MAIZE ANSWER MODELLING AT NUTRITION WITH NITROGEN AND PHOSPHOROUS WITHIN THE ROMANIAN SPACE

Mihai BERCA[1], Cristina Silvia BUZATU[1]
E-mail: uniberca@yahoo.com

Abstract

Basic nutrients N and P react very different at maize crop, depending on soil type and climate conditions. Based on personal researches and especially using the publications within the field, the authors have created a data basis ordered to elaborate several nutrition models, i.e.: two models regarding the reaction of maize at nitrogen and phosphorous depending on soil, but applied alone; four models regarding the response of maize at N and P for each of the four big soil groups chosen, and a general synthesis model. The models are useful to evaluate the necessary of nutrients with N and P for any agricultural unit based on its pedoclimatic coordinates presented in the paper. Depending on the soil type, the nitrogen brings increases of 20 - 60 q/ha at maximum doses of 200 kg N/ha, and phosporous of 500 - 600 kg/ha at doses of 40 - 80 kg/ha P_2O_5. The combination N x P in the soils models 3, 4, 5, 6 brings + 37,5 q/ha at N150P80 (soil model 1), + 49,1 q/ha at N200P160 (soil model 2 by extrapolation) + 47,4 q/ha at N200P160 (soil model 3 by extrapolation) and 67,2 q/ha at N200P160 (soil model 4 - extrapolation). The maximum yields obtained are not also the most economic ones. These latest ones can be found in this paper.

Key words: maize, soils, nitrogen, phosphorous, answer

Numerous authors consider that maize reacts better at basic fertilizers than other crops, wheat for example. This conclusion is questionable. Though, we can state that maize can answer better at N and P, provided that during its vegetation period several factors are met, which would lead to maize assimilation and utilization as useful biomass.

There is an abundant literature written by outstanding researchers of the country such as Cr. Hera (1972) [3], Gh. Sin et. al. (2010), V. Mihăilă, Cr. Hera (1981) [4], and many others with whom we have collaborated and who provided information and data in order to calculate and edit the answer models of this valuable crop at N and P fertilizers.

MATERIAL AND METHOD

In order to create the data basis, information were brought together from all publications of the stations within Fundulea Institute network, from specialized university publications, from interviews with specialists working in production, from our own experiences, and from surveys.

Depending on the information sources, we went back about 30-40 years.

From those approx. 400 data gathered for each model, we used 30 - 40, those which answered logically to the flux evolution. Data which diverted from the logical trunk of the maize crop reaction or which were not representative for the soils framed in our selection and which represent over 90% of the Romanian soils (Dumitru et al., 2000) were eliminated.

By analysing data we found on the Romanian territory the yields lying on several levels of height, and we selected data depending on this indicator, which is determined also by the ecological condition of soils, the mechanical technologies and the soil water supply. We did not take into account the experiments done in irrigation conditions, and we eliminated the exceses (small yields generated by abiotic and biotic stresses difficult to control), or those very big, generated by some advantages, atypical for culture (excesive precipitations, some ameliorating precursory plants but unconvincing for the global situation of the culture in the Romanian space). The four categories of soils are the following:

Soil type 1- Soils with some excesses, negative, with low biodiversity, poorly ecologized, slight acid or slight alkaline, with deficient physical characteristics, with variable quantities of humus (1-3%) and where the level of production within a limitating technology is around 2200 kg (N_0P_0) wich can reach an average of 3200 kg/ha if an average fertelizing level is applied. Generaly, from the pedologic point of view, these soils totalize up to 50 points. E_I = 2 - 2,5 (Berca M. et al., 2010).

Soil type 2 - In this level the yields are got in soils more close to normal, with an $E_I \approx 3$ and with

[1] University of Agronomical Sciences and Veterinary Medicine Bucharest

a medium capacity to hold the water, with a medium biological activity and humus between 2 - 4%. Precipitations' level influences a lot the yield. Here belong most of the Subcarpatian soils and also those of the eastern and southern plain and Dobrogea. Yield oscillates between 2800 kg in conditions of non-fertilizing, and come close to 5000 kg in optimum conditions of precipitations and fertilization (average 41,6). Pedologically these soils are placed between 40 - 70 points.

Soil type 3 - Yields are bigger with about 500 kg than on the previous one, the farmers being more interested in soil ecologization (I_E = 3,5). The physical properties are better framed, the structure stable, good water depositing and conservation. These are soils richer in humus (3 - 4%) and with a permeable profile. Maximum yield may reach 5000 kg in the conditions of a fertilization with NP by obeying balance rules. Pedologic score: 65 - 80 points.

Soil type 4 - Soils found on low lands, especially in the western part of the country, in Danube waterside, the beginning part of the Danube Delta, some areals of the Central Plateau, along the rivers. Even though these can be soils poor in heteropolicondensed humus, the phreatic contribution leads to the increase of the yield which reaches 5000kg/ha even without fertilizers and position at almost 6,8 to in the nutritional optimized variants.

In order to calculate and interpret the models we used special programs, of factorial analysis and of corelations with graphical expression in 2D and 3D.

RESULTS AND DISCUSSIONS

The analysis of the effect of each of the two nutrition elements N and P are presented in *figures no. 1 and 2*.

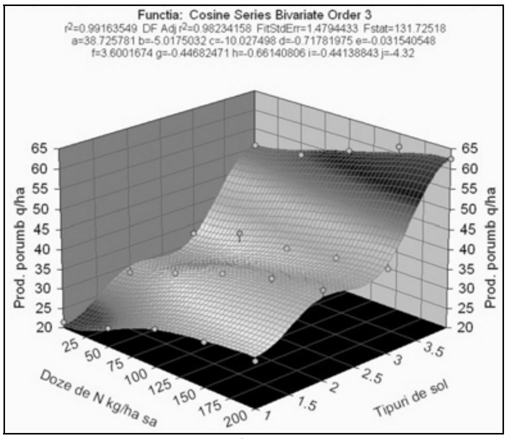

Figure 1 **The response of maize yield depending on soil and N doses, Romania**

Nitrogen (*fig. 1*) is the element which determines the biggest increase in maize yield, i.e. 20 q/ha on the weakest soils, up to over 60 q/ha on the best soils, in conditions when, we repeat, P was not applied. Otherwise, in order to get the maximum yield, 200 kg/ha a.s. are necessary. The practice itself is not accepted by the European Union. At the maximum dose of 150 kg N/ha accepted by the European Union, up to 60 q/ha can be got in P absence on the best soils, and on the weakest up to 29,5 q/ha. In absence of P the increase of N dose over 100 kg/ha is not at all necessary on none of the analysed soils.

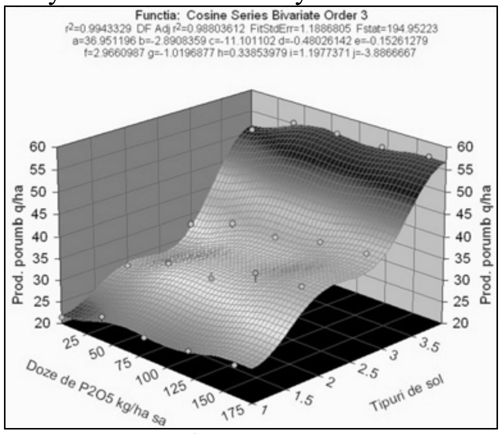

Figure 2 **Response of maize yield depending on soil types and P_2O_5 doses, Romania**

Phosphorous (*fig. 2*). When doses of P are increased in the absence of nitrogen between 0 and 160 kg/ha the yield is increasing slower on soils type 1, poorer, with maximum 400 kg/ha, more on soils types 2 and 3 (500-600 kg/ha), and also with 600 kg/ha the yield increases in the case of the best soils. The doses of 40-80 kg/ha are though sufficient in order to bring an increase economically secured on any of the studied soils.

The application of N and P together obliged us to create four models presented for each of the four groups of soils in *figures 3, 4, 5 and 6*, and in synthesis in *figure 7*.

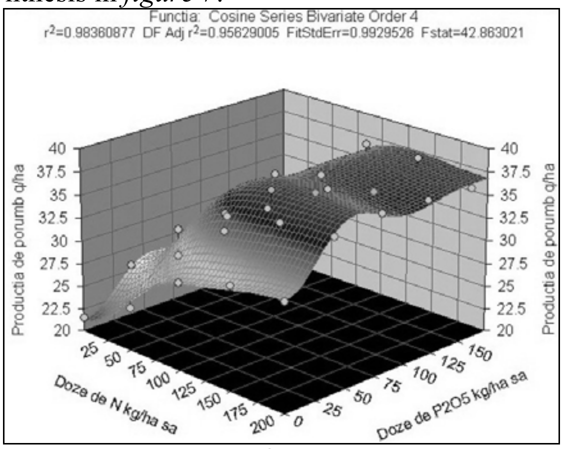

Figure 3 **Response of maize yield at N and P fertilizers on soils type 1, Romania**

For poor soils, with big physical and chemical restrictions, modelling shows us that a maximum yield can be obtained on average on at least 100 variants harvested in over 30 years of 37,5 q/ha at dose of $N_{150}P_{80}$.

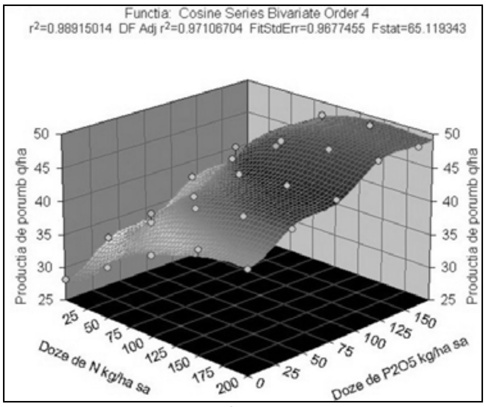

Figure 4 **Response of maize yield at N and P fertilizers on soils type 2, Romania**

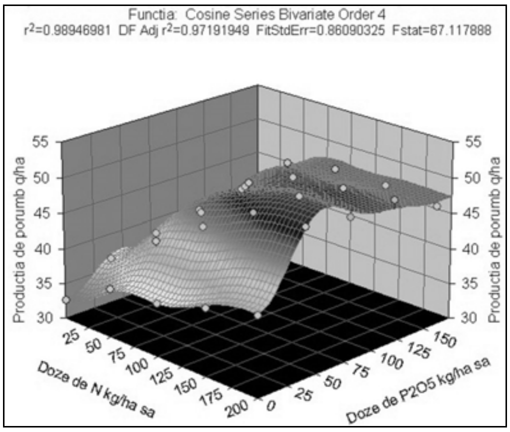

Figure 5 **Response of maize yield at N and P fertilizers on soils type 3, Romania**

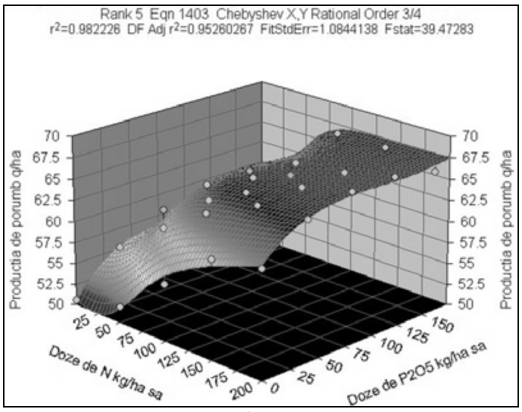

Figure 6 **Response of maize yield at N and P fertilizers on soils type 4, Romania**

Consequently: **Pmax = 37,5 q/ha = $N_{150}P_{80}$**

Simulation on function shows though that a close yield and with an economic pronounced character is got by rebringing within the combination of 50 kg N, i.e. **$N_{100}P_{80}$ = 37,26 q/ha**. Taking into account the maize consumption into getting the yield, this dose seems logical, economical and acceptable. For doses under 100 kg/ha around 31 q/ha yields are got. Therefore, for farmers with less resources placed on these soils, convinient results are brought by the combination **$N_{50}P_{80}$ = 31,5 q/ha** or by the combination **$N_{50}P_{140}$ = 30,42 q/ha**. Sure, in this last situation the maize yield solicits much the soil, the balance being in favour of the output, the plants taking out of the soil more than they receive, especially in case of nitrogen. The nitrogen can come into the system from very many sources, and this can be seen in the following models.

For the soils with a promissing ecologization beginning E_I = 3 *(fig 4)*, ecological value acceptable for today Romanian agriculture but insufficient for the big performance where yields oscilate from about 28 q/ha in the variant $N_{60}P_0$ at a little bit over 49 q/ha in the extrapolated variant $N_{200}P_{160}$. **$N_{200}P_{160}$ = 49,1 q/ha** is a non-economical variant because the same yield of 49,5 kg/ha is got with a much more economic dose $N_{150}P_{160}$. **$N_{150}P_{160}$ = 49,5 q/kg** or **$N_{150}P_{120}$ = 49,1 q/ha** or **N_{150} P_{80} = 45,1 q/ha** which we recommend to the producers with enough resources. Reduction with 50 kg of the nitrogen dose reduces with 4 q/ha the maize yield, therefore **$N_{100}P_{80}$ = 44 q/ha** and **$N_{100}P_{40}$ = 40,7 q/ha**.

Usual variants used today in many agricultural areas such as $N_{50}P_{40}$ = 37,4 q/ha get with less 11 q than in the best variant, and with 700 kg/ha less than in the variant two times bigger ($N_{100}P_{80}$). The evolution of outputs will settle the correctitude of efficiency of doses of N and P_2O_5 for these soils.

The third model *(fig 5)* reffers to the soils with a better ecological index E_I = 3,5 and which comprises a large areal, especially in the Southern Plain. The variation of average yields in relatively good technological conditions oscilated from 32,5 q/ha at N_0P_0 up to 47,4 kg/ha at variation $N_{200}P_{160}$. But this is not the best variant. The evaluation resulted from the 3D function demonstrate that the biggest yield at the level of 50,6 q/ha can be got with the combination $N_{150}P_{80}$; i.e. **$N_{150}P_{80}$ = 50,6 q/ha**. At only 0,5 q/ha under this the yield is **$N_{150}P_{40}$ = 42,7 q/ha** and represents the most efficient valorization of nitrogen and phosphorous, otherwise superior with 5 q/ha to the soils in areals type 2. Why is this possible in climate conditions almost similar? With big probability the phenomenon is due to the better ecological condition, to the presence of bacteria which mobilize phosphorous, and of those associate for the income of a suplimentary nitrogen quantity. The better condition of soil contributes to the more balanced developement of plants and to a more efficient production activity.

The 4th model *(fig 6)* is intended for soils with very low humidity restrictions. The results show an yield variation from 50,5 q/ha at N_0P_0 to 67,2 q/ha at variant $N_{200}P_{60}$ to 67,2 q/ha at variant $N_{200}P_{60}$, variant which we do not reccomend, as this is not the most economic response of the crop, although technically it occupies the primary position.

At only 500 kg difference is situated the combination $N_{150}P_{80}$ with a production of 66,7 q/ha, consequently:

$N_{200}P_{160}$ = 67,2 q/ha

$N_{150}P_{80}$ = 66,7 q/ha - to be recommended to farms with resources

$N_{100}P_{80}$ = 66,3 q/ha - economically even more convenient.

The variant much utilized in practice $N_{50}P_{40}$ is got at 60,4 q/ha, i.e. with 700 kg/ha under the combination which obtaines the maximum yield. On such soils and at maize crop it is hazardous such a small combination, and that's why we recommend at least the variant $N_{100}P_{80}$ regardless the source the two elements proceed from, provided that phosphorous is maintained in an accessable a longer period.

Finally, in *figure 7* we present an extremely elaborated model of maize yield at the level of the whole country for an average of about 30 years of research monitoring within the Romanian space. The four models for four soils, presented in *figures 3, 4, 5, and 6*, were overlaped for a better comparison, wherefrom we conclude the following:

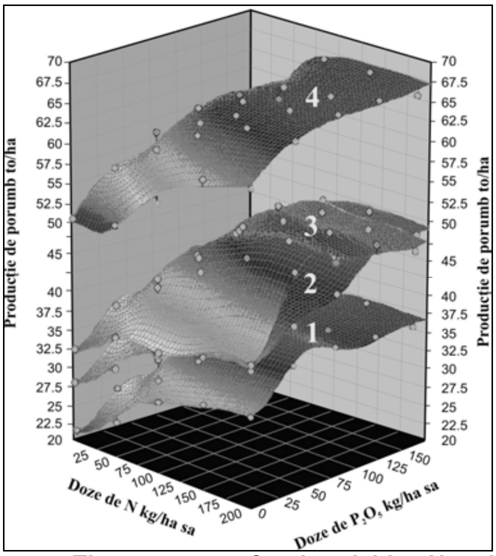

Figure 7 **The response of maize yield at N and P fertilizers. (Authour's calculation)**

Table 1

Function system

Fz	fz1 = cosine series bivariate order 4 (r^2 = 0,9836)
	fz2 = cosine series bivariate order 4 (r^2 = 0,9891)
	fz3 = cosine series bivariate order 4 (r^2 = 0,9894)
	fz4 = chebyshev x, y. Rational order 3/4 (r^2 = 0,9822)

The model in figure 7 is described by the following function system.

A pronounced detachment of soils type 4, without restrictions for water regime. In this case, the economic yields move towards $N_{150}P_{100}$. For cases 3 and 2 the combinations **$N_{100}P_{50}$** are the most economical, although the technical maximum goes towards s $N_{150}P_{80}$. In case 1, poor soils, we can be satisfied also with combinations **$N_{100}P_{40}$**, these soils being not able to valorize well big quantities of basical fertilizers.

The variation of maize yield, in the conditions of elimination of non-concordant data, oscilated between **20 q/ha la N_0P_0** on the poorest soils and almost **68 q/ha la $N_{150}P_{80}$**. The bigger doses are not economical and therefore not reccomended. The contribution of soils (62%) is bigger than the one of basical fertilizers (max. 38%), including their interactions. The model itself is interesting also for the fact it can be used as a nomogram, which in each moment can show us the response of maize crop to the basic fertilizers on most of Romanian soils.

CONCLUSIONS

The analysis by modelling of the maize response towards basic N and P fertilizing leads us to the following conclusions:

Unilateral fertilizing with N and P is not recommended outside other contribution methods or mobilization of the two elements in soil.

The reaction of maize crop at fertilizing varies depending on soil quality and their ecological condition, plus abiotical restrictions, especially water.

The amplitude of maize crop on average on 30 years in organized production systems varies from 2000 kg/ha to 6800 kg/ha (at N150P80).

The contribution of soils to the level of yields is 62%, much bigger than the one of basic fertilizers (max. 38%), including their interactions.

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