

Influence of fertilization systems to the soil inorganic compounds. Case study: monocultures of cereals, leguminous and oleaginous

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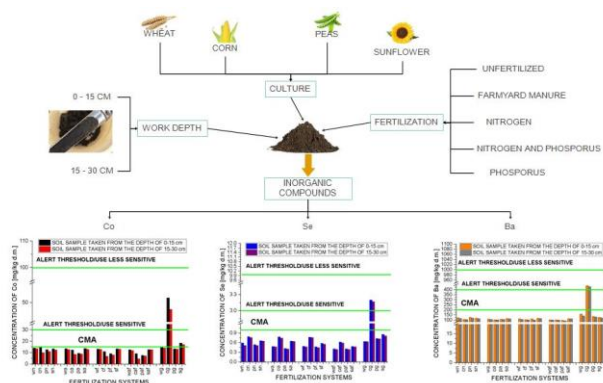
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Graphical abstract



Abstract

The main objective of this article is to observe the variation of the content of inorganic compounds in the soil (cobalt, selenium, barium) under the influence of fertilization systems applied to different monocultures of cereals (wheat, corn), leguminous (peas) and oleaginous (sunflower). High concentrations of cobalt, selenium and barium with phytotoxicity effect on the soil and future crops were recorded mainly in the experimental parcels cultivated with corn, respectively with sunflower and fertilized with farmyard manure. The highest phytotoxicity effect on soil and future crop was recorded in the case of cobalt, for the experimental monoculture variant of corn fertilized with farmyard manure where the cobalt concentration in the soil exceeded the alert threshold/sensitive use for inorganic compounds in the soil (51.2 mg/kg d.m.).

Keywords: Inorganic compounds, fertilization systems, monoculture.

1. Introduction

The use of mineral and organic fertilizers increases agricultural production. The application of fertilizers such as nitrogen, phosphorus and nitrogen-phosphorus over a long period leads to a decrease in the content of soil

micronutrients and macronutrients (Adamiak and Adamiak, 2015; Bindraban *et al.*, 2015; Diacono and Montemurro, 2010; Gomaa *et al.*, 2015; Huňady and Hochman, 2014; Scherer *et al.*, 2011; Sobolewska *et al.*, 2020; Vodyanitskii, 2016).

The purpose of using fertilizers is that the nutrients lead the plant grow in an optimum time. In reality, not all nutrients from fertilizers are used by plants. About 20–80% of the nutrients that come from organic and mineral fertilizers accumulate temporarily in the soil due to soil chemistry, which prevents immediate absorption into the plant (Basso, 2009; Bindraban *et al.*, 2015; Vodyanitskii, 2016).

For the application of an efficient fertilization system, both for soil and for plant crops, it is necessary an analysis of the soil from a chemical, physical and mechanical point of view, an analysis that will provide information's related to the nutrients soil supply (Bindraban *et al.*, 2015).

Wheat culture offers many advantages for soil and human consume such as (Adamiak and Adamiak, 2015; Bindraban *et al.*, 2015; Diacono and Montemurro, 2010; Gomaa *et al.*, 2015; Huňady and Hochman, 2014; Scherer *et al.*, 2011; Sobolewska *et al.*, 2020; Vodyanitskii, 2016): ensures satisfactory productions everywhere where it is cultivated, winter wheat reacts well to the application of fertilizers organic and mineral, farmyard manure can be applied directly to autumn wheat.

Wheat is very exigent to fertilization, due to the fact that: the root system is poorly developed and has a low capacity to use the hardly soluble nutrients in the soil (Basso *et al.*, 2009; Maucieri *et al.*, 2019; Muscalu *et al.*, 2018; Woźniak, 2019).

Corn presents a number of peculiarities (Basso, 2009; Bindraban *et al.*, 2015; Muscalu *et al.*, 2018; Muscalu *et al.*, 2019; Vodyanitskii, 2016; Woźniak, 2019) as a great ecological plasticity and can be cultivated in different climatic conditions. Also, it can be cultivated without special problems in monoculture for several years. Capitalizes very well on organic and mineral fertilizers, as

well as irrigation water. Corn for grains leave after the harvest, in most cases, a soil poor in water and a large amount of vegetable waste (Bindraban *et al.*, 2015; Vodyanitskii, 2016).

In the case of leguminous crops for grains (peas) the root system is well developed in depth, ensuring a good loose of the soil. After harvest, the peas leave a soil rich in nitrogen (Barsan *et al.*, 2020; Basso *et al.*, 2009; Belay *et al.*, 2002; Bindraban *et al.*, 2015; Heffer and Prud'homme, 2008; Jannoura *et al.*, 2013; Muscalu *et al.*, 2019; Shapiro and Wortmann, 2006; Sharar *et al.*, 2003; Sangar *et al.*, 2017; Ting-Hui *et al.*, 2006; Vodyanitskii, 2016).

In case of the culture of oleaginous - sunflower, it can be stated that (Bindraban *et al.*, 2015; Massignam *et al.*, 2009; Rashid *et al.*, 2014; Schultz *et al.*, 2018; Vodyanitskii, 2016) the structural and fertility condition of the soil after harvesting the sunflower crop is good. Also, has moderate requirements for nitrogen and phosphorus fertilization, but has higher requirements for potassium. Compared to corn, sunflower makes better use of soils with medium fertility and better withstands at water hydric stress.

In the field of soil chemistry, there are a number of heavy metals with a toxic effect on the soil, as well as on plant crops. Excess of barium and selenium from soil, water and plants, can disrupt the calcium content in the human body, leading to serious diseases (Bindraban *et al.*, 2015; Vodyanitskii, 2016). Some Romanian regulations indicates the maximum permissible concentrations of barium in the soil is 200 mg/kg d.m., for selenium is 1 mg/kg d.m. and for cobalt 15 mg/kg d.m. (Order no. 756, 2011).

The present research aimed to determine the variation of the content of inorganic compounds in the soil (cobalt, selenium, barium) depending on the fertilization system applied to different monocultures of cereals, leguminous and oleaginous (wheat, corn, peas, sunflower).

2. Experimental part

The soil samples were collected (Zeenit, 2009) from an experimental field, part from a research institute (National Agricultural Research and Development Institute – Fundulea, Romania, experiments have been carried out following a two-factor experience, stationary and multiannual, mounted in 1968 and up to date, with reference to emphasizing the effect of fertilization sequence on soil), after harvesting the existing cereals, leguminous and oleaginous on the experimental field. The content of barium, selenium and cobalt from soil, was determinate in the laboratory, by using the atomic absorption spectrometer, ZEENIT AAS (method atomic absorption spectrometer) (ISO 11464:2006 (2006)). The forms of the experiments performed on the experimental field are presented in Figure 1.

The original conditions of the soil before the cultivations are presented in Table 1.

The measurement values of the analyzed parameters were compared with maximum permissible concentrations (CMA) for soil inorganic compounds,

according with Romanian Order no. 756 (Order no. 756, 2011).

Table 1. Original conditions of the soil before the cultivations

Soil	Concentration		
	Cobalt	Selenium	Barium
Work depth	[mg/kg d.m.]		
0-15 cm	11.56	0.53	120.7
15-30 cm	10.3	0.51	118.69

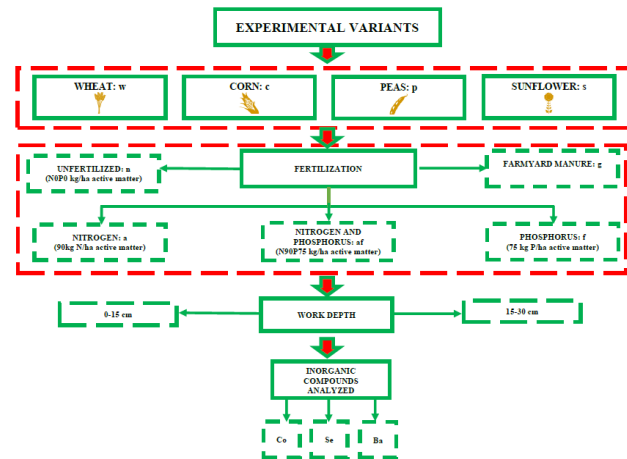


Figure 1. Working methodology

Abbreviations

wn	wheat monoculture unfertilized
cn	corn monoculture unfertilized
pn	peas monoculture unfertilized
sn	sunflower monoculture unfertilized
wa	wheat monoculture fertilized with nitrogen (90kg N/ha active matter)
ca	corn monoculture fertilized with nitrogen (90kg N/ha active matter)
pa	peas monoculture fertilized with nitrogen (90kg N/ha active matter)
sa	sunflower monoculture fertilized with nitrogen (90kg N/ha active matter)
wf	wheat monoculture fertilized with phosphorus (75 kg P/ha active matter)
cf	corn monoculture fertilized with phosphorus (75 kg P/ha active matter)
pf	peas monoculture fertilized with phosphorus (75 kg P/ha active matter)
sf	sunflower monoculture fertilized with phosphorus (75 kg P/ha active matter)
waf	wheat monoculture fertilized with nitrogen and phosphorus (N90P75 kg/ha active matter)
caf	corn monoculture fertilized with nitrogen and phosphorus (N90P75 kg/ha active matter)
paf	peas monoculture fertilized with nitrogen and phosphorus (N90P75 kg/ha active matter)
saf	sunflower monoculture fertilized with nitrogen and phosphorus (N90P75 kg/ha active matter)

wg wheat monoculture fertilized with farmyard manure
 cg corn monoculture fertilized with farmyard manure
 pg peas monoculture fertilized with farmyard manure
 sg sunflower monoculture fertilized with phosphorus farmyard manure.

3. Results and discussion

For the inorganic cobalt compound, respectively for the experimental variant wg - 0-15 cm (wheat monoculture fertilized with farmyard manure, working depth 0-15 cm, Figure 2) the highest concentration was registered, this being 3.26% lower than the maximum permissible concentration for inorganic compounds in soil (15 mg/kg d.m.).

The lowest value of cobalt concentration was resulted from in the case waf - 15-30 cm, the resulting value being 78.6% of the CMA for inorganic compounds in the soil. For none of the five fertilization systems applied to wheat-grown soil, there were no exceedances of the CMA for inorganic compounds in the soil, respectively for cobalt.

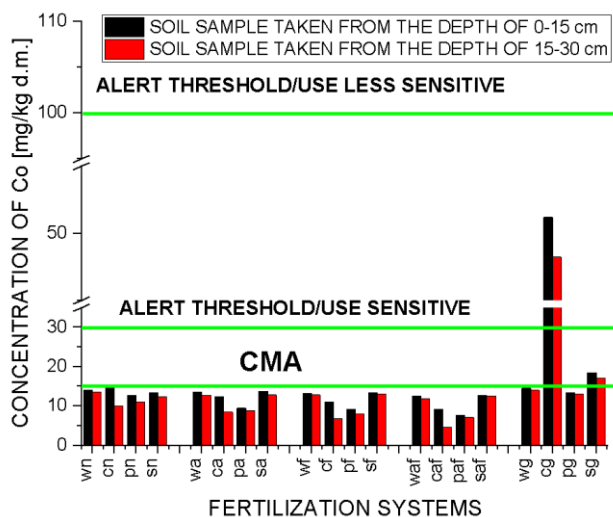


Figure 2. The concentration of inorganic compounds in the soil - cobalt, after harvesting the monocultures of wheat, corn, peas and sunflower, to which different fertilization systems were applied

In the case of the cn - 0-15 cm experiment, the concentration of cobalt from the soil exceeded the CMA for inorganic compounds in the soil with 103% (Figure 2).

For the fertilization system with farmyard manure in the case of experiments of the form cg - 0-15 cm and cg - 15-30 cm, the concentration of cobalt from the soil has exceeded the alert threshold/use sensitive (AT/SU) for inorganic compounds in the soil with 170.66%, respectively with 160.76%.

For all other experimental variants on which corn was grown, the CMA was not exceeded for inorganic compounds in the soil, for cobalt respectively. For none of the five fertilization systems applied to the soil cultivated with peas (Figure 2), there were no exceedances of the CMA for inorganic compounds in the soil, respectively for cobalt (the maximum concentration of inorganic

compound cobalt was recorded for the experiment of the form pg - 0-15 cm, this having the value of 13.37 mg/kg d.m.).

In the case of oleaginous sunflower crops, increases in cobalt concentration were observed (Figure 2) over the CMA for inorganic compounds in the soil, for experiments of the form sg - 0-15 cm (with 123.33% higher) and sg - 15- 30 cm (with 114% higher). The recorded concentrations were above CMA for inorganic compounds in the soil, but below the AT/SU (alert threshold/sensitive use) value for experiments of the form sg - 0-15 cm and sg - 15-30 cm. Figure 3 shows the values of the inorganic compound content of sol-selenium, respectively for the monocultures of wheat, corn, peas and sunflower, to which different fertilization systems were applied.

The concentration of the inorganic selenium compound in the soil varied as follows (Figure 3):

- Wheat monoculture: all values recorded for selenium in the soil were below the CMA for inorganic compounds in the soil (1 mg/kg d.m.), the maximum concentration of selenium being recorded for the experiment form wg - 0-15 cm (being 36 % lower).
- Corn monoculture: increases in selenium concentration were observed for experiments of the form cg - 0-15 cm and cg - 15-30 cm over AT/SU (3 mg/kg d.m.) for inorganic compounds in the soil by 106.66 %, respectively with 105.66%.
- Pea monoculture: all values recorded for selenium in the soil were below the CMA for inorganic compounds in the soil, the maximum concentration of selenium being recorded for the experiment of the form mg - 0-15 cm (being 27% lower).
- Sunflower monoculture: all values recorded for selenium in the soil were below the CMA for inorganic compounds in the soil, the maximum concentration of selenium being recorded for the experiment of the form sg - 0-15 cm (being 14% lower).

For the barium inorganic compound, respectively for the experimental variant of the form wg (wheat monoculture fertilized with farmyard manure, working depth 0-15 cm, Figure 4), the highest concentration was registered, this being 20.5% lower than CMA for soil inorganic compounds (200 mg/kg d.m.).

The lowest value of barium concentration resulted from the form experiment waf- 15-30 cm, the resulting value being 50.52% of the CMA for inorganic compounds in the soil. For none of the five fertilization systems applied on wheat-grown soil, there were no exceedances of the CMA for inorganic compounds in the soil, respectively for barium. For the experimental variants of the form: cn, ca, cf and caf on which corn was grown, the CMA was not exceeded for inorganic compounds in the soil, respectively for barium. For the fertilization system with farmyard manure, in the case of experiments of the form cg - 0-15 cm and cg - 15-30 cm the concentration of barium in the

soil exceeded AT/SU for inorganic compounds in the soil by 109.75% and 107.81% respectively (Figure 4).

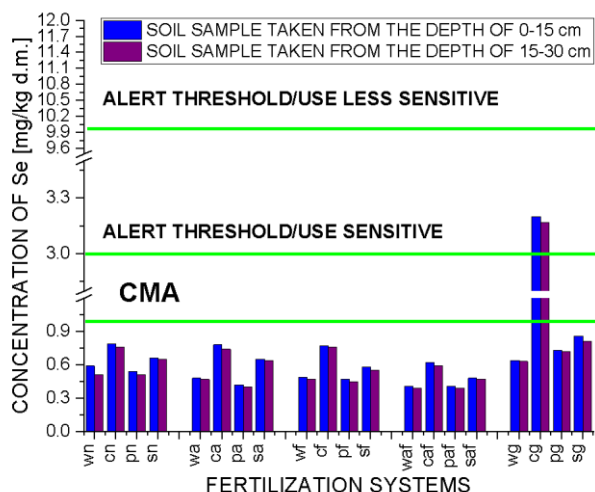


Figure 3. The concentration of inorganic compounds in the soil - selenium, after harvesting the monocultures of wheat, corn, peas and sunflower, to which different fertilization systems were applied

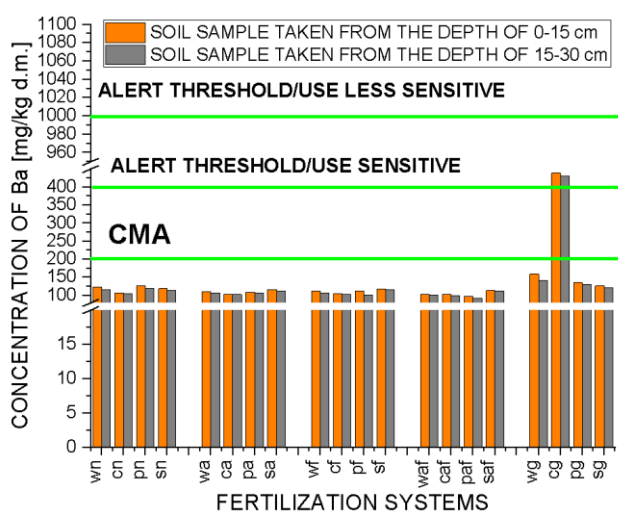


Figure 4. The concentration of inorganic compounds in the soil - barium, after harvesting the monocultures of wheat, corn, peas and sunflower, to which different fertilization systems were applied

For none of the five fertilization systems applied to the soil cultivated with peas (Figure 4), there were no exceedances of the CMA for inorganic compounds in the soil, respectively for barium (the maximum concentration of inorganic compound - barium was recorded for the experiment of the form pg - 0-15 cm, this having the value of 135.06 mg/kg d.m.).

For none of the five fertilization systems applied to the soil cultivated with sunflower (Figure 4), there were no exceedances of the CMA for inorganic compounds in the soil, respectively for barium (maximum concentrations of inorganic compound - barium were recorded for the experiment of the form pg - 0-15 cm and pg - 15-30 cm, these having values between 120.73 mg/kg d.m. and 126.56 mg/kg d.m.).

4. Conclusions

According to the Romanian regulation no. 756, the cobalt content in the soil was within the normal cobalt limits for soil loading with potential pollutants for most experimental parcels. Exceptions are the experimental parcels cg and sg, where:

- The values of the cobalt content were between the limit of the normal content (15 mg/kg d.m.) and the alert threshold (warning, 30 mg/kg d.m.) for sensitive uses for the experimental parcel sg.
- The cobalt content values ranged between the alert threshold limit (warning, 30 mg/kg d.m.) for sensitive uses and the alert threshold limit (warning, 100 mg/kg d.m.) for less sensitive uses for the experimental parcel sg.

Selenium concentration values showed that high amounts of residues did not accumulate in the soil, which may have phytotoxicity effects for future plant crops, with the exception of the cg experimental parcel, where the selenium content was within the alert threshold (warning, 3 mg/kg d.m.) for sensitive uses and the alert threshold limit (warning, 10 mg/kg d.m.) for less sensitive uses.

The values of barium concentration for most of the analyzed experimental variants decreased, compared to the values recorded in the case of unfertilized soil parcels. This decrease in micronutrient content may indicate an absorption in the cultivated plant on the experimental plot, micronutrients being necessary for plant health.

The recording of high concentrations of cobalt, selenium and barium in the soil may be due to climatic conditions, the inability of different plant species to assimilate nutrients from the soil due to the root system, soil compaction, soil works etc.

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