AGRICULTURE'S CONTRIBUTION TO THE ECONOMIC RECOVERY – POSSIBILITIES OF REDUCING THE CURRENT INPUT CRISES

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Abstract: *This paper approaches an extremely current topic, namely the substitution of synthetic nitrogen, very expensive and polluting, with nitrogen of biological synthesis, through the peas and Rhizobium system, cheap and non-polluting. The entire economy is going through a period of crises, generated by people's ineptitude in managing precisely their most important problems, namely those of food and social security and safety. Over time, there has been a correlation between the price of gas, which 80% goes into the nitrogen processing, and that of fertilizers. In 2022, the price of gas increased, on average, 9 times, reaching 450 EUR/1000 m^3, and the price of fertilizers reached 1200 EUR/t. Between 2020 and 2022, the fuel price also doubled, and the value of other inputs was well above the multiplier of 2. By mid-2022, the price of wheat increased from 80-85 EUR/t, to 300-310 EUR/t, with very large fluctuations even from one day to another. However, the high price of wheat cannot cover all the expenses involved in the cultivation process, which puts mankind's bread in danger. The situation is similar for other agricultural crops. It's becoming clear that there is an urgent need to turn over research in order to find solutions for ameliorate the state of deep crisis in which bread and other food production are, as well as public health, after two years of the Covid-19 pandemic and during a war in the immediate vicinity of Romania's borders.*

Keywords: *wheat, peas, inputs, crisis, price increase*

JEL classification: Q11, Q12, Q14, Q16, Q17

INTRODUCTION

Nitrogen (N) is one of the basic elements of life and the strategic building block of proteins, including DNA and RNA acids. The Earth's main source of nitrogen is the atmosphere (the air), where it is found in 78%. As a gas, nitrogen has a density (D) of 1.251 kg/m3, resulting in a quantity of nearly 1 kg N/m3 of air.

$$N_{echiv} = 1,251 \times 0,78 = 0,97578 \text{ kg } N_2$$

So, above each ha and at a height of 1000 m (1 km) there is an amount of:

$$10.000 \times 1000 \times 0,97 = 9.700.000 \text{ kg N/ha} = 9.700 \text{ t N/ha}$$

According to some authors (Rutting et al., 2018), this amount would be much higher. There is, however, enough nitrogen for plant nutrition, both through Haber-Bosch chemical synthesis (very expensive and polluting) and through biosynthesis (bacteria and other fixing organisms).

Rhizobium bacteria, whose original name was *Bacillus radicicola*, fixes up to 280 kg N/ha by entering into symbiosis with the roots of legumes (Lohnis, 1921). There are numerous other species of microorganisms that have the ability to fix nitrogen in various forms (Bodirsky et al., 2012).

Agriculture, and not only it, is going through a period of crises (Horoiaș et al., 2022) generated by people's lack of skill in managing exactly their most important problems, namely the issues of food and social security and safety (Vatta et al., 2022). But it's not only that. A careful analysis of the international situation shows that these crises, with a very high probability, were generated by basic exponents of human society. As researchers, we are obliged to remove the negative side from our thinking and look for solutions to move society forward.

People need food, bread, but also many other foods. Given that the total value of the costs related to the use of inputs necessary for wheat production has become unimaginably high (Kostic et al., 2021; Langemeier & Zhou, 2022), we must find solutions to bring them back within the still bearable limits, in order to avoid new crises, such as food crisis, environmental crisis (Abrol et al., 2007; Martinez-Dalmau et al., 2021) etc.

For wheat crop management, we note that, at this moment, the realization costs have multiplied by a factor of 2.5 ± 15% (own calculations), so:

$$C = C_{2019} \times 2.5$$

, where: C = costs/ha in 2022;

C_{2019} = costs/ha in 2019.

For Romanian farmers this is a big problem. With the current technologies and price levels of inputs, it is not possible to do efficient and sustainable agriculture. The present paper presents the results of some studies carried out in 2022, is based on field research and aims to propose some solutions to solve the nitrogen deficiency, the basic nutrient element of plants, by replacing, even partially, the synthetic nitrogen obtained from fossil fuels, so expensive today, with nitrogen of microorganic biosynthesis (symbiosis, associative and free) taken from the air, atmosphere. Currently, for the south of Romania, this desired can be achieved by introducing the pea crop in the crop rotation used, being the legume with the best yield in non-irrigated conditions (Berca et al., 2018; Muniz et al., 2017).

MATERIALS AND METHODS

The aim of the work is to search for solutions for substituting nitrogen nutrition from chemical synthesis with nitrogen obtained through biochemical synthesis (symbioses, associations, free fixation).

The objectives of the article are:

a) reducing the very high costs currently generated by Haber-Bosch synthesis nitrogen nutrition;
b) reducing the carbon footprint of nitrogen nutrition, the largest one generated by wheat inputs – moving towards an ecological, bioeconomical nutrition.

In order to achieve the proposed objectives, research was carried out in the field regarding the influence of crop rotation, and especially the pea-wheat rotation, on the fixation of atmospheric nitrogen in locations in southern Romania (Teleorman and Calarasi counties). The amount of nitrogen fixed symbiotically on the roots of peas, variety Belmondo, as well as its availability to wheat was determined.

Starting from these researches, calculations were made to demonstrate how much nitrogen the pea can fix during its vegetation period, how much of it is used for its own production and how much it makes available to the wheat, which follows in the rotation. At the same time, it was aimed to find out the expenses that can be recovered from the sum of the costs of nitrogen nutrition for the wheat crop. Tools such as scatter analysis of functions and correlations were used to separate random from factorial (non-random) variations, to demonstrate the repeatability of the results obtained.

The studies were carried out in the southern part of the Romanian Plain, on soils of the chernozem type, more leached and with a loamy-clay texture in Teleorman county and less leached, slightly carbonated and with a clayey texture in Calarasi county.

Observations and measurements spanned a period of 10 years (2012-2021) and were carried out on research plots cultivated in subdivided plots, in 4 repetitions, in order to perform statistical calculations by analysis of variance.

RESULTS AND DISCUSSIONS

The research and calculations developed in this paper represent a model for reducing the large amounts of nitrogen applied from chemical synthesis and replacing them, as much as possible, with biosynthesis nitrogen extracted from the atmosphere.

There are at least three models of atmospheric nitrogen fixation by biochemical processes – free, associative and symbiotic. Taking into account the fact that the most productive biological fixation is in legumes, in order to achieve the objective of this work it is necessary to establish how we make as much of this nitrogen as possible reach the following crops. We can say that the solution to chemical nitrogen, very expensive and polluting, is atmospheric nitrogen, for several reasons:

- it is free;
- it is enough;
- is non-polluting;
- remains in the natural nitrogen circuit, without side effects;
- can be used through natural models or biotechnological engineering models.

The first solution consists in using rotations of at least 3-5 crops. In the rotation it is necessary to have at least one improving, nitrogen-fixing plant. In our own research in the two locations in southern Romania (Teleorman and Calarasi) a 4-year rotation was used, of the type: peas → wheat → maize/sunflower → rapeseed, and the results from the period 2012-2021 are presented in the form of a complex functions.

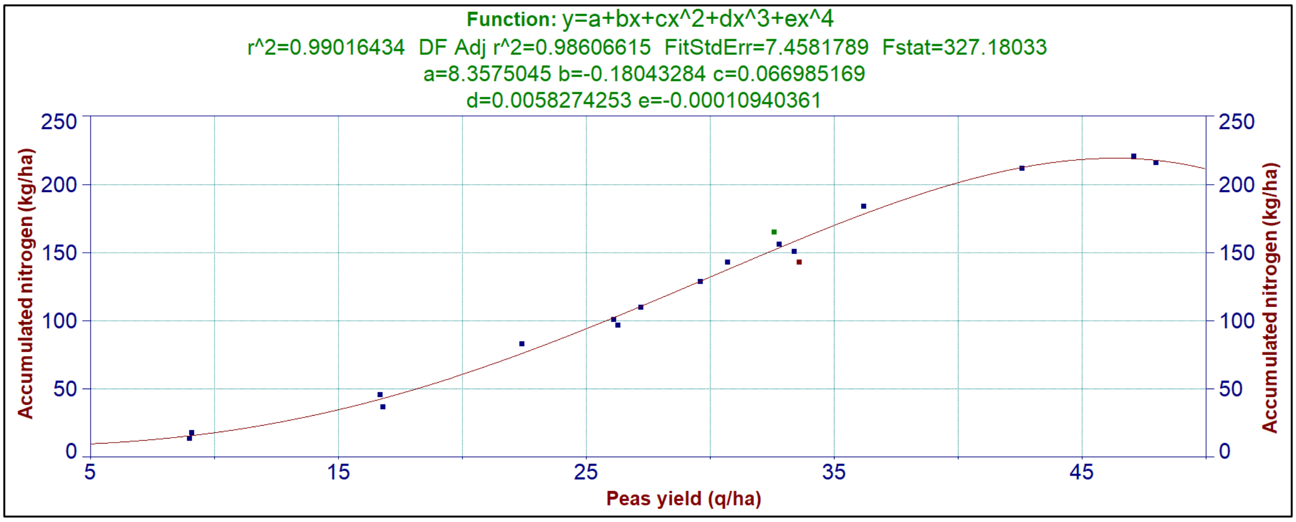

Fig. 1. Correlation between pea production and accumulated nitrogen, 10-year average, 2012-2021 (original)

From the large volume of data obtained during the 10 years of experimentation, in Fig. 1 shows the correlation between pea production, as a determining factor, and the amount of accumulated nitrogen. These averages were obtained by calculating production data and measuring nitrogen, at the end of each agricultural year, taking into account the differences generated by the action of biotic and abiotic factors, but also by the preceding plant. The amount of nitrogen fixed varies greatly from one year to another, being observed to be directly proportional to the pea production obtained. The fixation range starts from 17 kg N/ha in the year with the lowest production, going up to 216-221 kg N/ha when the maximum production of 4700 kg peas/ha was obtained.

The goal is to obtain, through symbiosis or another form of atmospheric nitrogen fixation, as much nitrogen input as possible, in order to reduce the extremely high costs of nitrogen fertilizers.

Starting, therefore, from the average values for 10 years – 2888 kg peas/ha and 183 kg N fixed, to which is added the 62 kg N/ha obtained in the roots, as the calculations in Fig. 2. The total accumulated nitrogen (from aboveground and underground parts of the pea crop) is 183 + 62 + 8.5 = 253.5 kg N/ha. From this amount, subtract the 116 kg N from the grains, resulting in an approximate value of 137.5 kg N/ha by simply incorporating the biomass, after harvesting.

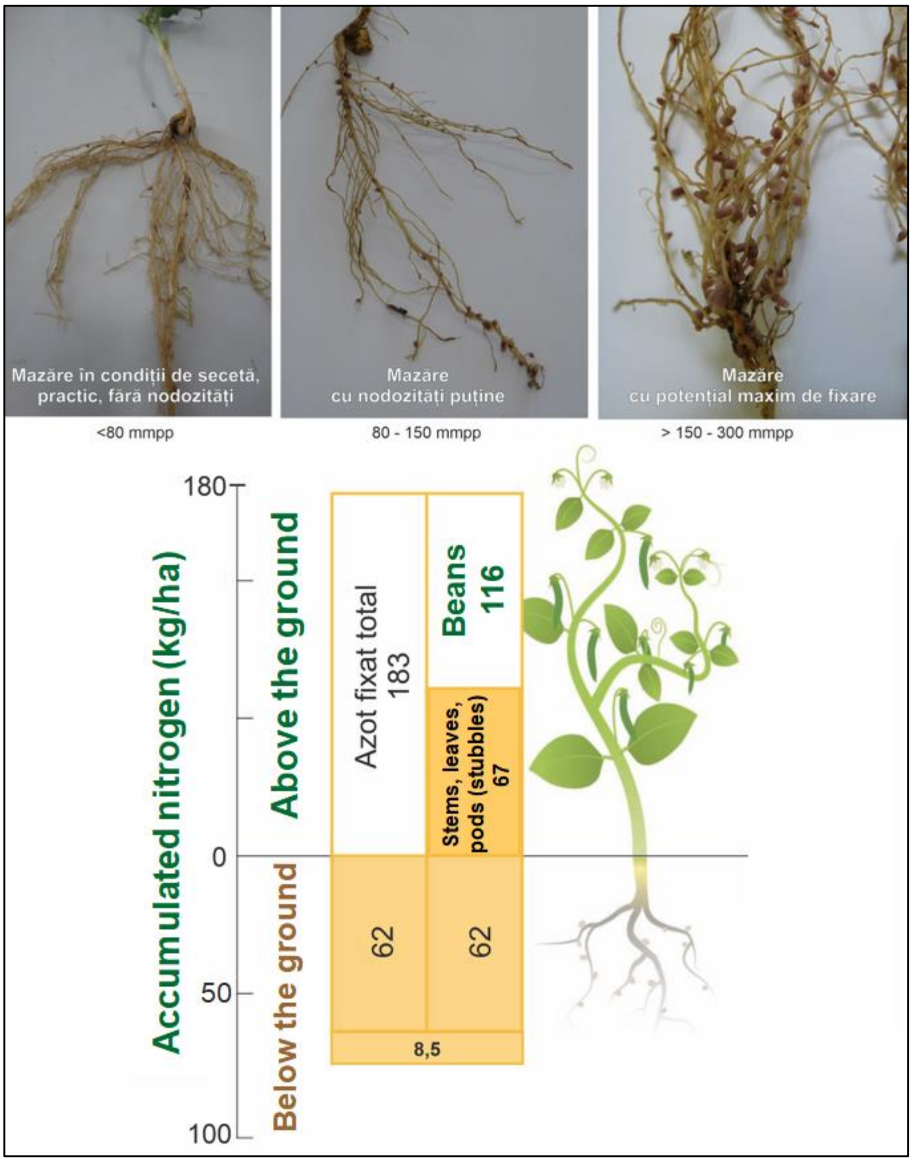

Fig. 2. The total amount of nitrogen fixed by peas, by plant components (original)

With the approximately 70 kg N left in the soil only from the peas (62 kg N/ha from the roots + 8.5 kg N/ha from the shaken grains and left in the soil = 70.5 kg N/ha) 3000 kg can be obtained wheat/ha, if this will be the next crop, as it was in our case. This means that we have halved the cost of nitrogen inputs – if we consider that a tone of fertilizer is €1200, it means that we could reduce the cost to €600, a substantial gain for any farmer.

Peas are an example and a handy variant for southern Romania, but there are other leguminous plants that fix large amounts of nitrogen and which have been included in research by various authors. Lupins and lentils are some of these legumes, fixing even more nitrogen than peas

(Kelstrup et al., 1996). Also, perennial legumes (alfalfa, clover) can accumulate up to 300 kg N/ha, being very useful in the soil restoration process.

CONCLUSIONS

Pea is a basic proteinaceous plant that, in the research fields from southern Romania (Teleorman and Calarasi counties), obtained average yields over a period of 10 years of 2888 kg/ha, good harvests for a semi-arid climatic environment. In the experimental field the maximum production was 4700 kg/ha (Belmondo variety, 2021).

Soils in the south of the country have sufficient *Rhizobium leguminosarum* bacteria. The amount of nitrogen fixed by the biosynthesis of the symbiosis, on average over 10 years, was 124 kg N/ha. Nitrogen fixation correlates very significantly with the level of precipitation in April-June. In conditions of severe drought, the production was around 900 kg/ha, and the fixed nitrogen was 14-18 kg N/ha (year 2020). At more than 4700 kg of peas/ha and under conditions of sufficient and accessible moisture, the amount of nitrogen fixed is 216-221 kg/ha (years 2015 and 2021).

The correlation between grain pea production and accumulated nitrogen is very high and highly significant (r2 = 0.99; D = 99%). This function and the correlation allow us to estimate the amount of nitrogen that accumulates in Romanian soils, provided that the technological rules that influence the process of symbiosis and fixation are respected, with an emphasis on the elimination of monoculture.

REFERENCES

1. Abrol, Y.P., Raghuram, N. & Sachdev, M.S. (2007). Agricultural nitrogen use & its environmental implications. I.K. International Publishing House Pvt. Ltd., New Delhi.
2. Berca, M., Robescu, V.O., Croitoru, G. & Horoias, R. (2018). Symbiotic fixation of nitrogen in Belmondo pea variety in a suggested crop rotation system – technical, ecological and economic efficiency. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 18(2), 35-40.
3. Bodirsky, B.L., Popp, A., Weindl, I., Dietrich, J.P., Rolinski, S., Scheiffele, L., Schmitz, C. & Lotze-Campen, H. (2012). Current state and future scenarios of the global agricultural nitrogen cycle. Biogeosciences Discuss, 9, 2755-2821.
4. Horoias, R., Tita, V. & Nijloveanu, D. (2022). Study on the new management strategy for agricultural farms in Romania, as a result of the energy crisis from 2021-2022. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 22(2), 401-406.
5. Kelstrup, L., Rowarth, J.S., Williams, P.H. & Ronson, C. (1996). Nitrogen fixation in peas (*Pisum sativum* L.), lupins (*Lupinus angustifolius* L.) and lentils (*Lens culinaris* Medik.). Proceedings Agronomy Society of New Zeeland, 26, 71-74.
6. Kostic, M.A., Tagarakis, A.C., Ljubicic, N., Blagojevic, D., Radulovic, M., Ivosevic, B. & Rakic, D. (2021). The effect of N fertilizer application timing on wheat yield on chernozem soil. Agronomy, 11, 1413.
7. Langemeier, M. & Zhou, L. (2022). International benchmarks for wheat production. farmdocDAILY, University of Illinois at Urbana-Champaign, Department of Agricultural and Consumer Economics, 12, 65. Retrieved September 20, 2022 from https://farmdocdaily.illinois.edu/2022/05/international-benchmarks-for-wheat-production-5.html.
8. Lohnis, F. (1921). Nodule bacteria of leguminous plants. Journal of Agricultural Research, Washington D.C., XX(7), 543-559.
9. Martinez-Dalmau, J., Berbel, J. & Ordonez-Fernandez, R. (2021). Nitrogen fertilization. A review of the risks associated with the inefficiency of its use and policy responses. Sustainability, 13, 5625.
10. Muniz, A.W., Dalla Costa, M., de Sa, E.L.S., Fiuza, A.B. & Brose, E. (2017). Symbiotic efficiency of pea (*Pisum sativum*) rhizobia association under field conditions. African Journal of Agricultural Research, 12(32), 2582-2585.

11. Rutting, T., Aronsson, H. & Delin, S. (2018). Efficient use of nitrogen in agriculture. Nutrient Cycling in Agroecosystems, 110, 1-5.
12. Vatta, K., Bhogal, S., Green, A.S., Sharma, H., Petrie, C.A. & Dixit, S. (2022). Covid-19 pandemic-induced disruptions and implications for national food security and farm incomes: farm-level evidence from Indian Punjab. Sustainability, 14, 4452.