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INFLUENCE OF LONG TERM FERTILIZATION WITH NITROGEN AND PHOSPHORUS ON WHEAT PRODUCTION AND ON SEVERAL CHEMICAL CHARACTERISTICS OF THE SOIL

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Abstract

This paper presents the evolution of soil fertility as a result of long-term fertilization (35 years) with NP. The doses of nitrogen and phosphorus were: 0, 50, 100, 150, 200 kg/ha. The experimental field is located on chernozem soil. Soil samples were collected on 0-20 cm depth. Fertilization with $P_{100}N_{100}$, $P_{100}N_{150}$, $P_{100}N_{200}$ led to very significant increases of production (42%, 53% and 52%) after 35 years of fertilization of wheat crop; the variants fertilized with $P_{100}N_{150}$ have ensured the highest production (7522 kg/ha) followed by those fertilized with $P_{100}N_{200}$. Doses of 150 and 200 kg/ha nitrogen have significantly increased soil humus level from 3.06% for the control variant to 3.27%, respectively 3.25%. The application for 35 years of doses of 50-200 kg/ha phosphorus with the same doses of nitrogen did not led to statistically significant changes of the humus level, total nitrogen and mobile potassium. The content of phosphorus in the soil increased significantly once a dose of phosphorus was applied.

Key words: *long-term experience, wheat, nitrogen, phosphorus.*

INTRODUCTION

This experience is part of the 18 long-term experiences placed by Academician Cristian Hera in 1966 in a network with different climate and soil conditions specific to Romania. The organization of the experiences was made after a single concept. In the period after 1990 scientific research in agriculture was undercapitalized on all "fronts", without bringing in new sources for the revitalization of new structures that could continue the reconstruction of Romanian agriculture. Thus, 12 of these experiences are now left (Hera, 2013), one of which is at Valu lui Traian.

At the time the experimental scheme for these experiences was established it was expected that in Romania the use of mineral and organic fertilizers will increase. It was estimated that no matter how good the organic fertilizers are, even if the number of animals will increase, the amount of organic fertilizer will remain insufficient to provide the necessary for agriculture. Mineral fertilizer consumption increased until 1986 when there were applied, 129.9 kg/ha of NPK fertilizers on arable land, or 86.4 kg NPK/ha on agricultural land. In the year 2012 in Romania were used 290 000 t of nitrogen, 113 000 t of phosphorus and 35 000 t of potassium, which implies a total of 438 thousand tons NPK fertilizers, respectively 30.85 kg/ha arable N, 12 kg/ha P and 3.7 kg/ha K (Anuarul Statistic al României, 2015).

Long-term experiences with nitrogen and phosphorus started from the following premises:

1) The soils in our country ensure an important nitrogen amount for plant nutrition through humus mineralization, yet this usually insufficient to achieve high productions (Vintilă et al., 1984);

2) The use of fertilizers with phosphorus is based on the experimental results regarding the response of crops fertilized with phosphorus under different conditions and due to the need of increase of the accessible phosphorus content from the soil to optimal levels, in order to comply with the nutritional requirements of plants and with the increase of agricultural production (Davidescu et al., 1974; Hera and

Borlan, 1980; Borlan and Hera, 1984). It was considered that in most soils with medium and soft texture from the temperate zone, the potassium from soil presents a satisfactory level (Borlan and Hera, 1973, 1977; Băjescu and Chiriac, 1984).

Given all of the above in this experience was followed the effect of different doses of mineral fertilizers with phosphorus and nitrogen on corn production and on some chemical characteristics of the soil.

MATERIALS AND METHODS

The experience organized on chernozem followed the influence of the interaction of phosphorus doses (P_0, P_{50}, P_{100}, P_{150}, P_{200} kg/ha) with nitrogen doses (N_0, N_{50}, N_{100}, N_{150}, N_{200} kg/ha).

The experiment consisted of 25 placed in a randomized block design using 18 variants in 3 replications. To investigate the chemical characteristics, the soil samples that were collected at the depth of 0-20 cm, and the following analyzes were performed: pH, humus, total nitrogen, accessible phosphorus, accessible potassium, soluble salts, carbonates and total forms of heavy metals (copper, zinc, cadmium and lead).

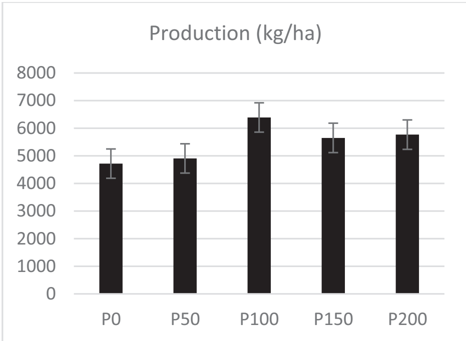
The methods used for the chemical characteristics are presented as follows:

- STAS 7184/21-82. - Organic matter (humus): volumetric method - Walkley Black, Gogoașă.
- SR7184/13-2001 - pH: determined by potentiometric method with combined with glass and calomel electrode in aqueous suspension soil/water - 1/2.5.
- SR ISO 11261: 2000 - total nitrogen (N%): Kjeldahl method, H_2SO_4 digestion at 350 °C, using potassium sulfate and copper sulfate as catalyst;
- Accessible (mobile) phosphorus: Egner-Riehm-Domingo method and spectrophotometric determination with molybdenum blue in accordance with Murphy-Riley method (reduction with ascorbic acid);
- Accessible (mobile) potassium: extraction according to Egner-Riehm-Domingo method and determination by flame photometry.

RESULTS AND DISCUSSIONS

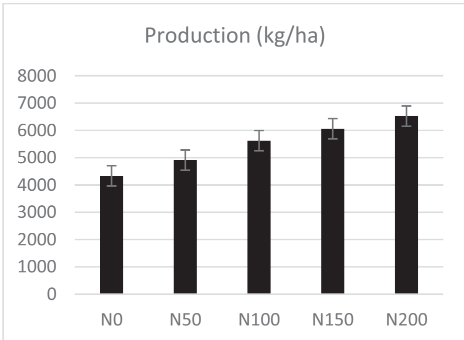
1. The influence with different nitrogen and phosphorus doses on wheat production

The influence of different phosphorous and nitrogen doses on the production of wheat grown on chernozem at Valu Traian are shown in Figures 1-3.



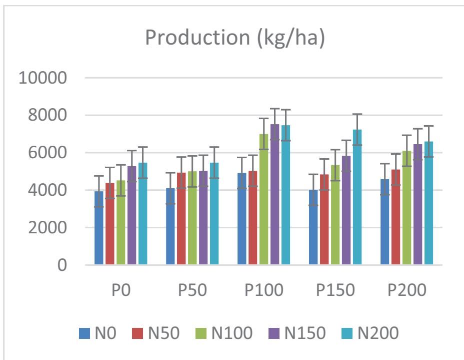
DL5% 531; DL1% 772; DL0.1% 1158

Figure 1. Phosphorus influence on the wheat yield



DL5% 371; DL1% 496; DL0.1% 652

Figure 2. Nitrogen influence on the wheat yield



DL5% 829; DL1% 1108; DL0.1% 1457

Figure 3. Influence of interaction phosphorus and nitrogen on wheat yield

The dose of phosphorus of 100 kg/ha, without nitrogen, led to the largest production increase (35%) compared to the unfertilized variant. The application of nitrogen on a background unfertilized with phosphorus shows that the production increased very significantly at doses > than 100 kg/ha nitrogen. The production yield, on a soil well supplied with organic matter and under irrigation conditions increased with the dose of nitrogen and was statistically ensured only at doses of 150 (distinctly significant) and 200 kg/ha nitrogen (very significant).

Variants fertilized with doses of P_{100} and N_{100}, N_{150} and N_{200} led to very significant increases of production (42%, 53% and 52%); the largest production (7522 kg/ha) was assured at variants $P_{100}N_{150}$ followed by those fertilized with $P_{100}N_{200}$.

At the application of $P_{150}N_{200}$ was obtained the highest production (7233 kg/ha), where the production yield compared to the nonfertilized variant with nitrogen was 80% (3220 kg/ha). A very significant increase of production of 1820 kg/ha was obtained also after the fertilization with $P_{150}N_{150}$.

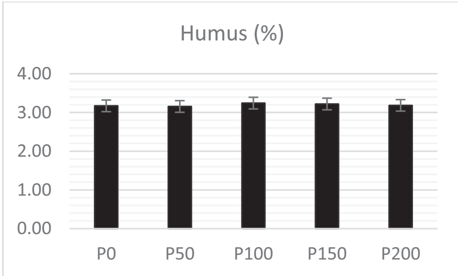
On a background of fertilization with P_{200}, the doses of 100, 150 and 200 kg/ha nitrogen led to very significant increases of production, the production increased with the increase of nitrogen dose; the combination of P_{200} and N_{200} provided a high production (6600 kg/ha), but much smaller than in the case of application of 150 and 200 kg/ha nitrogen on a background of 100 kg/ha phosphorus. The soils with high cation exchange capacity and saturation degree in bases larger than 75-80% are conditions for a better use of phosphorus fertilizers under soluble form (Berca, 2008).

Under irrigation conditions, the best corn productions of were obtained by fertilization with 100 kg/ha phosphorus and 150-200 kg/ha nitrogen; when the corn is well stocked with water, the nitrogen is efficiently exploited even if in high doses, and the phosphorus is seen as an amplifier of nitrogen effect (Zamfirescu, 1977). Similar results are were reported by Hera (2015); in many cases it was noted that the associated application of nitrogen and phosphorus fertilizers led to higher productions compared to the separate application of these fertilizers; therefore there is an interaction between these elements (Hera et al., 1984).

On background of P_{100} fertilization the average increase of production per kg of nitrogen in the case of fertilization with N_{100} and N_{150} was 10.4 kg, and in the case of fertilization with N_{200}, 8.5 kg.

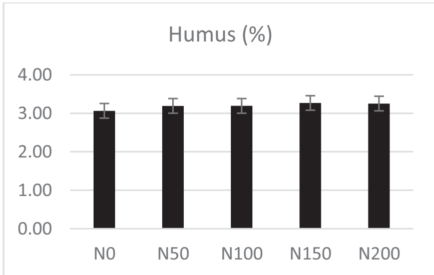
2. The influence of different doses of nitrogen and phosphorus on humus in soil

The effect of phosphorus and nitrogen doses applied for 35 years on humus content in the soil is presented in Figures 4, 5, 6. It was found that the doses of 150 and 200 kg/ha nitrogen have significantly increased the humus level in the soil.



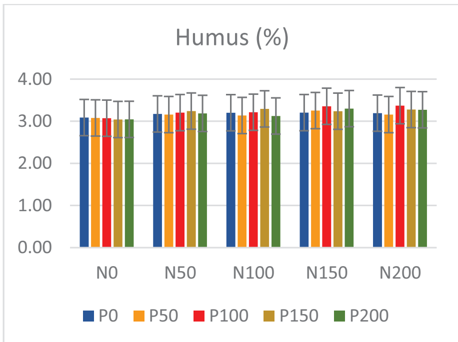
DL5% 0.15; DL1% 0.21; DL0.1% 0.32

Figure 4. Phosphorus influence on the humus evolution



DL5% 0.19; DL1% 0.26; DL0.1% 0.34

Figure 5. Nitrogen influence on the humus evolution



DL5% 0.43; DL1% 0.57; DL0.1% 0.75

Figure 6. Nitrogen and phosphorus influence on the humus evolution

Long term researches conducted by Andrieş (2007) in Moldova showed that the systematic application of mineral fertilizers leads to the stabilization of organic matter in the soil; in the long-term experiences from Halle (Germany) it has been found that after mineral fertilization, soil organic substance was maintained for 80 years at the same level (Eliade et al., 1983); the content of organic carbon from the soil presents significant decreases in NP combinations (without organic resources) and the high mineral doses (over 120-150 kg/ha and 80 kg/ha P_2O_5) balances after 30-40 years these changes and bringing them at least at the initial levels on account of the amount of organic material in the soil, depending on the nitrogen dose (Hera, 2013). Rusu et al. (2005) shows that mineral fertilization decreases soil humus and the organic fertilization increases the organic nitrogen and humus content and ensures favorable development of soil fertility. Otherwise, the long-term humus-reducing measures affect the fertility and the buffering capacity of soils, making them more vulnerable to degradation and pollution factors.

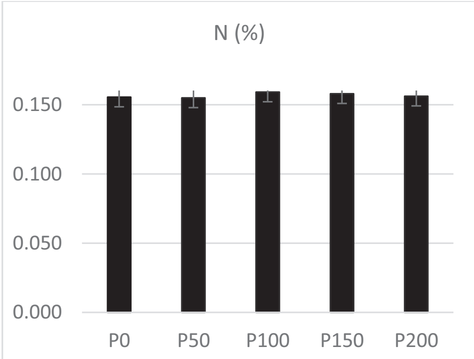
3. The influence of different doses of nitrogen and phosphorus on nitrogen in soil

Nitrogen cycle in the soil-plant system is very dynamic and complex. The transformations of nitrogen in soil, its uptake in plants and the immobilisation are determined by climate variability, soil type and plants (Fageria, 2009; Mocanu et al., 2005).

Part of the nitrogen applied from chemical fertilizers and the one resulted from the humus mineralization and unused for plant nutrition is lost during the nitrification process. The nitrate ions resulted are leaching on the soil profile at the same time with rainfall or irrigation water (Lăcătuşu et al., 2005; Ghiglieri et al., 2009; DEFRA, 2010). Researches carried out by Borlan et al. (1994) have shown that on middle texture soils with good water permeability, from the nitrogen applied in optimum economical doses after chemical fertilization, the denitrification losses are 20-25% and 5-10% from the organic nitrogen resulted from humus mineralization.

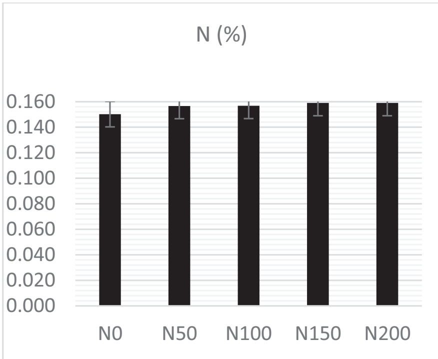
In Figures 7-9, is presented the effect of various doses of nitrogen and phosphorus on the total nitrogen content on chernozem.

Fertilization with phosphorus in doses of 50-200 kg/ha and nitrogen in doses of 50-200 kg/ha for 35 years did not led to significant changes in the total nitrogen in soil. The nitrogen cycle is closely linked to the carbon cycle (Andrieş, 2011), and the lack of changes in humus content justified the absence of changes in total nitrogen content in the soil.



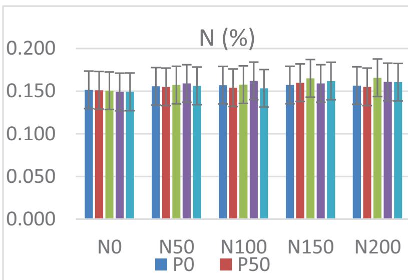
DL5% 0.007; DL1% 0.011; DL0.1% 0.016

Figure 7. Phosphorus influence on the evolution of soil nitrogen



DL5% 0.010; DL1% 0.013; DL0.1% 0.017

Figure 8. Nitrogen influence on the evolution of soil nitrogen

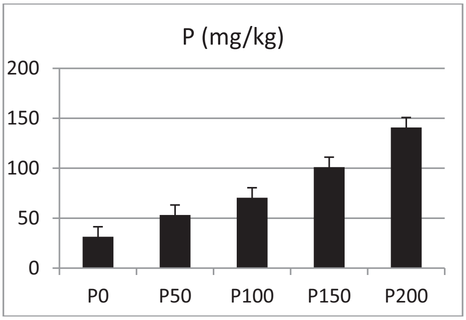


DL5% 0.022; DL1% 0.029; DL0.1% 0.038

Figure 9. The influence of fertilization with nitrogen and phosphorus on soil nitrogen evolution

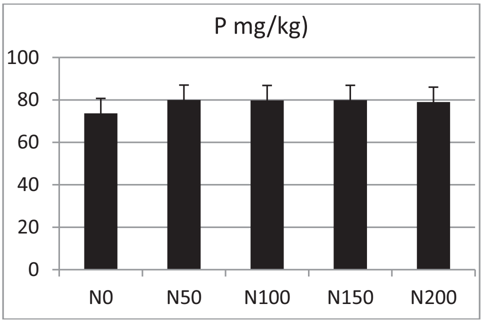
4. The influence of different doses of nitrogen and phosphorus on the mobile phosphorus in soil

In Figures 10-12 is presented the influence of phosphorus and nitrogen fertilization for 35 years on mobile phosphorus content.



DL5% 10; DL1% 14; DL0.1% 21

Figure 10. Phosphorus influence on the evolution of phosphorus in soil



DL5% 7; DL1% 9; DL0.1% 12

Figure 11. Nitrogen influence on the evolution of phosphorus in soil

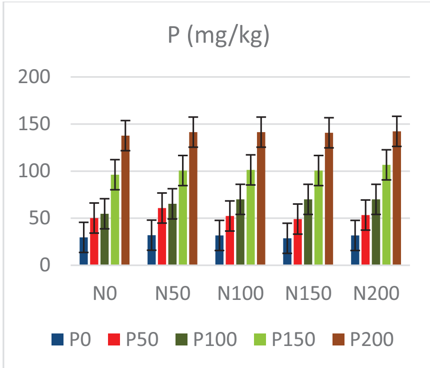
The phosphorus content in soil increases significantly with the increase of phosphorus dose; at the dose of 50 kg/ha phosphorus the increase is distinctly significant and at dosages ≥100 kg/ha phosphorus the increase is very significant.

Mobile phosphorus content in soil was not afected by the application of different doses of nitrogen.

Under the influence of fertilization with doses of phosphorus higher than the productive consumption, the content of mobile phosphorus significantly increases during the first 20 years of the experiment (Hera, 2013).

Borlan et al. (1990) show that mineral fertilization with nitrogen negatively influences the of mobile phosphorus content from the arable layer of the soil. This was not the case in our study since the soil is well supplied with phosphorus and saturated with bases.

Avarvarei et al. (1997) showed that organic matter protects phosphorus ions precipitation by forming chelates organomineral compounds, that retain phosphorus ions. Also certain organic ions can release phosphate ions fixed on soil particles and the CO_2 released after organic matter mineralization, can play an important role in the solubilization of phosphates.



DL5% 16; DL1% 21; DL0.1% 28

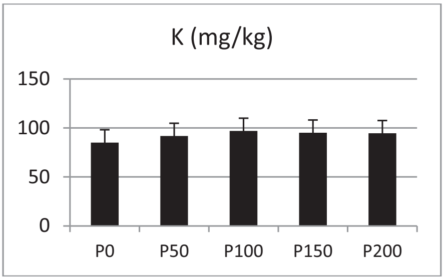
Figure 12. The graphical representation of the influence of nitrogen and phosphorus fertilization on the evolution of the mobile phosphorus in the soil

McBride et al. (1987) (cited by Vrânceanu et al., 2010) showed using various adsorption environments that the presence of high concentrations of phosphate ions in solution leads to the decrease of zinc and copper adsorption.

The phosphate ion does not form stable complexes with zinc and copper, but it is absorbed on soil surface, blocking the access of the copper and zinc ions to the specific adsorption sites.

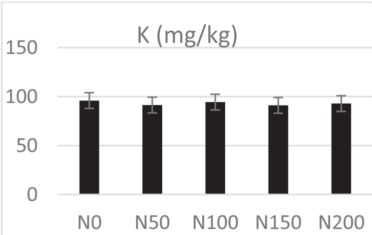
5. The influence of different doses of nitrogen and phosphorus on the mobile potassium in soil

The influence of long-term treatments (35 years) with nitrogen and phosphorus on the mobile potassium content in the soil are shown in Figures 13-15 and highlight that the long term fertilization with dose of 50-200 kg/ha nitrogen and similar phosphorus doses did not led to significant changes in the mobile potassium content of the soil.



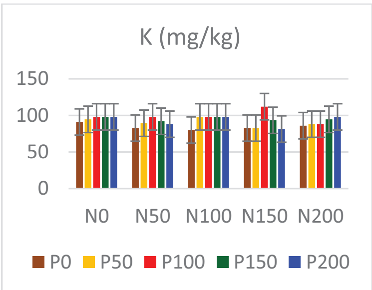
DL5% 13; DL1% 19; DL0.1% 29

Figure 13. Phosphorus influence on the evolution of mobile potasium in soil



DL5% 8; DL1% 11; DL0.1% 14

Figure 14. Nitrogen influence on the evolution of mobile potasium in soil



DL5% 18; DL1% 24; DL0.1% 31

Figure 15. Graphical representation of the influence of fertilization with nitrogen and phosphorus on the evolution of the mobile potassium in the soil

Borlan (1998) estimated that only nitrogen and phosphorus fertilization decreases the value of mobile potassium. Such that on soils poor on mobile forms of potassium ($K_{AL} \leq 100$ mg/kg) the efficiency of NP fertilization decreases.

The rate of decrease of the mobile potassium content seems to intensify with the decrease of the saturation with bases and bases content in soils (Borlan et al., 1982). The mobile potassium level from our experimental variants did not decreased because the soil was saturated with bases.

The long-term fertilization with different doses of phosphorus and nitrogen did not lead to any statistically significant changes of pH. We mention that the soil is 100% saturated with bases and its calcium carbonate content that ranges between 0.08 and 0.70%. Values were between 7.9-8.0 pH units.

CONCLUSIONS

The production presented a significant increase in the variants fertilized with 50 kg/ha nitrogen and very significant in those with doses above 100 kg/ha nitrogen; the production yields under irrigation conditions, on a soil well supplied with organic matter, increased with the increase of nitrogen dose.

On a background unfertilized with phosphorus, the corn production increased with the dose of nitrogen, being statistically ensured only at the doses 150 (significantly distinct) and 200 kg/ha nitrogen (very significant).

On a background of P_{50} fertilization, nitrogen doses of 50, 100 and 150 kg/ha provided a significant production yield, and the doses of 200 kg/ha nitrogen led to a distinctly significant production yield.

On a background of P_{100} fertilization, N_{50} fertilization with did not result in statistically ensured increases of production; the N_{100}, N_{150} and N_{200} doses led to significant production increases (42%, 53% and 52%); the variants with fertilized $P_{100}N_{150}$ have ensured the highest production (7522 kg/ha) followed by those fertilized with $P_{100}N_{200}$.

On a background of P_{150} fertilization, the highest production (7233 kg/ha) was obtained in variants fertilized with N_{200}, the production yield compared to the variant non-fertilized with nitrogen was 80% (3220 kg/ha); fertilization with $P_{150}N_{100}$ ensured a distinctly significant production yield and $P_{150}N_{150}$ fertilization ensured a very significant production yield.

On a background of P_{200} fertilization, the dose of 50 kg/ha nitrogen did not ensured a significantly statistic production yield, while the doses of 100, 150 and 200 kg/ha nitrogen led to very significant increases of the production, the production increased with the increase of nitrogen dose; the combination of P_{200} and N_{200} provided a high production (6600 kg/ha), but much smaller than in the case of

150 and 200 kg/ha nitrogen application on a background of 100 kg/ha phosphorus.

Under irrigated conditions the best wheat productions were obtained after fertilization with 100 kg/ha phosphorus and 150-200 kg/ha nitrogen.

On a background of P_{100} fertilization, the average production yield per kg of nitrogen in the case of N_{100} and N_{150} fertilization was 10.4 kg, respectively 8.5 kg in the case of using N_{200} fertilization.

Application for 35 years of doses of 50-200 kg/ha phosphorus with the same doses of nitrogen did not result in statistically significant changes of the level of total nitrogen and mobile potassium from the chernozem.

The mobile phosphorus content increases significantly with the increase of phosphorus dose; at the dose of 50 kg/ha phosphorus the increase is distinctly significant and at the doses ≥100 kg/ha phosphorus the increase is very significant.

The long-term fertilization with different doses of phosphorus and nitrogen did not led to statistically significant changes of pH.

REFERENCES

Andrieş S., 2007. Optimizarea regimurilor nutritive ale solurilor şi productivitatea plantelor de cultură. Ed. Pontos, Chişinău.

Andrieş S., 2011. Agrochimia elementelor nutritive. Fertilitatea şi ecologia solurilor. Ed. Pontos, Chişinău.

Avarvarei I., Davidescu D., Mocanu M., Goian M., Caramete C., Rusu M., 1997. Agrochimie. Ed. Sitech, Craiova.

Băjescu I., Chiriac A., 1984. Distribuţia microelementelor în solurile din Romania. Implicaţii in agricultură. Ed. Ceres, Bucuresti, pp. 219.

Berca M., 2008. Managementul integrat al nutriţiei plantelor. Ed. Ceres, Bucureşti.

Borlan Z., Hera Cr., 1973. Metode de apreciere a stării de fertilitate a solului în vederea folosirii raţionale a îngrăşămintelor. Ed. Ceres, Bucureşti.

Borlan Z. şi Hera Cr., 1977. Îndrumător pentru stabilirea necesarului de îngrăşăminte şi amendamente la plantele de câmp. Ed. Ceres, Bucureşti.

Borlan Z., Hera Cr., Ghidia A., Pasc I., Condei Gh., Stoian L., Jidav E., 1982. Tabele şi monograme agrochimice. Ed. Ceres, Bucureşti.

Borlan Z. şi Hera Cr., 1984. Optimizarea agrochimică a sistemului sol-plantă. Ed. Academiei R.S.R., Bucureşti.

Borlan Z., Hera Cr., Dornescu D., Kurtinecz P., Rusu M., Buzdugan I., Tănasee Gh., 1994. Fertilitatea şi fertilizarea solurilor. Ed. Ceres, Bucureşti.

Borlan Z., 1998. Prognoza evoluţiei însuşirilor agrochimice şi corelarea acestora cu cerinţele de amendare şi fetilizare a solurilor agricole. In monitoringul stării de calitate a solurilor din România, Bucureşti, Vol. II, pp. 363-400.

Davidescu D., Borlan Z., Davidescu V., Hera C., 1974. Fosforul în agricultură. Ed. Academiei R.S.R., Bucureşti.

Eliade Gh., Ghinea L., Ştefanic Gh., 1983. Bazele biologice ale fertilităţii solului. Ed. Ceres, Bucureşti.

Fageria N.K., 2009. The use of nutrients in crop. CRC Press Taylor & Francis Group.

Ghiglieri G., Barbieri G., Vernier A., Carletti A., Demurtas N., Pinna R., Pittalis D., 2009. Potential risks of nitrate pollution in aquifers from agricultural practices in the Nurra region, northwestern Sardinia, Italy. Journal of Hydrology, Vol. 379, Issues 3-4, pp. 339-350.

Hera Cr., Borlan Z., 1980. Ghid pentru alcătuirea planurilor de fertilizare. Ed. Ceres, Bucureşti, pp. 15, 18, 23, 36, 45-52.

Hera Cr., Borlan Z., 1984. Optimizarea agrochimică a sistemului sol-planta. Ed. Academiei, Bucureşti, pp. 66, 71, 102, 119, 128-145.

Hera Cr., 2013. Cuvânt de recepţie. Chişinău.

Hera Cr., 2015. Al VIII-lea Congres Mondial de ştiinţa solului - eveniment de referinţă în ştiinţa românească. În Al VIII-lea Congres Mondial de ştiinţa solului. Pledoarie pentru sol. Hera C., editor, Ed. Academiei Române.

Lăcătuşu R., Lungu M., Kovacsovics B., 2005. Poluarea nitrică - o temă veche de marea actualitate. CIEC-Diversitatea sortimentului de îngrăşăminte şi îmbunătăţirea calităţii acestora în raport cu cerinţele agriculturii durabile, Ed. Agris.

McBride M.B., 1987. Processes of heavy metal and oxyanion sorption by soil constituients. Lucrările Congresului al XIII-lea al Societăţii Internationale de Ştiinţa Solului, 13-20 august 1986, Hamburg.

Mocanu R., Mocanu A.M., Susinski M., 2005. Efectul unor tipuri de îngrăşăminte cu azot la unele culturi pe diferite tipuri de sol din Oltenia. CIEC-Diversitatea sortimentului de îngrăşăminte şi îmbunătăţirea calităţii acestora în raport cu cernţele agriculturii durabile, Ed. Agris.

Rusu M., Marghitaş M., Oroian I., Mihăiescu T., Dumitraş A., 2005. Tratat de agrochimie. Ed. Ceres, Bucureşti.

Vintilă I., Borlan Z., Răuţă C., Daniliuc D., Ţigănaş L., 1984. Situaţia agrochimică a solurilor din România. Prezent şi viitor. Ed. Ceres, Bucureşti.

Vrînceanu N.O., Dumitru M., Motelică D.M., Gamenţ E., 2010. Comportarea unor metale în sistemul sol-plantă. Ed. Solness, Timişoara.

Zamfirescu N., 1977. Bazele biologice ale producţiei vegetale. Ed. Ceres, Bucureşti.

***Anuarul statistic al Romaniei, 2015.

***DEFRA Department for Environment Food and Rural Affairs, Fertiliser Manual (RB 209), 8th Edition UK, 2010.