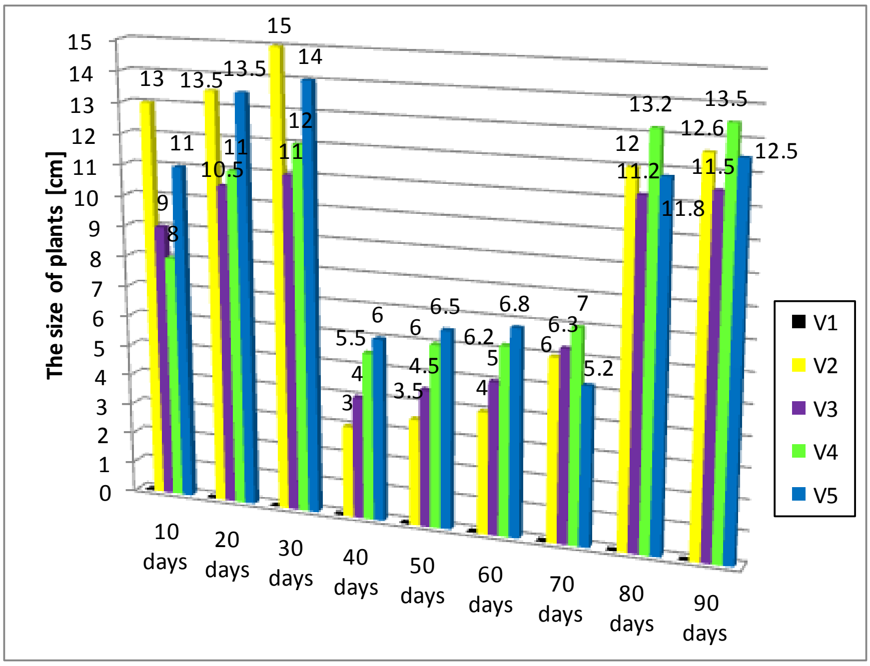

Fig. 11. The dynamics of plant size from V2, V3, V4, and V5 samples

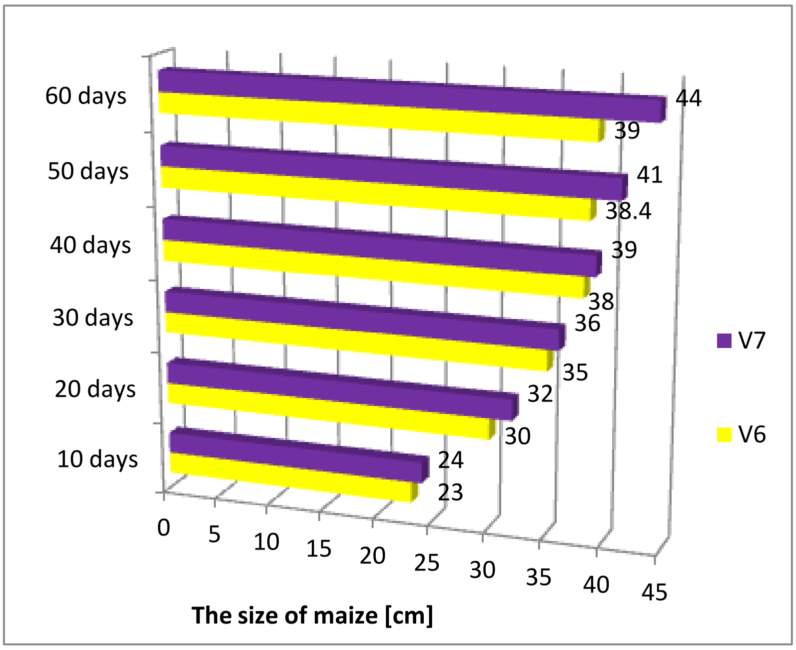

Fig. 12. The dynamics of maize size from V6 and V7 samples

The results from Table 2 show same biometric measurements achieved in the period of experiment. In Figs 9 and 10 are presented the dynamics of size for perennial plants (Fig. 11) and maize (Fig. 10) after each sampling period (I, II and III). For maize was observed a continued growth over a period of 60 days (Fig. 12). The difference of maize size appeared at V7 sample (44 cm after 60 days). Therefore, for V7 sample the presence of 300 g amendament (DEL-CA-MAG) in soil was benefic for maize growth.

If is analyzed the growth energy (Table 2 and Fig. 13) of perennial plants it observed a high difference of plant density (e.g. maximum 13 plant threats/cm^2 for V2 or 12 plant threats/cm^2 for V5 and minimum 6 plant threats/cm^2 for V3) comparative with growth energy of maize from V6 and V7 (1plant threats/cm^2 for both samples).

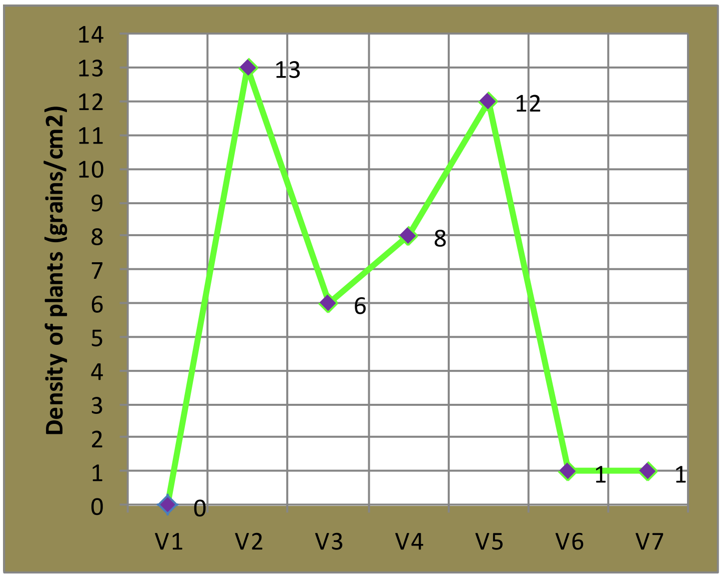

Fig. 13. The density of analyzed plants from experimental samples.

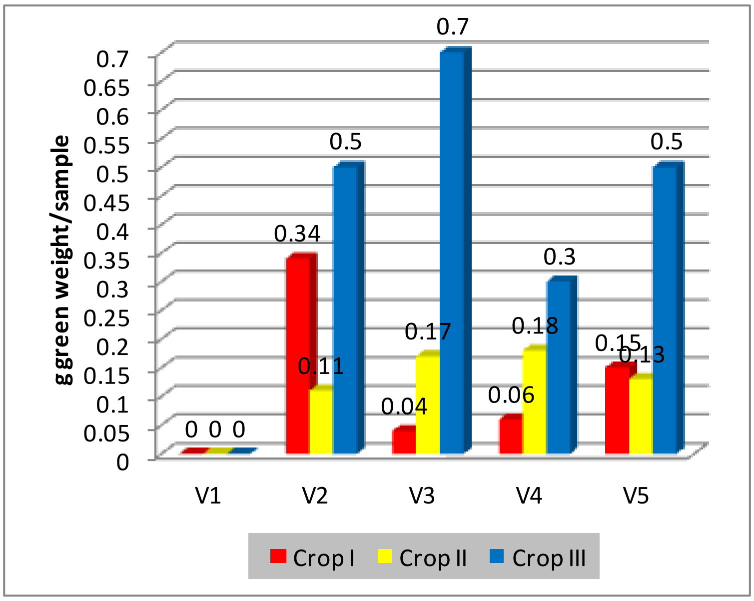

Fig. 14. Graphic representation of crops.

It was interesting to analyze the experimental crops (I, II and III, Fig. 14). Thus, it can see (Fig. 14) that V3 sample present a minimum (i.e. 0.04 g green weight/sample) and maximum (i.e. 0.70 g green weight/sample) production. It can conclude that the addition of dolomite in soil as amendament for 30 g mixture of perennial plants including *Festuca rubra* - 80%, *Poa pratensis* - 10% and Lolium perenne - 10% and then for 16 g *Medicago sativa* (crop III) lead to this difference between crop I and crop III. An ascendant growth of production after each sampling it observed for V4 sample. For each sampling of V2 and V5 samples were observed a green weight, which varies between minimum and maximum production of V3 sample.

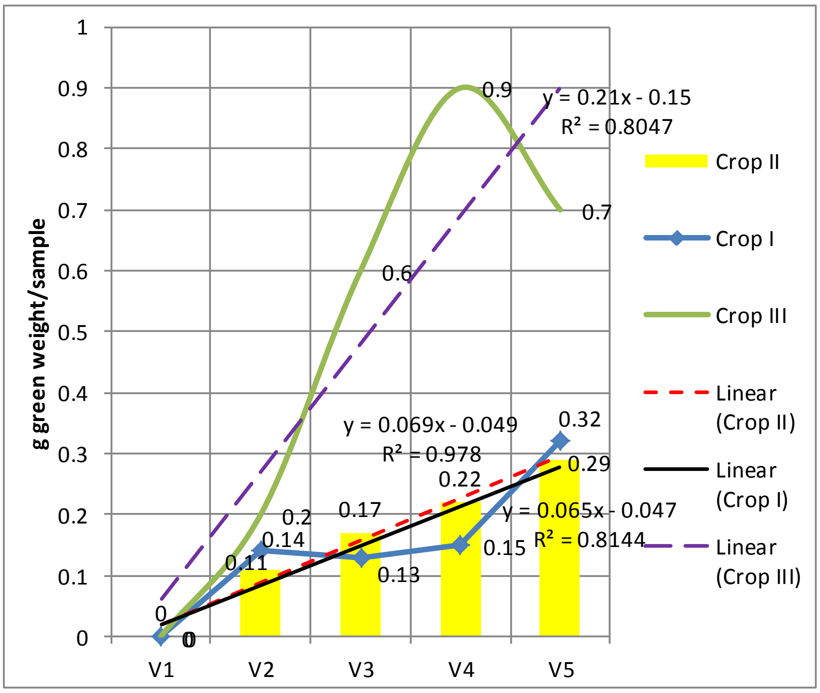

Fig. 15. The correlation of production in all crops.

Regarding the correlation of green plants production in all crops (Fig. 15) it can observe an increase of production at the first sampling at V3, V4 and V5 variants in which the soil was amended with dolomite. However, the maximum of production was for V5 sample (Fig. 15).

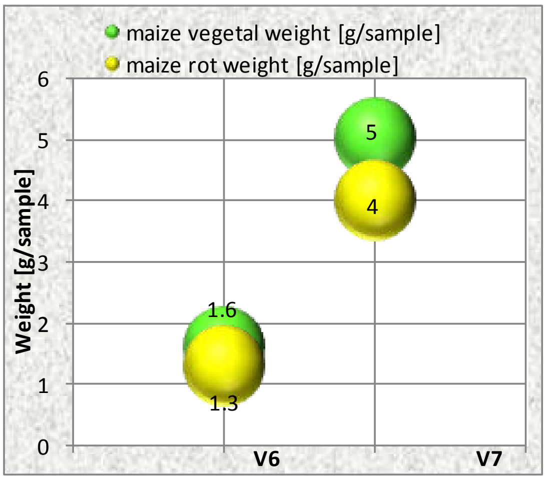

Fig. 16. The correlation between vegetal production and root weight at maize samples.

Concerning the correlation between vegetal production and root weight at maize samples (Fig. 16) it can conclude that the root of maize from V7 sample had a well developed radicular system due to the amendament (e.g. 300 g DEL-CA-MAG) and from this reason the maize has increased harmonious and healthy comparative with the maize from V6 sample which increased on a soil without dolomite.

Certainly, the crops production is influenced by the properties of soil. In this respect, the physicochemical indicators of collected soil were analyzed (Table 3). It is well known that the phenomenon of soil acidification is due to the high amounts of rainfall, which fell during the year, cumulated with the low temperatures and irrational exploitation of farmland. From Table 3 and Fig. 17 it can observe that the high humidity of soil (72.18%) has V2 sample, a soil without dolomite, and a low humidity of soil (33.67 %) has the V7 sample, where the soil was amended with 300 g dolomite.

Table 3. Physicochemical indicators of soil collected from Valea Voievozilor area

Indicator	Sample						
	P_1	P_2	P_3	P_4	P_5	P_6	P_7
Temperature [°C]	20.0	20.1	20.3	20.6	20.5	20.7	20.8
pH	7.95	7.99	8.04	8.01	8.05	7.5	7.4
Soil reaction	Weak basic	Weak basic	Weak basic	Weak basic	Moderate basic	Weak basic	Weak basic
Turbidity of aqueous extract [NTU]	39.29	43	39.23	30.57	20.9	12.27	7.2
Conductivity [mS]	9.34	9.42	9.43	9.17	9.09	8.9	9.05
Salinity [$\%_0$]	5.8	6	5.9	5.8	5.9	5.2	5.1
TDS [mg/l]	5690	5510	5520	5630	5570	4200	5530
Humidity [%]	44.77	72.18	70.09	63.79	69.05	47.09	33.67
$CaCO_3$ [%]	0.1	0.2	4	5	10	5	10
NO_2^- [mg/g dry soil]	0.07	0.102	0.093	0.114	0.109	0.1095	0.123
NO_3^- [mg/g dry soil]	2.38	2.67	2.14	2.53	2.43	2.431	2.61
Redox potential [mV]	471 Normal	470.4 Normal	481.2 Normal	480.6 Normal	484.2 Normal	463.2 Normal	471 Normal

Soil pH is one of the most important indicators of the chemical properties of a soi, which influence favorable or unfavorable the nutrient uptake by all plants. Application of chemical fertilizers, particularly those on base of nitrogen, something cheaper, without performing in advance an agrochemical study, which can specify the supply state of soil with nutrient and establishing doses for each culture, or total absence of fertilizer, has led to a pronounced decrease of pH as well as a drastically reducing the productive potential of farmland from Valea Voievozilor – Razvad area. However, the pH of aqueous extract for each soil sample (P1-P7) recorded values between 7.4 (P7) to 8.05 (P5), characteristic values for a weak basic reaction to a moderate basic reaction, respectively (Table 3 and Fig. 18).

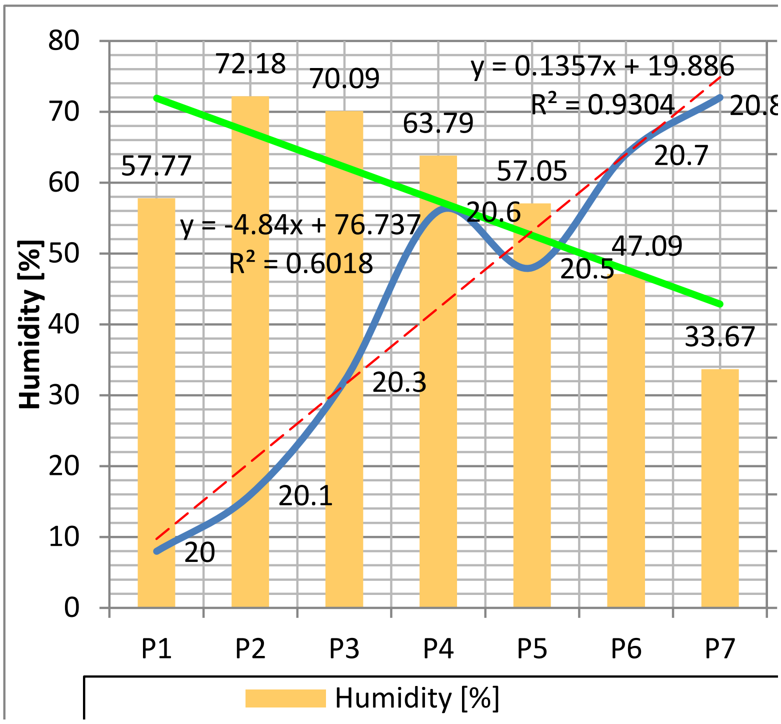

Fig. 17. Correlation between humidity and temperature of soil.

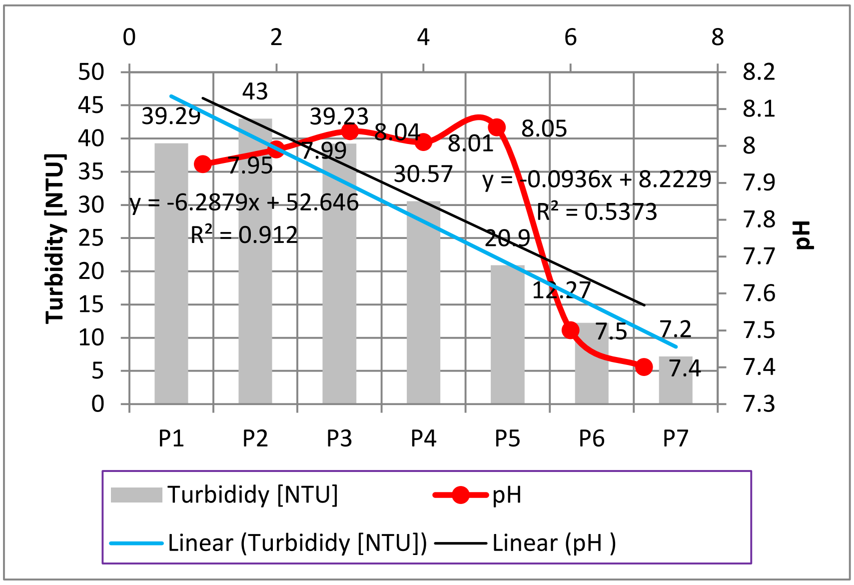

Fig. 18. Correlation between turbidity and pH in aqueous extract of soil.

The pH is influenced by the form of certain nutrients in the soil and in turn can affect the solubility of nutrients. Two nutrients whose form affects pH are nitrogen and calcium. Mainly, calcium occurs in the soil as $CaCO_3$ and therefore its concentration influences the pH of soil (Fig. 19).

Regarding the concentration of $CaCO_3$ (Figs. 19 and 20) it is possible that for perennial plants (V3, V4, V5) the $CaCO_3$ from dolomite is benefic for plant growth and this amount lead to increase the pH of soil to weak acid at weak basic. Too high a level of carbonate can cause a depression in the uptake of some nutrient including potassium and magnesium in these plants. In the case of V6 and V7 samples the presence of carbonate in high concentrations not induces a profund modification of soil pH (Fig. 19).

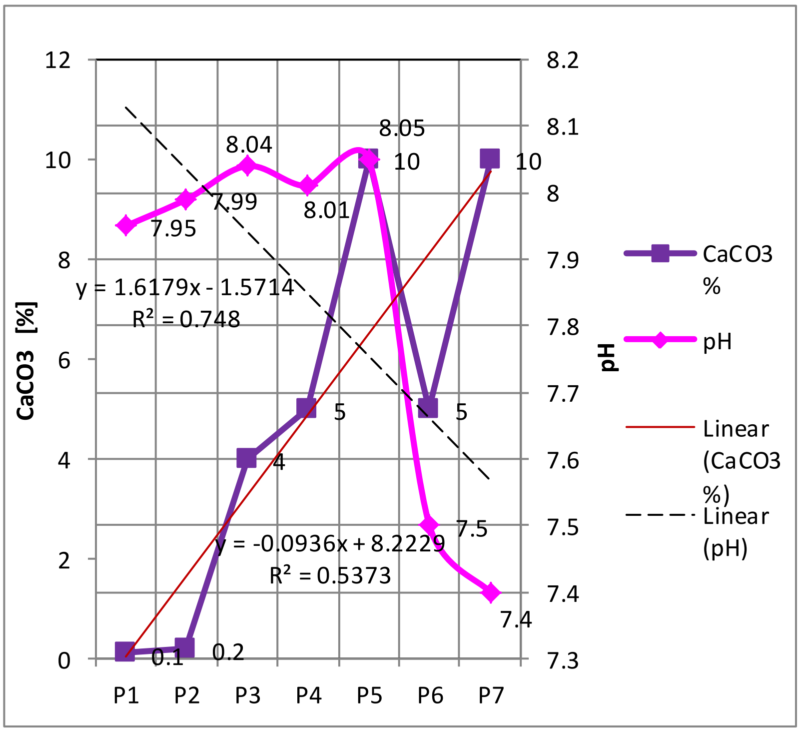

Fig. 19. Correlation between pH and amount of $CaCO_3$

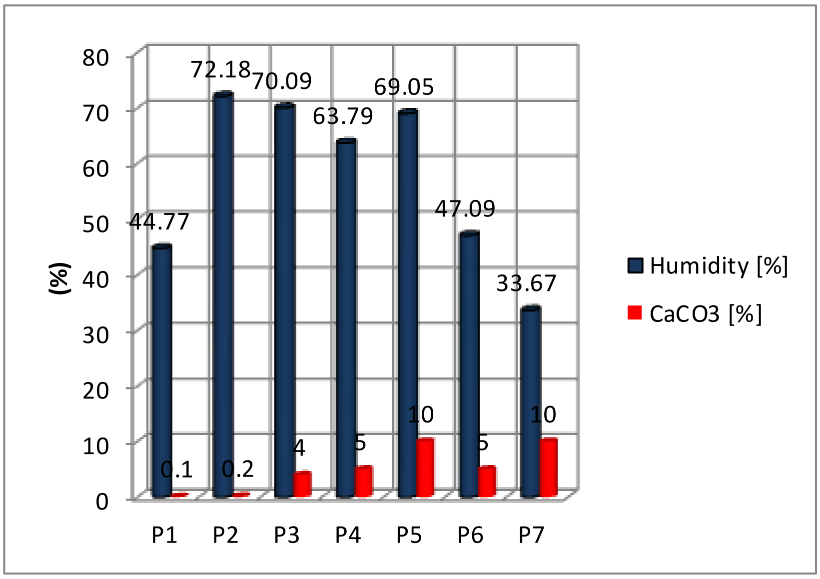

Fig. 20. Correlation between humidity and amount of $CaCO_3$

From Fig. 21 it can see that the analyzed soil is salinized. This can be explained by the presence of an oil park of the PETROM Society. The high salinity of soil was recorded in P1 sample, the blank, as well as in P2, P3, P4 and P5 samples. A lower salinity was recorded at P6 and P7 samples, thus the maize crop depletes soil by the salts. The conductivity was recorded around the value 9.0 mS for P6 and P7 samples and between 9.17 and 9.43 mS for other samples including the blank (9.34 mS)

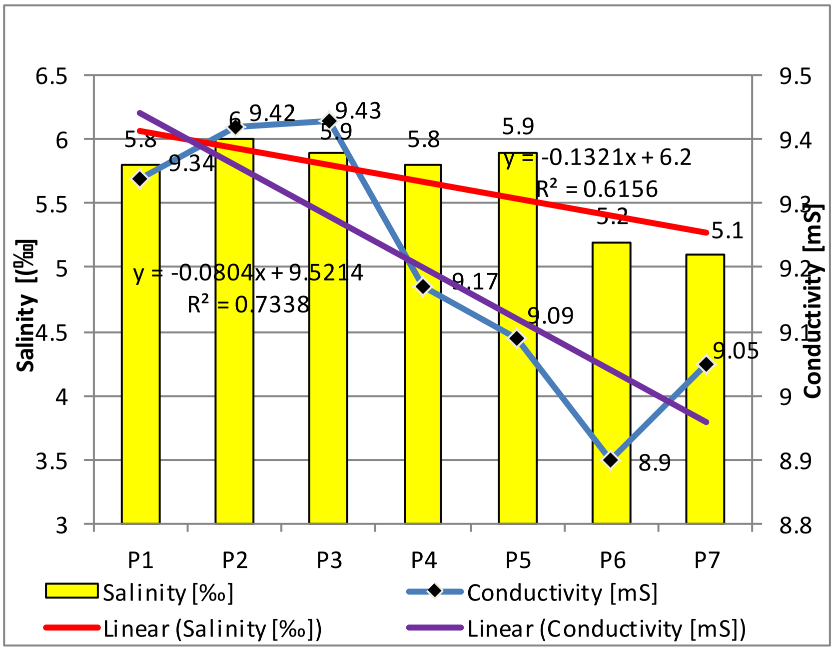

Fig. 21. Correlation between conductivity and salinity of aqueous extract of soil

The presence of carbonates in soil can be observed especially at P3, P4, P5 and P7, soils which were amended with dolomite. A soil amendment is any material added to a soil to improve its physical properties, such as water retention, permeability, water infiltration, drainage, aeration and structure. The goal of amendment is to provide a better environment for roots of plants. Dolomite is the most natural effective neutralizing conditioner for acidic soil and provides magnesium and calcium, essential plant nutrients. The chemical composition of dolomite (DEL-CA-MAG) used in this study is in according with Fig. 22.

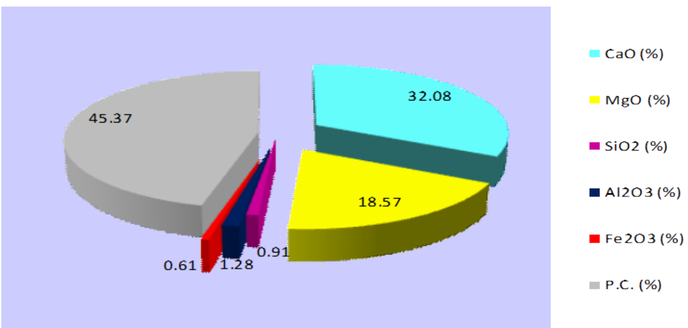

Fig. 22. Chemical composition of dolomite (DEL-CA-MAG)

By analyzing the correlation between pH and amount of amendment (Fig. 23) it can observe a decrease of pH value concerning the P6 and P7 samples. For P1 and P2 samples, where soil is without dolomite, the pH values are 7.95 and 7.99 respectively. In this case the quality indicators of soil were mentained. In the case of P3, P4 and P5 samples, where the soil was mixed with dolomite, it was observed an increase of pH till 8.05 characteristic to a moderate basic reaction.

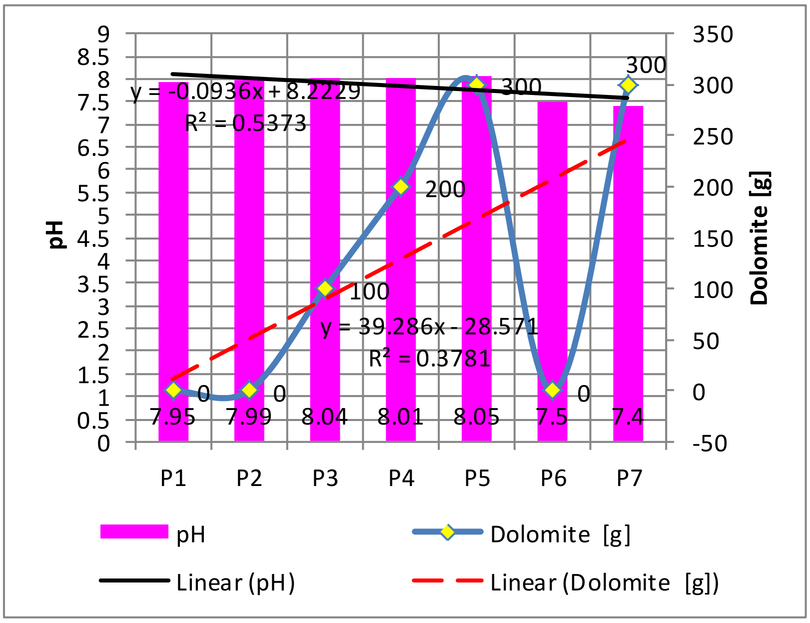

Fig. 23. Correlation between pH and amount of amendment (DEL-CA-MAG)

For leaching to occur, nitrogen must be soluble in water, mobile form and abundant enough to transport nitrogen through the soil. The nitrite is mobile as well, but neither exists in high concentrations in soil. Nitrate is the nitrogen form most susceptible to leaching. Nitrate leached below the root region for most agronomic crops will eventually leach downward until it reaches a saturated zone. The rate of nitrate movement downward depends on a variety of factors, including soil texture, precipitation and irrigation amounts, and crop uptake of water and nitrate. In this study the nitrate/nitrite concentrations in soil (Table 3 and Fig. 24) are in acceptable limits according with Romanian legislation.

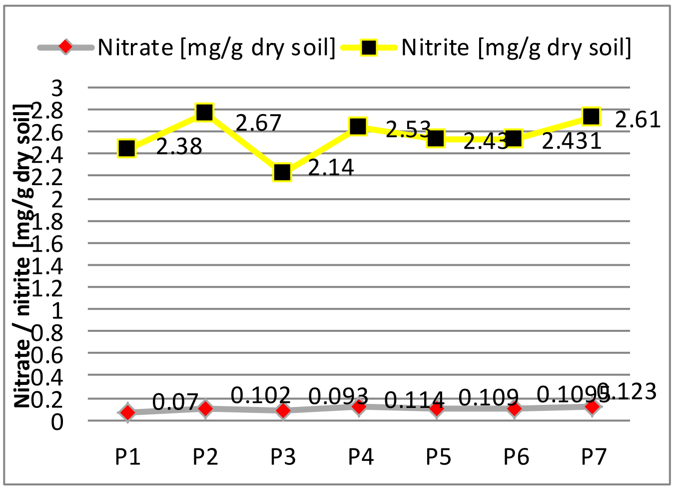

Fig. 3.24 Content of nitrate/nitrite in soil

4. CONCLUSIONS

By this study it can conclude that the mixture of perennial plants can be an ecological alternative concerning the self-adjustment and regeneration process of soil from Valea Voievozilor area, thus removing additional amendment including dolomite (DEL-CA-MAG). Unfortunately, the owners applied successive amendments in the last ten years, without a agrochemical research of the land in desire to obtain the maize crops largest possible. Three years ago, the last amendment has maintained a weak basicity of soil, which is favorable to maize crop. Once every three or five years it is recomended that the owners from Valea Voievozilor area, applied an amendment with DEL-CA-MAG, which has a benefic contribution in nutrients (i.e. calcium and magnesium) in order to assure the maize growth, maintaining an weak/moderate basic pH of soil. Certainly, if the owners intend to change the category of using from maize crop in grassland it is not recommended the amendment soil because the perennial grasses provides a natural self-adjustment process of the soil, offering the possibility to maintain the soil quality indicators.

REFERENCES

[1] *****Institutul National de Cercetare-Dezvoltare pentru Pedologie, Agrochimie si Protectia Mediului – ICPA Bucuresti, *Studiu documentar asupra zacamantului de dolomita de Ia Delnita, judetul Harghita, in legatura cu importanta acesteia pentru agricultura*, 2011.
[2] Borlan, Z., Hera, Cr., *Metode de apreciere a starii de fertilitate a solului în vederea folosirii raționale a îngrasamintelor*, Ed.Ceres, Bucuresti. 1973.
[3] Davidescu, V., Davidescu, D., *Compendium agrochimic*, Editura Academiei Române. Bucuresti, 1999.
[4] Vintila, I., Borlan. Z., Rauța, C., Daniluc, D., Țiganas, L., *Situația agrochimica a solurilor din România*, Ed.Ceres Bucuresti, 1984
[5] *****EPA/600/8-69/046, *Research and Development. Soil Sampling. Quality Assurance*. User's Guide, Second Edition, 1989
[6] Benton Jones Jr., J., *Laboratory Guide for Conducting Soil Tests and Plant Analysis*, CRC Press, 2001.
[7] ***** HG nr. 1408/2007, *Ghid Tehnic privind modalităţile de investigare şi evaluare a poluării solului şi subsolului*
[8] STAS 7184/12-88, *Soluri. Determinarea proprietăţilor de schimb cationic*
[9] STAS 7184/16-80, *Soluri. Determinarea carbonaţilor alcalino-pământoşi*
[10] STAS 7184/9-79, *Soluri. Determinarea umidităţii*
[11] Norman, R.J., Stucki, J.W., *The Determination of Nitrate and Nitrite in Soil Extracts by Ultraviolet Spectrophotometry, Soil Science Society of America Journal*, **45**(2), 347, 1981.