

CAUSES AND SOLUTIONS FOR THE REMEDIATION OF THE POOR ALLOCATION OF P AND K TO WHEAT CROPS IN ROMANIA

Florin SALA, Ciprian RUJESCU, Cristian CONSTANTINESCU

Banat University of Agricultural Sciences and Veterinary Medicine “King Michael I of Romania”,
Timisoara, Calea Aradului 119, 300645, Timișoara, Romania, Phone: +40 256 277280,
Fax: +40 256 200296, Email: florin_sala@usab-tm.ro, rujescu_ciprian@yahoo.com

Corresponding author, email: florin_sala@usab-tm.ro

Abstract

The aim of the present study was to establish the main cause of the poor allocation of PK fertilizers to wheat crops, as this phenomenon has been observed in Romania. The experimental research consisted in differentiated allocation of fertilizers with N and the PK complex in order to create controlled nutrition deficits. It was conducted within the Didactic Station in Timisoara, from 2012 to 2014. Based on the yields obtained and on the associated economic elements, two scenarios were used: variation of wheat selling price and the price of fertilizers; each scenario had several variants. For each variant, the study assessed the optimal dose of N and PK respectively that resulted in the maximum profit. The model employed for this purpose was a model given by the production function verified by experimental data. The results were analysed and processed with SPSS and the graphic representations with Wolfram Alpha. The study discovered that the main cause of the Romanian farmers' low interest in using PK fertilizers is the dissonance between the cost of PK fertilizers and the low market price of wheat. Given the current price of wheat - between 0.5 - 0.6 lei/kg⁻¹, the authorities have to adopt incentive pricing for PK fertilizers in order to stimulate the use of such fertilizers by Romanian farmers. These measures will result not only in better quality and quantity of the yield, but also in medium and long-term improvement of soil fertility.

Key words: fertilization, models, phosphorus, potassium, wheat.

INTRODUCTION

Wheat is one of the most widely used cereals in the world, together with rice and corn. On average, the world produces over 600 million tons of wheat annually (Shewry, 2009).

Wheat production is mainly concentrated in a few large areas: the European Union is responsible for around 21% of the entire production of wheat in the world (Eurostat Database). Over 50% of the wheat production is obtained in France (about 41 Mio. tons), Germany (approx. 24 Mio. tons) and the UK (approx. 15 Mio. tons). Other countries with large wheat yields are Poland (approx. 10 Mio. tons), Italy (approx. 6 Mio. tons), Denmark, Romania and Spain (approx. 5 Mio. tons each), Bulgaria and Hungary (almost 4 Mio. tons each). The development of better crop technologies and the improvement of the biologic material in recent years have led to a significant increase in wheat production worldwide (Vigani et al., 2013). Romania is among the biggest 6 producers of wheat in

Europe: here, wheat is cultivated on an area of approx. 2.135 million ha, with an average yield of 3479 kg ha⁻¹ and a total production of 7.428 million tons (INS, 2014).

Fertilizers are necessary for increasing the productivity of agricultural crops, especially wheat crops. Nevertheless, fertilization has to be well-balanced in terms of nutrients and soil fertility, the consumption needs of plants and the estimated yields (Otiman and Creț, 2002; Havlin et al., 2005; Sala, 2011). Addition of macro- and micro-elements and balanced fertilization are essential for ensuring good quality and quantity of the wheat yield (Calderini and Ortiz-Monasterio, 2003; Malakouti, 2008; Habib, 2009; Zeidan et al., 2010; Pislea et al., 2013; Hamzeh and Sala, 2015; Wang et al., 2016).

The basic principles of plant nutrition are known (Marschner, 1995; Mengel and Kirkby, 2001), as are a series of principles and methods for establishing fertilization programs and fertilizer doses in relation to different agricultural systems (Borlan and Hera, 1982;

Buresh and Witt, 2007; Cui et al., 2008; Chuan et al., 2013). Nevertheless, certain limitations of technical and economical nature have generated imbalance in the optimal allocation of fertilizers in Romania, affecting soil fertility over large areas, the yields of different crops and the productivity of agricultural exploitations (Otiman, 1999).

It is well-known that, after 1989, in Romania, the allocation of fertilizing substances has been unevenly distributed in relation to the types of agricultural exploitations, being generally insufficient and generating nutritive imbalance on extensive areas (Dumitru, 2002; Hera, 2010).

Eurostat statistics show that, when compared to countries such as Germany or France, where on average 7-8 kilos P are added per hectare, as reported to UAA, or Croatia, where on average the allocation is 13 kg P/ha reported to UAA, in Romania the average allocation is 3 kilos P/ha, as reported to UAA. Certainly, if we look at the area cultivated with cereals (from UAA), which in Romania is approximately 37%, the quantity of phosphorus fertilizers allotted to cereal crops will be higher than the average mentioned above, but from the point of view of the biological potential of the cultivated plants and the necessary support for soil fertility in relation to the estimated yields, it is insufficient (Hera, Otiman et al. 2015). Eurostat statistics show that things are similar in respect to K fertilization, as well: almost 2 kg K/ha reported to UAA in Romania, while in France there are 13 kg K/ha reported to UAA, and in Germany there are 20 kg K/ha reported to UAA (Eurostat Database).

Optimization of wheat crop fertilization has always been of interest. Thus, a series of studies have developed models focusing on the interdependence among fertilizers, yield and quality in relation to the soil and climate conditions and to the cultivars (Fu et al., 2014; Swain et al., 2014; Rawashdeh et al., 2015; Sala et al., 2015; Nutall et al., 2016). Others have focused on optimizing the fertilization process with insufficient quantities of fertilizers (Sala and Boldea, 2011; Boldea and Sala, 2013). Recent measures for financing agriculture, based on the use of an initial fix capital, have introduced a different approach to

the optimization issue (in this case abandoning the idea of increasing the profits by minimizing the costs - concept that often involves fertilization deficit). In this sense, some studies have been made on particular cases, regarding the determination of optimal productions for a reference area, given a certain initial capital (Rujescu et al., 2014, 2015).

Taking into consideration the demand for quality wheat for human consumption and also some aspects that have been identified in the Romanian agricultural practice, the aim of the present study was to establish, through adequate mathematical analysis, the fact that the main cause of poor allocation of PK fertilizers is given by the lack of correlation between the market price of wheat and the prices of PK fertilizers, as well as to indicate threshold values for economic profitability.

MATERIALS AND METHODS

The starting point of the study is represented by direct results obtained under experimental conditions at the Didactic Station within BUASVM Timișoara, regarding the influence that different doses of N fertilizers and PK fertilizers, respectively, have on wheat yield. The variety of wheat cultivated was Alex. The studies were done on cambic chernozem with medium fertility, neutral reaction (pH = 6.7-6.8), good humus supply (H = 3.2%), nitrogen index IN = 2.8, high base saturation (88-90%), poor phosphorus supply (P = 11.4 ppm) and medium potassium supply (K = 130.5 ppm). The experiments were run between 2012 and 2014, and the climate conditions were favourable for wheat crops.

The fertilization variants were made based on the PK complex in rates between 0-150 kg ha⁻¹ and N in rates between 0-200 kg ha⁻¹.

Variants and combinations of variables. The study was focussed on two variables and the phosphorus and potassium fertilization was determined/motivated in relation to them. These variables are the price of wheat and the price of PK fertilizers. Price variations of the two variables were simulated in order to find the justification for fertilizer application at farmer level, Table 1.

Table 1. Schematic representation of the simulation variants – input data

V 1 Fixed data: $p_{\text{wheat}} = 0.5$ lei/kg; $p_N = 4.1$ lei; fixed costs per 1 hectare $c = 1900$ lei Variable: $p_{PK} = 6.1$ lei (current price)				
V 1A $p_{PK} = 4.1$ lei	Variables:		V 1C $p_{PK} = 5.1$ lei	V 1D $p_{PK} = 5.6$ lei
V 2 Fixed data: $p_{\text{wheat}} = 0.6$ lei/kg; $p_N = 4.1$ lei; fixed costs per 1 hectare $c = 1900$ lei Variable: $p_{PK} = 6.1$ lei				
V 2A $p_{PK} = 5.1$ lei		Variables:		
		V 2B $p_{PK} = 5.6$ lei		
Fixed data: $p_N = 4.1$ lei; $p_{PK} = 6.1$ lei; Fixed costs per 1 hectare: $c = 1900$ lei				
V3 $p_{\text{wheat}} = 0.7$ lei/kg		Variables V4 $p_{\text{wheat}} = 0.8$ lei/kg		V5 $p_{\text{wheat}} = 0.9$ lei/kg

The aim of the simulation was to indicate, for each variant, the optimal quantity of N and PK respectively, to be allocated for obtaining maximum profit. The negative values of the production factors PK indicate that the optimal point is not located in the first quadrant of the rectangular coordinate system $ONPK$, but in a different one, which translates into economic inefficiency under the respective initial conditions. The threshold values of the input were observed, which led to positioning the optimal point in the positive region of the coordinate system.

The mathematical model and functions. The first stage consisted in determining the production function $Q = Q(N, PK)$, which immediately led to the determination of the technical maximum, with the help of SPSS software. The expression of Q is given by a real-valued function with two real variables, N and PK, respectively, and real coefficients a_1, \dots, a_6 , of the form:

$$Q(N, PK) = a_1 N^2 + a_2 PK^2 + a_3 N \cdot PK + a_4 N + a_5 PK + a_6$$

expressions which give an objective description of the yield variation in relation to certain production factors, and on which one can easily apply the techniques for determining the extreme points (Intriligator, 2002).

The issue was then discussed from an

economic perspective, with prices for fertilizers and wheat that are currently on the market. After that, a simulation was made for various hypothetical prices of wheat and PK fertilizers, respectively, which resulted in the identification of variants/combinations which could indicate an increase in the interest to allocate P and K fertilizers in higher rates. The graphical representations in the present paper were made by using the application Wolfram Alpha.

RESULTS AND DISCUSSIONS

The differentiated conditions of plant nutrition ensured by fertilization with the two types of fertilizers, N and the PK complex, determined a specific development of the wheat crop in the experimental variants in relation to the nutrients supplied. Table 2 presents the yield results obtained.

Starting from the results obtained in real conditions, through the SPSS software, the corresponding production function was determined, represented by expression (1) and Figure 1.

$$Q(N, PK) = -0.0643N^2 - 0.0237PK^2 + 0.02362N \cdot PK + 26.333N + 5.361PK + 3300.53 \quad (1)$$

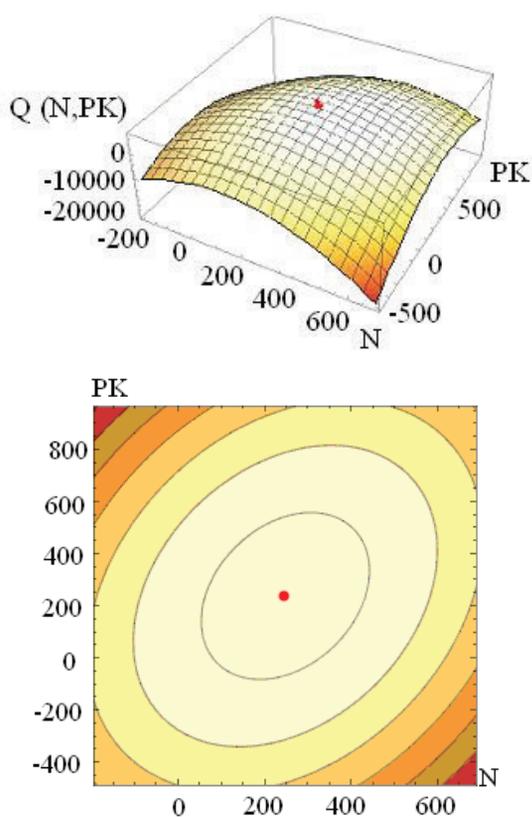


Figure 1. Graphical representations of the production function (graph and isoquants)

The high value ($r = 0.995$) of the correlation coefficient indicates closeness of the chosen functional model to the real phenomenon. By annulling the partial derivatives of function $Q(N, PK)$ one can get to the N and PK quantities that lead to the technical maximum of the function, namely 7204 kg ha^{-1} .

$$N = 248 \text{ kg/ha}, \text{ PK} = 236 \text{ kg/ha}$$

Table 2. The influence of the rates of N and PK fertilizers respectively on the wheat yield

N	PK	Q
0	0	3290
100	0	5180
200	0	6045
50	50	4765
100	50	5845
200	50	6385
100	100	5650
150	100	6445
200	100	6740
150	150	6655
200	150	6995

Taking into account the aim of the present paper, the variations in the prices of wheat and

PK fertilizers were simulated, in order to find the economic moment/conditions where PK fertilization is profitable and motivating for farmers.

The results obtained through simulation are described below, together with their graphical distribution in accordance with each variant.

Simulation variant 1 (V 1)

The input considered in variant 1 was: $p_{\text{wheat}} = 0.5 \text{ lei/kg}$; $p_N = 4.1 \text{ lei}$; $p_{PK} = 6.1 \text{ lei}$; fixed costs per 1 hectare $c = 1900 \text{ lei}$ and output: $N = 126 \text{ kg ha}^{-1}$, $PK = 81 \text{ kg ha}^{-1}$.

It is easy to note that the result obtained through simulation does not justify the use of PK fertilizers, for two reasons: the low price of wheat and the high price of PK fertilizers. This aspect will be justified in the following results, for other values of the market price of wheat and of PK fertilizers, respectively.

Simulation variant 1A (V 1A) considered the following input: $p_{\text{wheat}} = 0.5 \text{ lei kg}^{-1}$; $p_N = 4.1 \text{ lei ka}^{-1}$; $p_{PK} = 4.1 \text{ lei kg}^{-1}$; fixed costs per 1 hectare $c = 1900 \text{ lei}$, and output: $N = 143 \text{ kg ha}^{-1}$, $PK = 11 \text{ kg ha}^{-1}$, profit 390 lei ha^{-1} . The cost of 4.1 lei/kg PK induces an economic optimum which is realized for a positive value of PK rates. This is realized even if the wheat is sold for a low price, 0.5 lei kg^{-1} .

Simulation variant 1B (V 1B) considered the input: $p_{\text{wheat}} = 0.5 \text{ lei kg}^{-1}$; $p_N = 4.1 \text{ lei kg}^{-1}$; $p_{PK} = 4.6 \text{ lei kg}^{-1}$; fixed costs per 1 hectare $c = 1900$; Output: $N = 138 \text{ kg ha}^{-1}$, $PK = 11 \text{ kg ha}^{-1}$, profit 390 lei ha^{-1} . With these values of the prices for wheat and PK fertilizers, respectively, the results obtained through simulation do not justify the use of PK fertilizers.

Simulation variant 1C (V 1C) considered the input: $p_{\text{wheat}} = 0.5 \text{ lei kg}^{-1}$; $p_N = 4.1 \text{ lei ka}^{-1}$; $p_{PK} = 5.1 \text{ lei ka}^{-1}$; fixed costs per 1 hectare $c = 1900$; Output: $N = 134 \text{ kg ha}^{-1}$, $PK = 35 \text{ kg ha}^{-1}$, profit 402 lei ha^{-1} .

With these values of the prices for wheat and PK fertilizers, respectively, the results obtained through simulation do not justify the use of PK fertilizers.

Simulation variant 1D (V 1 D) considered the input: $p_{\text{wheat}} = 0.5 \text{ lei kg}^{-1}$; $p_N = 4.1 \text{ lei kg}^{-1}$; $p_{PK} = 5.6 \text{ lei kg}^{-1}$; fixed costs per 1 hectare $c = 1900$; Output: $N = 130 \text{ kg ha}^{-1}$, $PK = -58 \text{ kg ha}^{-1}$, profit 426 lei ha^{-1} .

With these values of the prices for wheat and

PK fertilizers, respectively, the results obtained through simulation do not justify the use of PK fertilizers.

Simulation variant 2 (V 2) considered the input: $p_{\text{wheat}}=0.6 \text{ lei kg}^{-1}$; $p_{\text{N}}=4.1 \text{ lei ka}^{-1}$; $p_{\text{PK}}=6.1 \text{ lei ka}^{-1}$; fixed costs per 1 hectare $c=1900$; Output: $N = 46 \text{ kg ha}^{-1}$, $\text{PK}=-28 \text{ kg ha}^{-1}$, $\text{profit}=977 \text{ lei ha}^{-1}$. With these values of the prices for wheat and PK fertilizers, respectively, the results obtained through simulation do not justify the use of PK fertilizers.

Simulation variant 2A (V 2A) considered the input: $p_{\text{wheat}}=0.6 \text{ lei kg}^{-1}$; $p_{\text{N}}=4.1 \text{ lei ka}^{-1}$; $p_{\text{PK}}=5.1 \text{ lei kg}^{-1}$; fixed costs per 1 hectare $c=1900$; Output: $N=153 \text{ kg ha}^{-1}$, $\text{PK}=10 \text{ kg ha}^{-1}$, $\text{profit}=968 \text{ lei ha}^{-1}$.

The cost of 5.1 lei/kg PK induces an economic optimum which is realized for a positive value of PK rates. This is realized even if the wheat is sold for a low price, 0.6 lei kg^{-1} .

Simulation variant 2B (V 2B) considered the input: $p_{\text{wheat}}=0.6 \text{ lei kg}^{-1}$; $p_{\text{N}}=4.1 \text{ lei ka}^{-1}$; $p_{\text{PK}}=5.6 \text{ lei ka}^{-1}$; fixed costs per 1 hectare $c=1900$; Output: $N=149 \text{ kg ha}^{-1}$, $\text{PK}=-9 \text{ kg ha}^{-1}$, $\text{profit}=968 \text{ lei ha}^{-1}$.

With these values of the prices for wheat and PK fertilizers, respectively, the results obtained through simulation do not justify the use of PK fertilizers.

Simulation variant 3 (V 3) considered the input: $p_{\text{wheat}}=0.7 \text{ lei kg}^{-1}$; $p_{\text{N}}=4.1 \text{ lei ka}^{-1}$; $p_{\text{PK}}=6.1 \text{ lei ka}^{-1}$; fixed costs per 1 hectare $c=1900$; Output: $N=160 \text{ kg ha}^{-1}$, $\text{PK}=9 \text{ kg ha}^{-1}$, $\text{profit}=1552 \text{ lei ha}^{-1}$.

A higher market price for wheat, 0.7 lei kg^{-1} , induces an economic optimum which is realized for a positive value of PK rates, even if the cost of fertilizers is 6.1 lei kg^{-1} PK.

Simulation variant 4 (V 4) considered the input: $p_{\text{wheat}}=0.8 \text{ lei kg}^{-1}$; $p_{\text{N}}=4.1 \text{ lei kg}^{-1}$; $p_{\text{PK}}=6.1 \text{ lei ka}^{-1}$; fixed costs per 1 hectare $c=1900$; Output: $N=171 \text{ kg ha}^{-1}$, $\text{PK}=37 \text{ kg ha}^{-1}$, $\text{profit}=2164 \text{ lei ha}^{-1}$.

A higher market price for wheat, 0.8 lei kg^{-1} , induces an economic optimum which is realized for a positive value of PK rates, even if the cost of fertilizers is 6.1 lei kg^{-1} PK. Moreover, the profit will be much higher than in the previous cases.

Simulation variant 5 (V 5) considered the input: $p_{\text{wheat}}=0.9 \text{ lei kg}^{-1}$, $p_{\text{N}}=4.1 \text{ lei kg}^{-1}$, $p_{\text{PK}}=6.1 \text{ lei kg}^{-1}$, fixed costs per 1 hectare

$c=1900$; Output: $N=180 \text{ kg ha}^{-1}$, $\text{PK} 59 \text{ kg ha}^{-1}$, $\text{profit}=2799 \text{ lei ha}^{-1}$. In this case, as well, a higher market price of wheat, 0.9 lei kg^{-1} , induces an economic optimum which is realized for a positive value of PK rates, even if the cost of fertilizers is 6.1 lei kg^{-1} PK. The profit will be much higher than in the previous cases. Figure 2 presents the graphical distribution of the values in the form of isoquants, obtained from the simulations.

After comparing the results generated in simulation variants V1, V1A-D, where the price of wheat was considered to be constant, 0.5 lei kg^{-1} , and the price of the nitrogen fertilizer 4.1 lei kg^{-1} respectively, the threshold value of the PK fertilizers over which there appears economic inefficiency was 4.1 lei kg^{-1} , suggested in simulation variant V1A.

Practically, higher costs of the PK fertilizers lead to a relocation of the optimum point to an area that indicates economic inefficiency when using PK fertilizers for wheat crops.

Now we can observe what would happen if the market price of wheat rose. Obviously, the threshold value for efficiency of buying PK would grow, so it would be more easily supported by subsidies. Thus, for simulation variants V2, V2A-B, where the price of wheat is 0.6 lei kg^{-1} and the price of nitrogen is kept constant, the threshold value for profitability when buying PK fertilizers is 5.1 lei kg^{-1} .

In the hypothetical situations given by the simulation variants V3-5 where the price of wheat was 0.7 lei kg^{-1} or higher, this type of fertilization would be attractive from an economic point of view, even with the current cost of PK of approximately 6.1 lei kg^{-1} . Therefore, it is safe to say that, if a fixed buying price is kept of 6.1 lei kg^{-1} for PK fertilizers and if all other given conditions are met, the threshold value for the price of wheat should be 0.77 lei kg^{-1} so that PK application can be profitable.

Taking into consideration the modification of soil fertility due to the lack of application of PK, as well as secondary acidification generated by unilateral application of N, PK application should be stimulated through direct measures (lower prices for fertilizers) and the costs could be recovered from selling the wheat, through improvements in both the quality and the quantity of the yield.

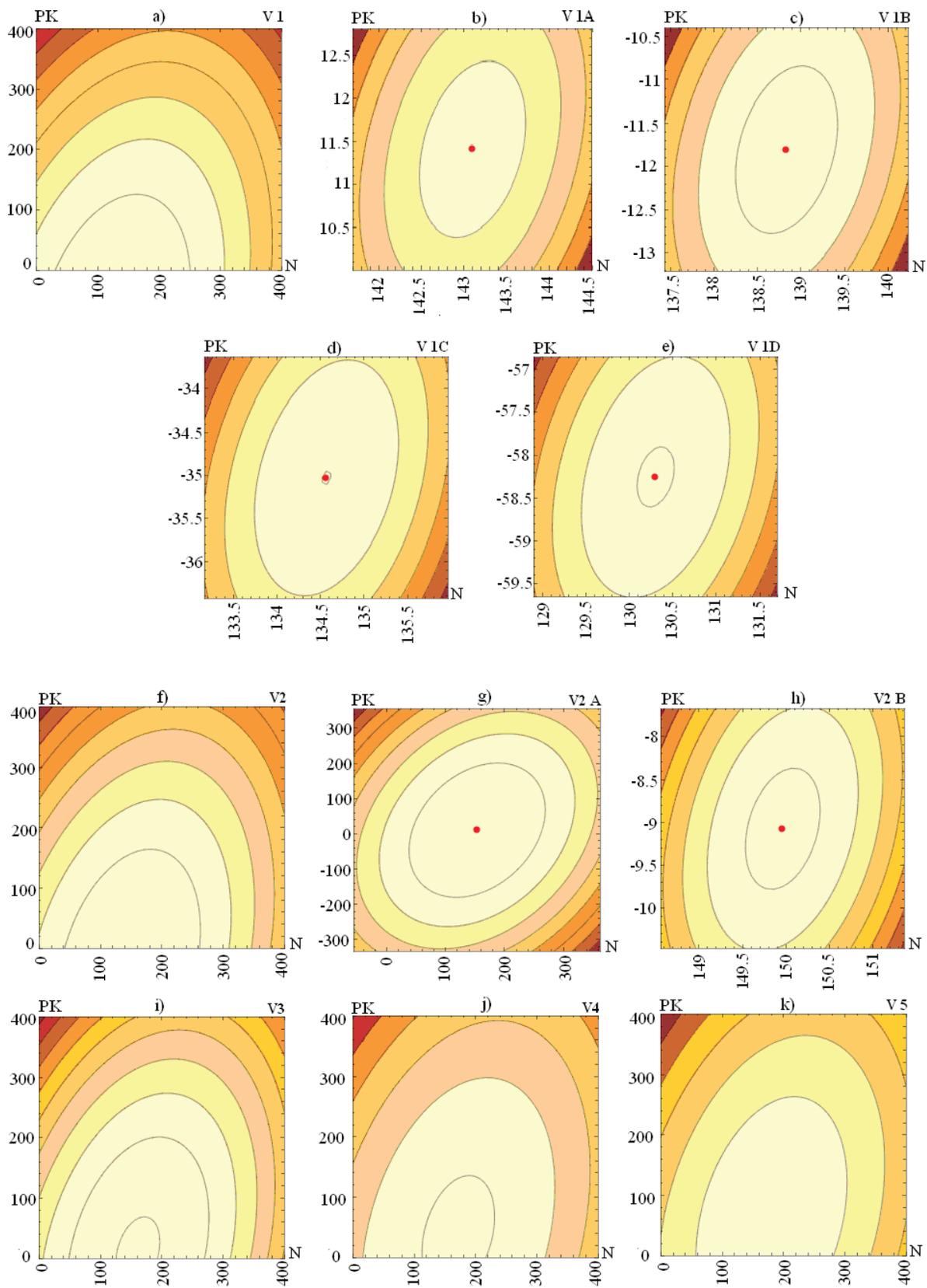


Figure 2. Graphical distribution, in the form of isoquants, of the results regarding the profitability of the wheat crop as the balance between the price of PK fertilizers and the price of wheat; a – V1, b – V1A, c – V1B, d – V1C, e – V1D, f – V2, g – V2A, h – V2B, i – V3, j – V4, k – V5.

Econometric studies of the optimization of wheat crops in relation to the cultivated area, the level of fertilization, the estimated yields and the types of agricultural systems, have been done in various geographical areas, with specific pedoclimatic and socio-economic conditions.

Efficient management of fertilizers in the agronomic practice, for ensuring the sustainability of the wheat crop, has proven necessary in relation to the biological material and germplasm potential (Hawkesford, 2014), agricultural system, pedoclimatic conditions, technological conditions and economic efficiency (Ghosh et al., 2003; Jat et al., 2012; Velasco et al., 2012; Poruțiu et al., 2015).

Due to the fact that nitrogen has a greater contribution to the wheat yield (Spiertz and De Vos, 1983; Marschner, 1995; Ortiz-Monasterio et al., 1997; Mengel and Kirkby, 2001), but at the same time a higher mobility, with the risk of loss on the soil profile, with unfavourable effects on the environment (Lehmann and Schroth, 2003; Liu et al., 2003; Beaudoin et al., 2005), many studies have focused on the optimization of the rates of nitrogen on wheat crops (Delogu et al., 1998; Merle, 2007; Gandorfer and Rajsik, 2008; Abedi et al., 2011; Hawkesford, 2014; Khalid et al., 2014).

Gandorfer and Rajsik (2008) addressed economic modelling of the optimum rate of nitrogen for the wheat crop, if the input affects the production and the price of the yield. However, phosphorus and potassium represented the object of the study, together with nitrogen, for the optimization of fertilizing treatments on the wheat crop; the economic aspects were dealt with in relation to the three nutrients.

Yadav (2003) made experiments at farm level, in different pedoclimatic conditions, in order to study the production of cereals (wheat and rice) in relation to the fertilizer unit used through agronomic efficiency (AE) and the partial factor productivity (PFP) through marginal analyses.

Niamatullah et al. (2010) communicated the results of studies performed over the course of 30 years, regarding the evolution of the areas covered by wheat crops, the evolution of support prices and of fertilizer use in Pakistan. They measured the significant contribution of

the price factor (support price) and the price of fertilizers on the production of rice and wheat. They found that the support price had a strong influence on the production of rice ($p < 0.05$) and wheat ($p < 0.10$) and that the use of fertilizers has a significant relation with the production ($p < 0.10$). These results are similar to those communicated in the present study and they highlight the necessity of support prices for enhancing the efficiency of phosphorus and potassium application for the final purpose of optimizing the fertilization process of wheat crops.

Jat et al. (2012) assessed the response of wheat crops (in the conditions of the Indo-Gangetic Plains) to the application of phosphorus fertilizers and the profitability of applying phosphorus according to some models/ equations that took into account the rates of phosphorus applied in the context of NPK fertilization, the yield obtained, the return on investment when applying P, and the costs of P fertilizers. Based on two scenarios, they assessed the profitability of phosphorus application on wheat crops (together with rice and corn) and concluded that, for the profitability of phosphorus application, besides other factors such as application rates, crop response to P application, and the cost of P fertilizers, there is another very important factor: the minimum support price for wheat crops.

These results are similar with the ones obtained in the present study. Taking into account the response of the wheat crop, the flexibility of the support prices had an important medium-term and long-term role. The flexibility of the support prices was in slight contradiction with the fertilizer price levels.

Therefore, the problem of the nutrient deficit in wheat crops (and for rice and corn crops, as well) was solved through balanced and flexible use of the market prices of wheat and the costs of fertilizers, of NPK especially, which played a crucial role in obtaining the yields for the respective crops.

Other studies have focused on the analysis of wheat crop performance as a response to different fertilizer rates (Aujla et al., 2010; Ali et al., 2015) or to differentiated N fertilization on gradual PK backgrounds (Sala et al., 2015). Singh and Sharma (2014) used a Fuzzy basic expert system for optimizing the fertilization

rate of the wheat crop. In order to do this, they considered 24 Fuzzy rules for describing the relations among the three inputs NPK, soil and wheat yield.

This study has highlighted the balance and flexibility of prices of fertilizers and wheat production, for an incentive and also to determine farmers to use fertilizers with phosphorus and potassium for balanced wheat crops. The results of this study are consistent with results obtained in other research and studies from different countries, to which reference has been made. These results were obtained in certain climatic conditions and biological material (Alex cultivar) specific but it is possible that the equilibrium level become other value according to other climatic conditions, or biological material. Thus, the dynamic and flexible nature of support prices for crop fertilization can solve the problem together with other financial incentives for farmers. Thereby the soil fertility will undergo a rebalancing as a result of fertilization with phosphorus and potassium, which will contribute to the sustainable use of agricultural land.

CONCLUSIONS

The main cause of Romanian farmers' low interest in using PK fertilizers is the low market price of wheat, correlated with the high cost of PK fertilizers. Thus, the results obtained from simulations indicate that only starting from a market price of wheat of 0.7 lei kg⁻¹, even with the current cost of PK fertilizer, which is 6.1 lei kg⁻¹, it would be profitable to use PK fertilizers. With the current price of wheat (between 0.5 and 0.6 lei kg⁻¹), it is mandatory to change the policy in such a way as to make it possible to buy PK fertilizers at a lower price. More exactly, for the price of 0.5 lei kg⁻¹ for wheat, the maximum acquisition price of PK fertilizers is approximately 4.1 lei kg⁻¹. If the price of wheat is 0.6 lei kg⁻¹, the results indicate the maximum acquisition price of PK fertilizers should be approximately 5.1 lei kg⁻¹ in order for their use to be profitable.

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