DOCTORAL THESIS ABSTRACT:

"RESEARCH REGARDING THE DYNAMICS OF SOME HEAVY METALS AND NUTRITIVE ELEMENTS CONTENT OF THE SOIL DURING LONG-TERM EXPERIMENTS"

KEY WORDS: Soil, fertility, fertilizer, heavy metals, nutritive elements.

Humanity is passing through a period in which the global population is growing at an accentuated rate, and food is becoming scarce.

1,1 billion people suffer from malnutrition and adjacent diseases, with 300 million dying of hunger annually (especially children). Their access to resources is limited, and water, soil and energy are becoming insufficient and polluted, leading to a reduction in the quality and quantity of food and to the depletion of biodiversity *(Dumitru et al., 2014).*

The agriculture of the future will have to answer to new challenges, to higher pressures placed over the natural resources (soil, water and genetic resources), but also to the climatic changes that lead to various phenomena, such as El Niño.

Chapter I contains information regarding the current state of soils on a national and international level.

In addition to this, theoretical aspects related to soil fertility are described in detail, including their influence over plant nutrition and fertilization and the mobility of nutrients in the soil.

Theoretical aspects of soil pollution due to heavy metals are presented in the last part of this chapter. This has become a global problem that leads to a loss in agricultural productivity.

In chapter II long term experiments in our country are presented. Thy served as the main method of studying soil fertility evolution based on factors such as type of fertilization used, recommendations regarding dosing, time and method of fertilizer application on different types of crops, economic efficiency and environmental protection in an agricultural context.

Chapter III highlights aspects related to the definition and characterization of the main indicators of soil fertilization quality, as well as their importance in agricultural systems.

Making use of various bibliographical sources, more details are shared on theoretical aspects of soil reaction, organic matter and humus content, calcium carbonate and salt content and, inevitably, concentrations of the main micro and macronutrients (Cu, Cd, Zn, Pb and N, P, K). Low concentrations of micronutrients can be found in the soil, playing an important role in the growth and development of plants, but they can also appear in higher concentrations, leading to toxic effects not only for the plants, but also for humans.

Aim, objectives and experimental methods are describe in chapter IV.

This research aimed to follow the evolution of soil fertility as a result of long term fertility treatments using organic (manure) and mineral (nitrogen and phosphorus) fertilizer to aid wheat yield in one of the long term experiences in S.C.D.A. Valu lui Traian, in order to promote a durable and non-polluting agriculture.

The main objectives of the research program were:

- ❖ Establishing the optimum doses of fertilizers to increase soil fertility, while accounting for environmental protection;
- ❖ Modifying the chemical soil fertility factors under the influence of fertilizer;
- ❖ Putting together a record of the soil fertilizer application rates;
- ❖ Establishing how often the effects of applying fertilizer manifest in relation to the dynamics of climatic and pedological factors;

Generalizations were made in order to plan the big volume of results highlighting the chemical characteristics of the soil, and the data were presented in graphs and tables representing the variations according to the variants, experimental method and applied treatment.

Chapter V contains a detailed characterization of the experimental natural frame: geographical location, geomorphology, physical and chemical characteristics of the typical Chernozem from the S.C.D.A. Valu lui Traian (CZ vm) region, class distribution based on soil suitability, as well as the evolution of temperatures and annual average precipitation.

The results of my research are presented starting with Chapter VI. This chapter refers to data about the influence of long term fertilization with nitrogen and phosphorus upon wheat yield and on several chemical characteristics of the soil.

Chapter VII highlights the influence of long term fertilization with NPK upon wheat yield and on several chemical characteristics of the typical Chernozem at Valu lui Traian.

The influence of mineral and organic fertilizers upon wheat yield and on several chemical characteristics of the soil it is outlined in Chapter VIII.

Organic fertilizer use has shown very complex effects and changes in the main soil fertility indicators towards the stabilization of its qualitative and productive functions. A substantial change was seen in both the organic matter content, and the main nutritive ions.

Further conclusions are presented as follows:

On soil not fertilized with phosphorus, upon wheat yield increased directly proportional with the nitrogen dose, being statistically secured only at doses of 150 (significantly different) and 200 kg/h nitrogen (really significant).

On soil fertilized with P_{150}, the biggest production (7233 kg/ha) was obtained in the variants fertilized with N_{200}, where the production increment compared to the variant unfertilized with nitrogen was 80% (3220 kg/ha); fertilization with $P_{150}N_{100}$ secured a significantly different production increment, and fertilization with $P_{150}N_{150}$ a very significantly different production increment.

On soil fertilized with P_{200}, the 50 kg/ha nitrogen dose didn't secure a statistically significant production increment, while the 100, 150 and 200 kg/ha nitrogen doses showed significant increases in production, which increased directly proportional with the nitrogen dose; although a combination of P_{200} and N_{200} generated a high production (6000 kg/ha), this was lower than the production obtained after the application of 150 and 200 kg/ha nitrogen on a base of 100 kg/ha phosphorus.

The best wheat yield was obtained through fertilization with 100 kg/ha phosphorus and 150-200 kg/ha nitrogen.

The mobile phosphorus level in the soil significantly increases with the phosphorus dose applied; at a dose of 50 kg/ha phosphorus, the increase is significantly different, and at doses of 100 kg/ha phosphorus and over, the increase is very significant.

Long term fertilization with different doses of phosphorus and nitrogen did not lead to statistically significant changes in pH levels, soluble salts contents, calcium carbonate and heavy metals (cadmium, copper, lead and zinc). Cadmium levels oscillated between 0,40 and 0,44 mg/kg, copper levels between 21 and 24 mg/kg, lead was measured at 20 mg/kg and zinc between 83 and 84 mg/kg.

Production increased directly proportional with the fertilizer doses; the highest production (4288 kg/ha) was obtained in the variants fertilized with $N_{100}K_{150}$, where the production increment grew by 216% as compared to the unfertilized control (1987 kg/ha).

Potassium fertilization generated a significant production increment (37%) when using 50kg/ha K, a significantly different production increment (49%) when using 100 kg/ha and a very significant production increment (153%) when using 150 kg/ha as compared to the unfertilized variant; potassium fertilization generated, on an average, a production increment of 46% or 13,8 kg of wheat per kg of potassium in the fertilizer. This is a significantly increased increment, given the poor supply of this particular element in the soil.

$N_{100}P_{100}$ fertilization secured a highly significant production increment (204%) as compared to the unfertilized control. As a result of this fertilization, the use of 50 kg/ha potassium secured a production increment of 209%, the use of 100 kg/ha K an increment of 211% and the use of 150 kg/ha K an increment of 207%. On a base fertilization with $N_{100}P_{100}$, potassium did not secure any significant production increments when compared to the results seen on base fertilization only; the wheat yield increment per kg of K was only 1.3 kg/kg.

Using lots in order to track the production increments, one can see that, as compared to the unfertilized control, sole use of K as a fertilizer led to an average production increment of 35%, by using P_{100} the average increment rose to 79%, by using N_{100} the average increment was 103% and by using $N_{100}P_{100}$, the average increment was 208%. The wheat increment per kg K was 13.8 kg/kg in the block fertilized using only K, 19 kg/kg when applying K on a P_{100} base, 9.4 kg/kg when applying K on a N_{100} base and 1.3 kg when applying K on $N_{100}P_{100}$ base.

The use of various doses of mineral fertilizers with NPK did not result in statistically significant

changes to the humus and total nitrogen content on the typical Chernozem at Valu lui Traian.

Fertilization using 100kg/ha phosphorus on its own or mixed with doses of 50-150 kg/ha potassium, as well as fertilization using $N_{100}P_{100}$ mixed with doses of 50-150 kg/ha potassium resulted in highly significant increases in the mobile phosphorus content of the soil.

In all the variants fertilized with 100 kg/ha P, the supply level of this chemical element in the soil became “very high”.

When compared to the unfertilized control, the mobile potassium level in the soil has significantly increased with the potassium dose applied.

Fertilization using 50 kg/ha potassium maintained a low level of mobile potassium supply in the soil, while the 100 kg/ha doses led to a “high” supply level, and the 150 kg/ha doses led to a “very high” supply level.

Long term fertilization (35 years) using NPK did not result in statistically significant changes in the pH level and the soluble salt and heavy metals (copper, zinc, lead, cadmium) contents of the soil.

Manure, a complex fertilizer containing all the nutrients necessary for plant growth and development, can improve the physical, chemical and biological characteristics of the soil.

The wheat yield increased directly proportional with the organic fertilizer dose applied; the production increments were 18% following fertilization using 20 t/ha manure generated by cattle, 140% following fertilization with a dose of 40 t/ha and 200% following a dose of 60 t/ha annually.

Fertilization using doses of 20, 40 and 60 t/ha manure (total of 120 t annually) secured a medium production increment of 2766 kg/ha (69.1 kg/t manure) in the variants where manure only was applied, an increment of 2524 kg/ha (63.1 kg/t manure) in the variants where manure was applied on a P_{50} base, an increment of 3020 kg/ha (75.5 kg/t manure) in the variants where manure was applied on a $P_{50}N_{50}$ base and an increment of 4168 kg/ha (104.2 kg/t manure) in the variants where manure was applied on a $P_{100}N_{100}$ base.

Research has shown that, in order to obtain a satisfactory production level (minimum 6000 kg/ha), the annual doses of manure should be 40-60 t/ha.

Fertilization using 20-60 t/ha manure did not result in a statistically significant change in the humus and total nitrogen content of the soil; this was not seen in previous experiments, and I appreciate that the manure doses corresponding to this experimental scheme were not used in the past years, especially due to the difficulty of procuring such a fertilizer in the area. On the basis of mineral fertilization with $P_{100}N_{100}$, organic fertilization has generated a distinct and quite significant increase in humus and total nitrogen levels in the soil;

Fertilization using 50 kg/ha phosphorus over 35 years did not lead to significant build-up of mobile phosphorus in the soil; one can appreciate that the potassium fertilizer dose of 50 kg/ha is regarded as a “maintenance dose”.

The use of $P_{100}N_{100}$ led to a very significant build-up of mobile phosphorus in the soil; the application of organic fertilizers on a base of $P_{100}N_{100}$ mineral fertilization generated significantly

increased levels of mobile phosphorus in the soil.

The unfertilized variant has a “low” level of mobile potassium. This level becomes “medium” following fertilization with 20 and 40 t/ha manure, and “large” following fertilization with 60t/ha manure annually over 35 years.

In soils with $P_{50}N_{50}$ and $P_{100}N_{100}$ mineral fertilization, the increases in mobile potassium levels were similar.

There were no statistically significant changes seen in the pH value, soluble salt content and heavy metals (Cu, Zn, Pb, Cd) under the influence of fertilization over 35 years with manure and mineral fertilizers based on NP.