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IMPORTANCE OF SYSTEMATIC FERTILIZATION WITH MINERAL AND ORGANIC FERTILIZERS FOR PRESERVING AND INCREASING SOIL FERTILITY

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Abstract

The present paper makes an analysis of the results obtained on the long-term experience with chemical and organic fertilizers with regard to the chemical condition of soils (pH, total nitrogen content, soluble phosphorous and humus). After thirty years of experiments, we like to make known the importance of systematic fertilizer application for preserving and/or increasing soil fertility, as sustainable development measure. Through long-term experiments with chemical and organic fertilizers, located in representative pedo-climatic area of Romania, important information werefound. They covered crop fertilization with adequate fertilizer application rates for obtaining maximum and economically optimum yields, the best use of nutrients and gaining high quality harvests; at the same time, important information could be acquired on the complex interactions between crops x soil x weather, necessary data for conserving and/or increasing soil fertility and for environment protection. The use of nitrogen and phosphorous fertilizers, on large scale, in Romania determined us to investigate the results under the fertilization variants with these macro-elements. At the same time, we also took into consideration the results on the evolution of the soil chemical condition through the application of organic fertilizers (manure) every four years.
The pH level in the variants chemically fertilized with nitrogen and/or phosphorous decreased.

Key words: *fertility, fertilizers consumption, humus, soil*

INTRODUCTION

Romania has significant agricultural land resources (14,612 thousand hectares, accounting for 61% of the country's total area) with advantageous structure for a diversified agriculture practice: out of total agricultural area, the arable land accounts for 64%, the pastures and hayfields 33% and the vineyards and orchards 3%. The high diversity of soils has also contributed to this. Thus, the soil taxonomy in Romania includes 12 soil classes, 29 soil types and 266 soil subtypes (without the mixed ones), mainly separated by genetic bases [5]. The production potential of agricultural land, established based on average soil scores, reveals that 61% of Romania's soils fall into the first three quality classes, with a medium to good fertility [9].

Yet, the soils are significantly affected by a variety of limiting factors of physical, chemical and biological nature. In most cases, these factors act simultaneously determining the drastic reduction of soil quality. Among the natural factors, the small and very small humus reserve in soil represents a great obstacle to the development of agricultural production on 51% of total agricultural land. Furthermore, a significant land area has a poor and very poor phosphorous, potassium and nitrogen supply in soil (Table 1)[8]. This negatively influences soil characteristics and functions, soil bio-productive capacity respectively[2].
Fertility is the most important soil property. Specialists consider that the use of chemical fertilizers in recommended amounts, depending on the soil type and crop, applied in the optimum vegetation stage is the safest

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and fastest method to increase farm production and to preserve soil fertility[3][7].

Table 1. Agricultural land area affected by restrictive factors of productive capacity*, in the year 2013 (selection)

Name of factor	Affected area	
	Thousand hectares	Share of total agricultural land (%)
Small and very small humus reserve in soil	7,485	51.23
Poor and very poor mobile phosphorous supply in soil	6,330	43.32
Poor and very poor mobile potassium supply in soil	787	5.39
Poor nitrogen supply in soil	5,110	34.97
Microelements deficiencies (zinc)	1,500	10.27

*The same area can be affected by one or several restrictive factors.
Source: processing of NEPA data, 2014

In the last decades, mainly in the developed countries, remarkable results have been obtained in crop production largely due to chemical fertilizer application. Generally, it is difficult to assess the contribution of mineral fertilizers to agricultural production in view of the interaction of the many aspects involved in this biological process.

During 1961-2013, in Romania, the chemical fertilizer use evolution significantly reflects the socio-economic changes that took place (Figure 1).

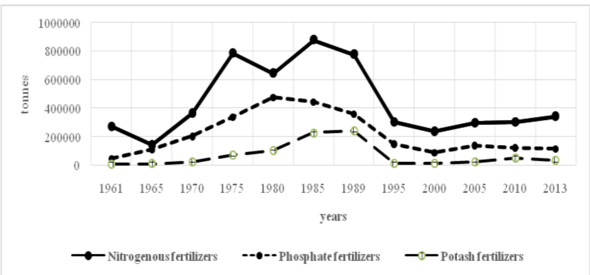

Fig.1. Consumption evolution by types of chemical fertilizers in Romania, in the period 1961-2013
Source:http://faostat.fao.org/site/422/DesktopDefault.aspx?PageID=422#ancorand National Institute of Statistics - NIS, TEMPO-ONLINE Database, 2015

In the communist period (1961-1989), the agricultural productions significantly increased under the background of agricultural land consolidation into large-sized state and cooperative farms and of the intensive use of agricultural inputs. In that time, the total fertilizer consumption increased 4.2 times, while the phosphate fertilizer consumption increased 7.8 times and nitrogen fertilizer consumption 2.8 times.

The shift towards market economy as a result of changes produced in the early 1990 was quite a long, costly and complex process.

The agricultural sector, like the entire economy, experienced a decline process. A very strong decline was also experienced in the case of chemical fertilizer consumption.

Thus, a strong negative trend was characteristic to the 1990-2000 decade. This situation overlapped other fundamental problems of the agricultural sector – land reform, poor agricultural markets, agricultural credit inadequacy to the new structures, etc.

During 1990-2013, the use of fertilizers had very low values, insufficient to replace the nutrients extracted from soil by agricultural production (Table 2). In 2013, fertilizer consumption represented only 44.59% of the fertilizer consumption in 1990: while in the year 1990 the fertilizer application rate was 146.52 kg active ingredient/ha, in 2013 only 79.40 kg active ingredient/ha were applied.

The most significant decline was found in the case of potash fertilizer. If we look at the economic effect of decreasing, the amount of fertilizer used is negative but positive effect on ecosystems could be.

Table 2. Chemical fertilizer consumption in agriculture in the period 1990-2013

Indicator	Chemical fertilizers			
	Total	Nitrogen	Phosphate	Potash
Total fertilizer consumption 1990 (tons)	1,103,075	656,094	313,108	133,873
Total fertilizer consumption 2013 (tons)	491,831	344,468	113,823	33,540
Evolution of total fertilizer consumption 1990-2013 (%)	44.59	52.50	36.35	25.05
Fertilizer consumption per hectare 1990 (kg/ha)	146.52	:	:	:
Fertilizer consumption per hectare 2013 (kg/ha)	79.40	:	:	:

Source: authors' processing of NIS data, TEMPO-ONLINE Database, 2015

The fertilizer amount applied per hectare, through its low values, generally had a low pressure upon soil throughout the transition

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period.
However, in the investigated period, many cases of misuse of chemical fertilizers were signaled out, as a result of the lack of knowledge and skills in this field or of the small farmers' limited financial resources. In certain situations, this led to the emergence or aggravation of soil degradation phenomena [9]. This is because agricultural practices sustainability depends on its long-term effects on productivity and soil health[1].

MATERIALS AND METHODS

The purpose of the paper is to reveal the importance of fertilization with nitrogen, phosphorous and manure fertilizers, under different application rates, on a single or mixed basis, for maintaining and/or improving the chemical characteristics of soils.
At the Agricultural Development Research Station Valul lui Traian, Constanta County, in 1970, on the experimental field, bifactor and trifactor experiments were located with nitrogen, phosphorous, potassium fertilizers and manure. The experiments have taken place on a continuous basis for 45 years and continue at present.
The experiments were located according to the randomized block method, with sub-divided parcels, the area of an experimental variant being 60 ^{m2}.
The experimental factors were the following: phosphorous application rates (kg/ha P2O5) - P0, P50, P100, P150, P200, nitrogen application rates (kg/ha N) - N0, N50, N100, N150, N200, manure application rates (t/ha) - G.g.0, G.g.20, G.g.40, G.g.60 and mixes of these.
Six-year crop rotations were practiced with wheat, barley, maize, sunflower, linseed and beans The area and number of crops decreased in time.
The soil samples for tests were taken after harvesting the wheat crop, hence representing the values of parameters measured after a part of the applied fertilizers were used by crops and extracted with the harvest.
Multiannual average yields obtained under the non-fertilized variants and the multi-annual averages under the nitrogen and phosphorous fertilization variant were the following: 28.0 q/ha /58.9 q/ha in wheat; 69.12 q/ha /99.22 q/ha in maize; 46.3 q/ha / 60.6 q/ha in barley; 26.3 q/ha / 34.3 q/ha in sunflower; 13.3 q/ha /20.6 q/ha in linseed for oil; and 21 q/ha /25 q/ha in beans.
Among the chemical fertilizers the ammonium nitrate and superphosphate were used. The phosphorous fertilizers were applied each year before plowing. The nitrogen fertilizers were applied in early spring with soil preparation for sowing and in the straw elongation period in winter wheat and barley.
The manure, coming from cattle, was applied once in a four-year period.
The experiments took place under irrigation system, maintaining soil moisture at 50% of IUA.
The soil is of calcaric chernozem type, formed on loess, with the characteristic profile A-AA-Cc [4].
From the physical and chemical point of view, the soil can be characterized as follows:

- structure moderately developed, grain structure, medium, the soil from this horizon is friable, in wet state, moderately cohesive in dry state, moderately plastic, moderately cohesive, slightly compact, non-cemented, with small pores; it features frequent fine fissures, frequent thin roots, right shift to next horizon ; crust formed on soil surface; loamy – sandy texture; clay content 34.7% in Ap1 and 37.0% in Ap2h (25-30 cm);
- the humus content is relatively high to medium in A (3.5% - Ap1, 2.7% - Ap2h, and 2.6% - Amk; the sum of exchangeable bases (SB) has high values, (29.2 – 28.2 me/100 g soil) in A horizon; nitrogen index (NI) has the value 3.5 in Ap1; the base status (V) has very high values (93.9% - 100%); the reaction is neutral slightly alkaline (pH 7.8 – 8.4).

The main hydro physical indices have medium to high values: CH decreases from 8.8% - 9.0% in the main 30 cm (Ap1 – Ap2h). to 8.6% in Amk and to 6.2% in Cn2k; Co, from 10.2% – 13.5% in Ap1 and Ap2h; Cc has values of 26.8% - 25.1% in A.

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RESULTS AND DISCUSSIONS

The analysis of the soil chemical condition, after 30 years of stationary experimentation with fertilizers, is made under the variants of fertilization with decreasing nitrogen and phosphorous application rates and of manure fertilization. We considered these variants for our analysis as in the agricultural practice crop fertilization is made with nitrogen and phosphorous and with manure, if available.

The phosphorous fertilizers, applied unilaterally, determine the pH value declining proportionally with the application rate (Fig.2.)

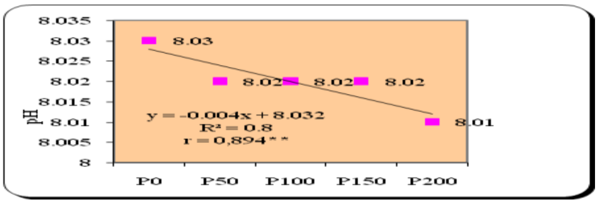

Fig.2. Soil pH after 30 years of application of phosphorus fertilizers.

The vermic-chernozem soil from Valul luiTraian, with a high calcium content and a high cation exchange capacity, the unilateral application of nitrogen fertilizers, under the form of ammonium nitrate have determined the decrease of pH values with the increase of the application rate. The irrigation water plays an important role in pH evolution by its content in mineral salts (Fig.3).

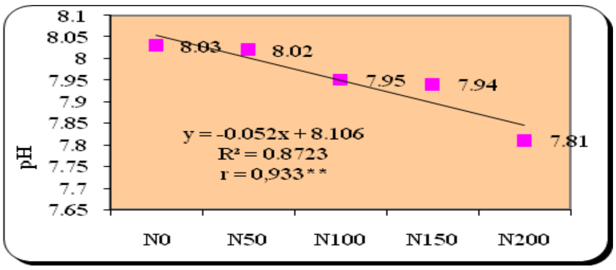

Fig.3. Soil pH after 30 years of application of nitrogen fertilization

Under the influence of mixed nitrogen phosphorous fertilization, the pH value mostly decreases with the maximum utilized application rates (P200N200).

By the nitrogen phosphorous fertilization, the yields increase and by this the nutrient consumption increases. The nitrogen fertilizers, with acidification power, act together with the natural soil debasification processes and increase of unsaturated soil acidity.

The mixed application of nitrogen and phosphorous fertilizers has determined pH decrease in time, from 8.04 to 7.12 (under the P200N200 variant), by 0.92% compared to the non-fertilized check variant (Figure 4).

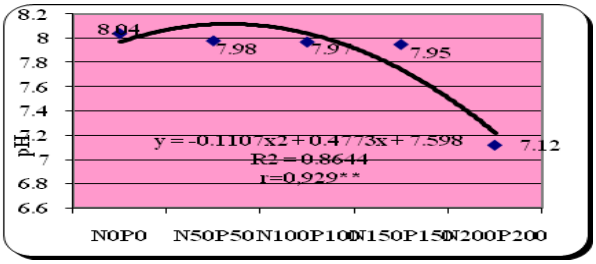

Fig. 4. Soil pH after 30 years of fertilization with nitrogen and phosphorus

The manure that has been applied periodically (every four years) has had as effect the slight pH increase from 8.04 under the non-fertilized variant to 8.25 under the fertilized variant with 60 tons of manure (Fig. 5).

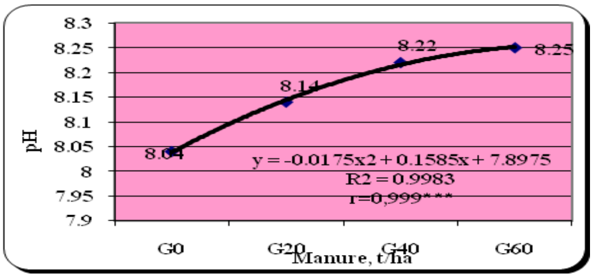

Fig.5. Soil pH after 30 years fertilizing with organic fertilizers

By its supply of basic mineral and organic substances, of organic salts and acids with soil reaction buffering functions, manure modifies the soil reaction towards slightly alkaline. The organic fertilizers applied together with the phosphorous and/or nitrogen have determined pH increase towards alkaline under all variants.

It has been noticed that by the unilateral use of nitrogen, the soluble phosphate content in soil decreases proportionally with the increase of nitrogen application rate, being in the low range of soil supply with this element.

Through the unilateral fertilization with phosphorous, the soluble phosphate content

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increases with the increase of phosphorous application rate, from 25 ppm in the non-fertilized variant to over 150 ppm in the variant with P200.
The same evolution can be noticed in the variants fertilized with nitrogen and phosphorous applied together, reaching the content of 163.6 ppm in variant P200N200 (Figure 6).

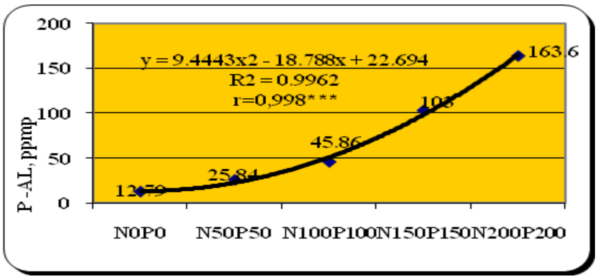

Fig. 6. Phosphorus content in soil after 30 years of phosphorus and nitrogen fertilization

The manure, whether applied alone or in different organic-mineral mixes, has determined the increase of soil content in mobile phosphates, from 12.79 ppm from the non-fertilized variant to over 33.73 ppm in the G60 variant (Figure7).

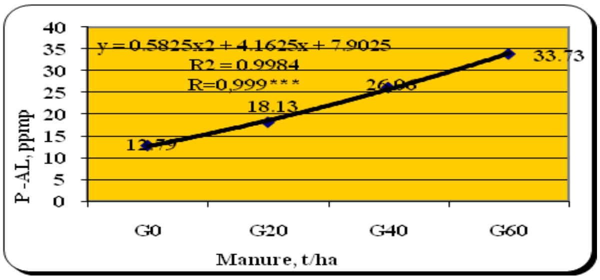

Fig.7. Phosphorus content in soil 30 years after fertilization with organic fertilizers

The mobile phosphate level in soil is an indicator of soil fertility as the efficiency of nitrogen and potassium fertilizers depends on the supply of mobile phosphate salts in soil. Ensuring an optimum level of mobile phosphates determines production stabilization under changing climate conditions. The total nitrogen content in soil has not suffered significant changes under the influence of chemical, organic or organic-mineral fertilization, being in the normal supply range (Figure 8, 9).

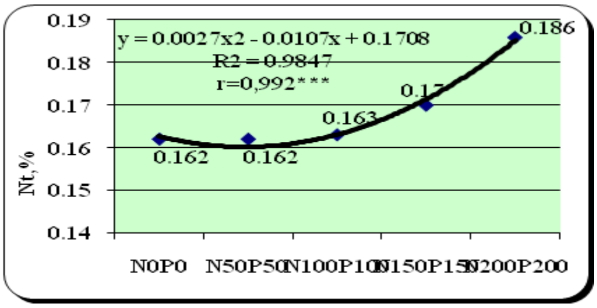

Fig.8. Nitrogen content in soil after 30 years of chemical fertilizers with phosphorus and nitrogen

It is recognized that the mineral fertilizers determine an acceleration of mineralization processes, mainly of the organic forms with easily degradable nitrogen, this contributing to the increase of total nitrogen content in soil.

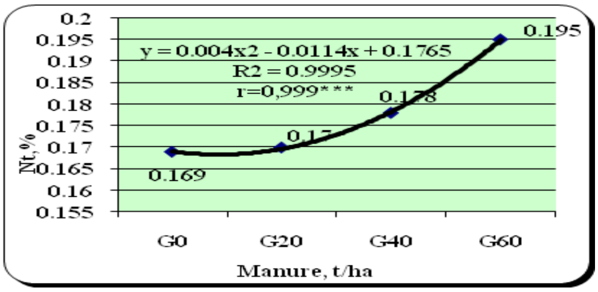

Fig. 9. Nitrogen content in soil 30 years after fertilization with organic fertilizers

As regards the humus content, it was noticed that the application of nitrogen and phosphorous fertilizers by increasing application rates determined the increase of humus content in soil under each variant (Figure 10).

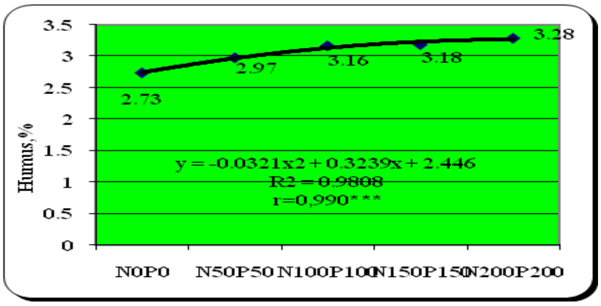

Fig.10. Humus content in the soil after 30 years of chemical fertilizers with phosphorus and nitrogen

The analysis (in other scientific research works) of the crop response to the same fertilization levels revealed that production proportionally increased with the fertilizer application rates. Thus, the applied fertilizers were well used by crops, and this could be seen in the obtained yields.

The periodical application (every four years) of the organic fertilizers determined the increase of humus content with the increase of application rates (Figure 11).

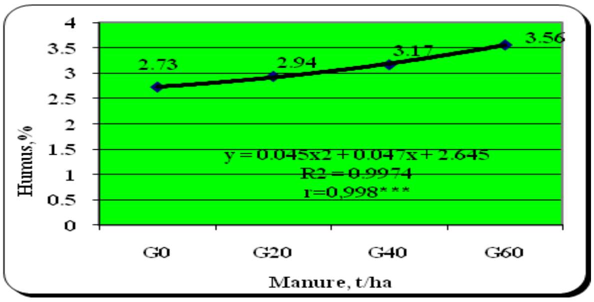

Fig. 11. Humus content in the soil after 30 years fertilizing with organic fertilizers

The effect of organic fertilization of soil has been occurred in time, this being linked to the accumulation of humic substances in soil and to the positive effect that this has developed on the physical and biological characteristics of soil [2].

CONCLUSIONS

The long-term experiments are patrimony goods that can make available concrete information on soil fertility evolution to experts and to the interested persons at any moment. They still offer multiple research directions.

From the above-presented facts, it results that in the absence of fertilization, soil loses some of its nutrients and humus, as even though the harvest level is not high, the nutrient export takes place.

The chemical fertilization with nitrogen and phosphorous used on unilateral basis produces disequilibria and soil becomes poor in humus, together with pH modification[10].

The systematic fertilization with moderate nitrogen and phosphorous application rates, applied in optimum timing for each crop in the field rotation, immediately leads to significant increase of harvests and to maintaining soil fertility in time.

Manure application contributes to maintaining and increasing soil fertility.

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