PRESENT ENVIRONMENT AND SUSTAINABLE DEVELOPMENT, VOL. 7, no. 1, 2013

DISTRIBUTION OF TWO ELEMENTS (P, K) WITH NUTRITION ROLE IN SOILS OF FĂLTICENI AND SÂRCA APPLE-GROWING AREAS (ROMANIA)

Ionuţ Mihai Prundeanu[1], Ovidiu Gabriel Iancu[2], Nicolae Buzgar[3]

Key words: mineral elements, orchard soil, fruit trees.

Abstract: The present paper analyses the distribution of two elements (K and P) with nutrition role in the soils of the apple orchards located in the NE of Romania. Three types of soil samples were collected; topsoil (0-20 cm) from the apple-tree rows, soil samples from the 20-40 cm depth interval and topsoil (0-20 cm) from the middle of the apple tree rows. Soil analyses were performed by means of EDXRF at the Geology department of "Al. I. Cuza" University from Iaşi. K and P concentrations were obtained from the K_2O and P_2O_5 total content in soils. Using specialized software distribution maps were created. The distribution tendency of the two elements shows that there is a quantifiable accumulation closer both to surface and the apple tree rows. The soil supply with P and the linear correlations between the elements and pH and $CaCO_3$ were also determined.

Introduction

Considering the content and their role in plants, K and P are included in the "major elements" group (Madjar et al., 2009).

Although they are present in small quantities in the composition of the living tissues, there were identified over 800 enzymes which contain mineral elements. For the fruit trees, some elements are useful in high quantities (tens of kg/ha), this being also the case of K and P (Voiculescu et al., 2001).

One of the main elements with role in the fruit tree nutrition is potassium. Soil concentrations in this element are controlled by the presence of K minerals, weathering and the leaching of the element.

In case of acid soils, like the ones present on the RPCFG (Research and Production Centre of Fruit-Growing) Fălticeni surface, K ions have a catalytic

[1, 2, 3] „Alexandru Ioan Cuza" University of Iași, Faculty of Geography and Geology, Department of Geology, 20A, Carol I Boulevard 700505, Iaşi, Romania, prundeanu.ionut@gmail.com, ogiancu@uaic.ro, nicolae.buzgar@uaic.ro

function in the bonding of $NH4^+$ ions. Bonding of K^+ can be done easier if the pH is higher, because K^+ ions are replacing Ca^{2+} easier than H^+ ions in the clay minerals (Hornung et al., 1975).

K doesn't form biochemical compounds; it is present as ions in the vegetal transport vessel system. K helps in the synthesis of carbohydrates and proteins, acting also in the adjustment of tissues permeability (Voiculescu et al., 2001).

P concentrations in soils range from 0.20% to 0.08%. In acid soils P is mainly bonded to the clay minerals and on the surface of the Fe and Al oxides. Therefore, mobile P is in inverse proportion with the clay content of soils (Hornung, 1975).

One of the energy sources used in the metabolic processes of the vegetal organisms is coming from phosphorous compounds, which trough enzymatic hydrolysis free up between 7000-13000 calories per molecule (Madjar et al., 2009).

P deficiency affects the growing process of the roots and branches, in the worst cases can lead to the defoliation of the fruit trees (Voiculescu et al., 2001).

The first studied area is located at the Research and Production Centre for Fruit-Growing Fălticeni. The settlement of RPCFG Fălticeni covers the southern versant and the first terrace of the Şomuzul Mare brook, as well as the first terrace of Moldova river, with slopes between 7-42%, (SCPPF, 1982).

The area's relief is formed by hills and alluvial plains. The crests of Stânişoara Mountains are located to the west, close being also the couloir of Moldova Valley, with several terraces. To the east, till the Siret Valley, extends the Fălticeni elevated plateau with altitudes between 260 m in Şomuz Valley and 351 m for the Oprişeni Hill (Erhan et al., 1964).

The climatic conditions are temperate to continental with Baltic influence with multi-annual (50 years) temperature average of 8.10°C (Agenda Locală 21, 2004).

Superimposed on the area corresponding to RPCFG Fălticeni are Volhinian deposits with some interbedded coal layers.

The soils present in the Fălticeni fruit-growing area belong mainly to the Haplic Phaeozem type, while on the calcium rich deposits (argillaceous marls) Rendzinic Phaeozem soil had formed (Costan et al., 1962).

Sârca apple-growing area is located in south-west of Jijia hilly plain. Farm no. 6, the second area from which the soil sampling has been made, is characterized by Chernozem soils, more precisely Haplic and Calcaro-calcic Chernozems (Boronia, 2010). The variation of the annual air mean temperatures is low (8.8–9.5°C), the multi-annual average at the Podu Iloaiei station is 9,3°C.

On the expansion of the Sârca fruit-growing area, beside Quaternary deposits, Sarmatian age deposits crop out.

1. Methodology

The soil sampling from the apple tree rows was done using a 100 m square grid. Beside the soil samples from the fruit tree rows, another two sets of samples were collected. One of them is from the 20-40 cm depth interval and the other one from the middle of the apple tree rows. These soil samples have a distance of 300 m between them.

Thus, 3 types of samples were taken:

I. Sârca fruit-growing area, sampled surface of approximately 50 ha (Fig.1):

- 60 samples from the apple-tree rows (Fig.4);
- 12 samples from the middle of the apple-tree rows;
- 12 samples from the 20-40 cm depth interval.

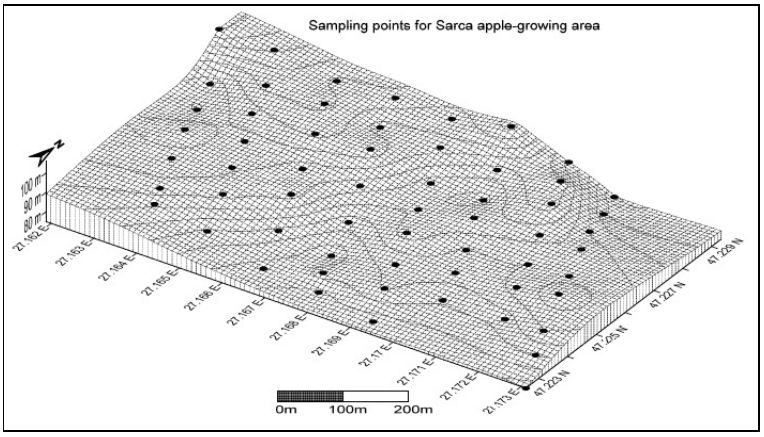

Fig.1 Sampling points distribution in the Sârca apple-growing area

II. Fălticeni fruit-growing area, sampled surface of approximately 40 ha (Fig.2):

- 49 samples from the apple-tree rows (Fig.2);
- 10 samples from the middle of the apple-tree rows;
- 9 samples from the 20-40 cm depth interval.

Each sampling point was located using 2 ASUS PDA 636 GPS's.

The 152 soil samples were grinded using a porcelain jar and then sieved to <1 mm. Trough consecutive quartering samples of approximately 30 g were obtained,

these were mixed with resin using a 4:1 ratio. The mixture was then homogenised for 15 min and 180 rpm with a „Fritz" planetary mill. Last step consisted in preparation of powder-pressed pellets from 9 g of soil–resin mixture at 20t/cm2.

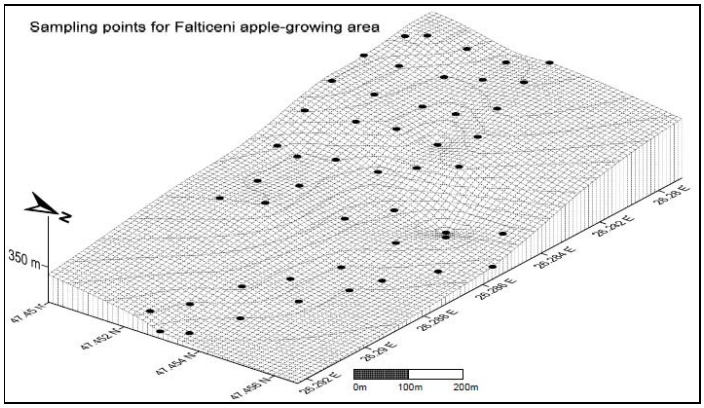

Fig.2 Sampling points distribution in the Fălticeni apple-growing area

The standardization of the EDXRF was performed by using 23 standards: 14 standards provided by Geological Survey of Japan (JA-1-3: andesite powder; JB-1-3: basalt powder; JLk-1: lake sediment powder ; JSd-1- 3: stream sediment powder; JR-1-2: rhyoliye powder; JMs-1-2: marine sediment powder), 8 standards provided by CCRMP-CANMET MMSL Natural Resources Canada (SO-1-4: regosolic clay soil, podzolic B horizon soil, calcareous C horizon soil and chernozemic A horizon soil; STSD-1-4: stream sediment powder) and 1 standard provided by USGS, United States Geological Survey, (RGM-1: rhyolite powder). The exposure time was 60 s. The detection limits for the elements analyzed are the following: K - 0.07%, P_2O_5 - 1650 mg/kg.

3. Results and discussions

The values of K and P concentrations used in this paper were obtained from the K_2O and P_2O_5 content.

In terms of abundance K is the eighth element in the earth's crust K (2-2.5%), is located in the IA group in the periodical table of elements. It's very chemically active, therefore isn't found free in nature. It doesn't have many applications in pure state, but K compounds are having an important role in the fertilizer industry. Is a white-silver colored metal with a melting point of 63^oC and a density of 0.862 g/cm^3 (Newton, 2010).

For the soil sampled from Fălticeni K concentrations range between 1.14-2.20%, with an average of 1.91%, this being a very similar value to the terrestrial

crust content. The results distribution shows a negative skewness of -1.28 with a low variation coefficient of 11.5% (Fig.3).

Regarding the interdependence between K contents and the soil parameters, as pH and %$CaCO_3$, a negative correlation was noted, with a significant value of -0.55 for the K&$CaCO_3$ pair.

2 variables removed

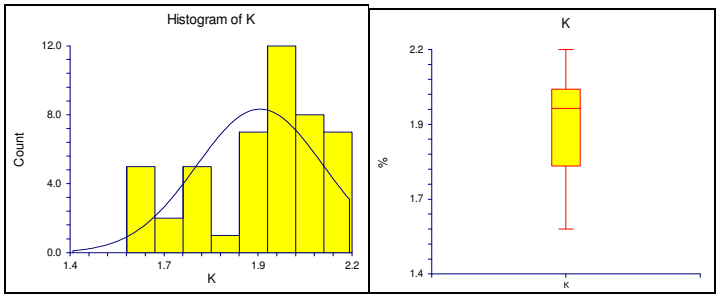

Fig.3 Histogram and Box Plot diagram for K in Fălticeni apple-growing area

The distribution of K content on the surface of RPCFG Fălticeni is mainly a random one with a certain tendency of concentrating in the low altitudinal areas, due to the soil washing by the meteoric water and a lower circulation of the underground water. An exception is made for the areas characterized by a high percentage of carbonates in soil as in the case of some samples from the N-NE (Fig.4).

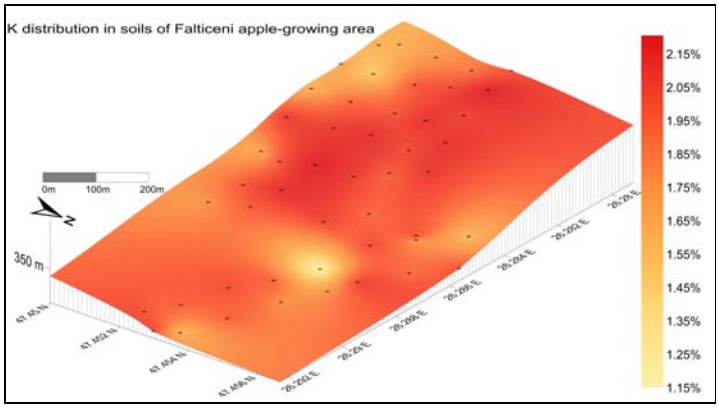

Fig.4 K distribution in soils of Fălticeni apple-growing area

At Farm no. 6 from Sârca the K concentrations ranging from 2.06% to 2.46%, with an average value of 2.31% K, similar with the abundance in the earth's crust. The data set shows a normal distribution, the skewness is -0.89 and the variation coefficient 3.74%. The kurtosis had also a small value, respectively 0.33 (Fig.5).

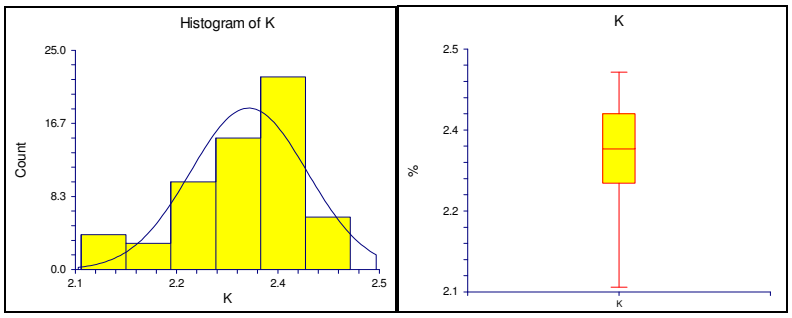

Fig.5 Histogram and Box Plot diagram for K in Sârca apple-growing area

The linear correlations between K & pH and $CaCO_3$ maintain the observed trend in the other study area, both values are negative, the difference in this case is given by the stronger negative correlation for the couple K and pH -0.36.

On the distribution map an area with high contents is taking shape in the centre-north part, close to an older apple orchard, while the area characterized by lower concentrations is represented by a parallel strip in the closeness of the highroad (Fig.6).

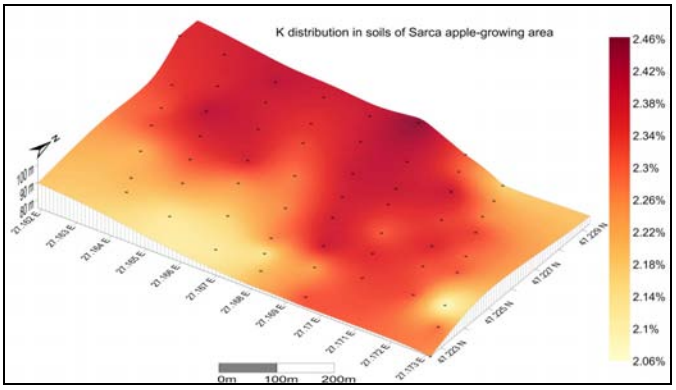

Fig.6 K distribution in soils of Sârca apple-growing area

Phosphorous is part of group VA from the periodic table, being the eleventh element by abundance in the earth's crust (0.12%). Is found mainly in phosphates composition, the primary use of P being in agriculture and then, on the second place, in the manufacture of detergents (Newton, 2010).

2 variables removed

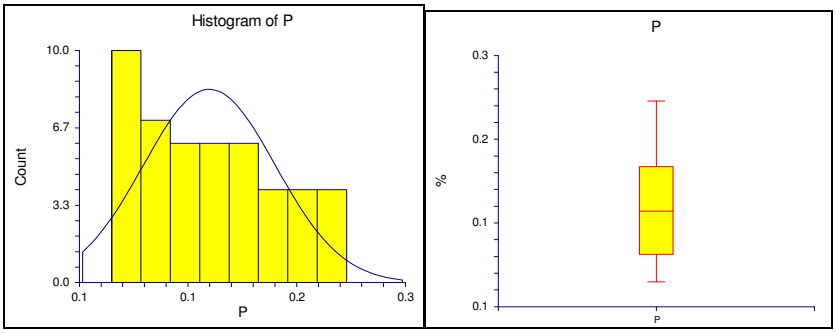

Fig.7 Histogram and Box Plot diagram for P in Fălticeni apple-growing area

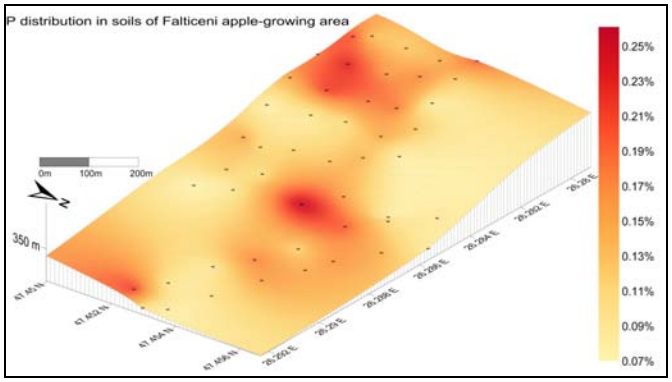

Fig.8 P distribution in soils of Fălticeni apple-growing area

The data distribution in the topsoil of RPCFG Fălticeni shows an average content of 0.134% P, with a range of 0.07-0.262% P. The statistical parameters show a normal distribution of the P contents with a skewness of 0.69 (Fig.7).

The level of soil supply with P can be determined depending on the P_2O_5 concentrations (Teaci; 1954 fide Hornung, 1975). For the Fălticeni study area the results show a P rich to very rich soil.

On the interpolated surface we can observe particular concentrations of P. In the central part one of the samples shows a clearly higher P content (Fig.8). This sample is close to a chemical preparation shack used to prepare the spraying solutions. Unwanted discharges can explain the high content of P also. Regarding the linear correlations for the P contents and the soil parameters, only the pH values have a significant connection with P concentrations, -0.37.

3 variables removed

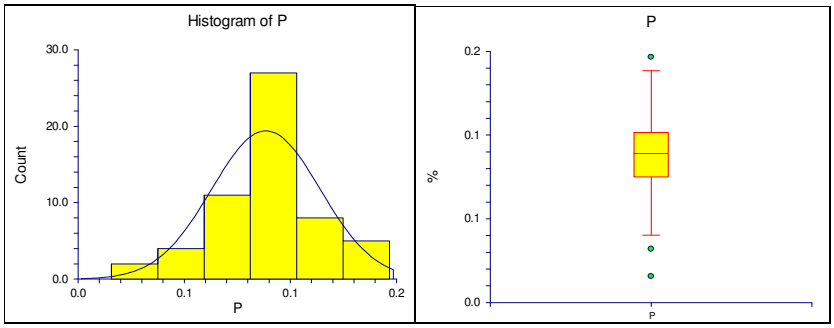

Fig.9 Histogram and Box Plot diagram for P in Sârca apple-growing area

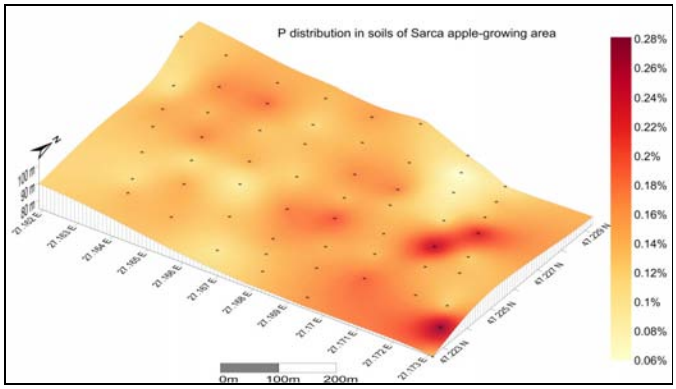

Fig.10 P distribution in soils of Sârca apple-growing area

Farm no. 6 from Sârca has a uniform geochemical distribution for the P contents, with the exception of three sampling points located in the eastern part of the studied area. For these abnormal concentrations wasn't found any direct explanation (Fig. 10). After the data processing results show a low variation coefficient of 27.21% and a skewness of 1.34 (Fig.9).

The average content of P is 0.14%, with a minimum value of 0.057% and maximum 0.284% P. The higher variation of the P concentrations for the Sârca study area is reflected also in the level of soil supply with this element; according to the values of P the soil is average to very well-supplied.

From the table 1 it can be observed that the K and P contents are higher for the Sârca study area, the difference being bigger for K, this can be explained by a more intensive presence of K-rich minerals.

When comparing the concentration values of the 3 soil sample types it can be easily seen an accumulation of K and P on the apple tree rows, where the average contents are considerable higher.

Tab.1 Statistical parameters for the soil sampled from the apple tree rows, middle of the apple tree rows and 20-40 cm depth interval. RM – rows of apple trees; MR – middle of the apple tree rows; 20-40 – 20-40 cm sampling depth interval

Statistical parameter	Location	K	P	Location	K	P
		%			%	
mean		1.913	0.134		2.307	0.140
G		1.899	0.127		2.305	0.136
Me	Fălticeni RM	1.984	0.127	Sârca RM	2.316	0.135
min	(n=49)	1.146	0.070	(n=60)	2.059	0.057
max		2.200	0.262		2.457	0.284
std dev.		0.219	0.046		0.086	0.038
mean		1.786	0.084		2.263	0.120
G		1.761	0.080		2.262	0.119
Me	Fălticeni MR	1.884	0.092	Sârca MR	2.283	0.118
min	(n=10)	1.154	0.035	(n=12)	2.084	0.096
max		2.133	0.109		2.366	0.153
std dev.		0.288	0.022		0.082	0.020
mean		1.894	0.086		2.239	0.115
G		1.868	0.084		2.236	0.109
Me	Fălticeni 20-	2.001	0.079	Sârca 20-40	2.254	0.111
min	40 (n=9)	1.345	0.061	(n=12)	2.042	0.074
max		2.266	0.118		2.366	0.266
std dev.		0.316	0.021		0.105	0.050

Considering the average content of K and P for the three soil samples types, one can observe the following order by abundance (Tab.1):

- K and P for RPCFG Fălticeni: RM>20-40>MR
- K and P for Farm no. 6 Sârca: RM> MR >20-40

(RM – rows of apple trees; MR – middle of the apple tree rows; 20-40 – 20-40 cm sampling depth interval)

The abundance distribution determined in the different types of soil samples are showing a clear layout of K and P contents in the two orchards, decreasing with depth and with the distance from the apple-tree rows. This effect is caused by the use of fertilizers and a different mobility of the elements in the topsoil due to topography, physical and/or chemical parameters.

Conclusions

The higher concentrations of the two elements (K and P) for the samples collected from the apple-tree rows (RM) compared to 20-40 cm depth interval and the samples taken from the middle of the fruit-tree rows, are directly generated by the use of fertilizers on the soil or by foliar sprayings.

The abundance arrangement of K and P, by the 3 samples types, can be the effect of the topography and the distinct physical and/or chemical soil parameters for the two studied areas.

In both locations, RPCFG Făticeni and Farm no. 6 Sârca, the average supply of the soil with P was determined to be very good.

Regarding the significant correlation coefficients between the two elements and pH&$CaCO_3$, the maximum value was identified for the K and $CaCO_3$ pair from the RPCFG Fălticeni, respectively -0.55.

Acknowledgements:

"This work was supported by the European Social Fund in Romania, under the responsibility of the Managing Authority for the Sectoral Operational Programme for Human Resources Development 2007-2013 [grant POSDRU/CPP 107/DMI1.5/S/78342]".

References:

Boronia G. (2010), *„Modul de utilizare a terenurilor şi favorabilitatea pentru pomicultură a solurilor din bazinul pomicol Sârca”,* Teză de doctorat, p. 201

Costan Gh., Botez A. (1962), *Study of soils from Fălticeni fruit-growing area and their agrochemical characterisation, in Romanian*, (Extras din Lucrări Ştiinţifice,vol.4), Bucuresti: Editura agro-silvică, pg. 99-111

Erhan El., Pleşca Gh. (1964), „*Contribuţii la cunoaşterea climei din zona oraşului Fălticeni”*, Analele ştiinţifice ale Univ. „Al. I. Cuza” din Iaşi, Sectiunea II b. Geologie-geografie, Tomul X

Hornung Ş. (1975) *Cerinţe faţă de sol în pomicultură*, Ed. Ceres, Bucureşti, pg. 206

Madjar R., Davidescu V. (2009), *Agrochimie,* USAMVB, Facultatea de Horticultură, Învăţământ la distanţă

Newton D. E. (2010), *Chemical elements, 2 nd edition*, Gale, Cengage Learning, ISBN 13: 978 1 4144 7608 7, pg. 688

Voiculescu N., Cepoiu N., Leca M. (2001), *Bazele ecopedologice ale nutriţiei speciilor pomicole,* Ed. Muntenia&Leda, ISBN 973-8082-46-3, pg.296

***** 1982, SCPPF (Research and Production Centre for Fruit-Growing from Fălticeni), 1982,** *25 years of activity in fruit-growing, Research and Production Centre for Fruit-Growing from Fălticeni*, in Romanian, ICMG/KG (Institutul de cercetări pentru pomicultura Piteşti Mărăcineni), Iaşi

***** 2003, SRTS** – *Sistemul Român de Taxonomie a Solurilor*

***** 2004, AGENDA LOCALÃ 21** – *Planul local de dezvoltare durabilă a municipiului Fălticeni*, Proiect PNUD ROM 98/012, 0033238