USING THE PHOSMOD MODEL FOR THE PHOSPHATES ACCESIBILITY MODELLING IN THE VEGETABLE CROPS

MODELAREA ACCESIBILITĂȚII FOSFAȚILOR DIN SOL PENTRU CULTURILE VEGETALE, FOLOSIND MODELUL PHOSMOD

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Abstract: *In all the soils types of the world a phosphate deficiency was observed, especially in the poorly countries, where the fertilisation level are inadequate. On the other hand, in one of the rich countries the phosphate level in soils are much more than it is necessary for the crops needs, so the environment is polluted. The crops dependence on the soil's phosphate level in the soils and plants growth interaction is materialized. To these, a predictive model is necessary, model in which the essential processes of plants growth being presented in equations form. One of these models is the PHOSMOD model. This model was developed by Greenwood et al. (2001a), mainly for vegetable crops. After some adjustments, the model is able to reproduce the observed responses to band placed P and starter fertilizer in plant dry matter, and to predict differences between soil types in the responses to applied fertilizer. The model calculates the effects of soil phosphates, starter fertiliser phosphates and granular fertiliser phosphates on daily crop growth, phosphates concentration in the plants, and the changes in the different forms of soil phosphates. It is considered that the fertilisers are applied immediately after the seeding and the phosphate from the soil is represented by the interaction between the soil type and their evolution. All others nutrient, including N and K, it is considered that are in sufficient quantities for the maximal plant growth. The phosphate transport in soils is by diffusion and takes account of soil type, buffer capacity and soil water content. Mass flow transport is ignored. The interchange between solution, labile and non-labile forms of phosphate are recalculated for each day in the phosphate depleted regions around each segment of root and in the fertilised and unfertilised regions of soil into which no roots have penetrated.*

Rezumat:. *În majoritatea solurilor din lume se constată o deficienţă a cantităţii de fosfat, cu precădere în ţările sărace unde procesul de fertilizare este neadecvat. Pe de altă parte, în anumite ţări bogate, nivelul de fosfaţi din sol este cu mult mai ridicat decât ar fi necesar recoltelor şi de aceea se poluează mediul înconjurător. Dependenţa recoltelor de nivelul de fosfaţi din sol este concretizată prin interacţiunea dintre sol şi procesul de creştere al plantelor. Pentru aceasta a fost necesară realizarea unui model predictiv în care procesele cheie care implică creşterea plantelor să fie prezentate sub forma unor ecuaţii matematice. Unul dintre aceste modele este cel denumit PHOSMOD. Acest model a fost realizat de Greenwood et al. (2001), în principal pentru recoltele vegetale. Modelul simulează efectele fosforului din sol şi ale fertilizanţilor granulari cu fosfor, asupra creşterii zilnice a culturii, asupra concentraţiei fosforului din plantă şi asupra interschimbărilor între diferite forme de fosfaţi. Se consideră că îngrăşământul este aplicat imediat după însămânţare, în timp ce fosforul din sol este rezultatul net al interacţiunii între tipul de sol şi evoluţia solului. Toţi ceilalţi nutrienţi – incluzând N şi K se consideră a fi în cantităţi suficiente pentru o dezvoltare maximă a plantelor. Transportul fosforului în sol se face prin difuziune şi ţine cont de tipul de sol, capacitatea de tamponare şi conţinutul de apă din sol. Se ignoră scurgerea de masă. Interschimbările între formele de fosfaţi din soluţie, cele mobile şi cele imobile sunt recalculate pentru fiecare zi în zonele sărăcite în fosfor din jurul fiecărui segment de rădăcină, dar şi în regiunile fertilizate şi în cele nefertilizate, în care nu a ajuns nici o rădăcină.*

Key words: *phosphates accessibility, fertiliser, daily crop growth.*
Cuvinte cheie: *accesibilitatea fosfaţilor, fertilizanţi, creşterea zilnică a recoltei.*

INTODUCTION

Phosphorus is one of the key essential elements in modern agriculture, an important nutrient to agricultural production. It increases the productivity of crops. Phosphorus is commonly applied to crops as fertilizer. In agricultural watersheds, phosphorus reaches the stream by various means including surface runoff, interflow, and soil erosion [6]. The crops and the plants growth are dependent of the soil's phosphate level. To these, a predictive model is necessary, model in which the essential processes of plants growth being presented in equations form. One of these models is the PHOSMOD model. To simulate the nutritional needs of plants we consider that is the best criterion to evaluate the crop response to applied nutrients. So, if phosphorus additions exceed uptake over time, concentrations of soil phosphorus increase. When the soils are left unfertilized, phosphorus fertility levels will progressively decrease, through crop production or phosphorus loss, to the point when they no longer adequately supply plant phosphorus needs. Because soil phosphorus is relatively immobile, most fertilizer with phosphorus content remains to the soil surface. In these case, more important is the crops need of phosphorus fertilizer, because also the phosphorus deficit a slowly soil productivity determinate.

MATERIALS AND METHOD

Crop growth depends on a balance nutrients supply. Excessive application of fertilisers leads to economic loss and environmental pollution. There are ways to optimise fertiliser application: experimental or using models.

For that we use the PHOSMOD model that is presented in next pages.

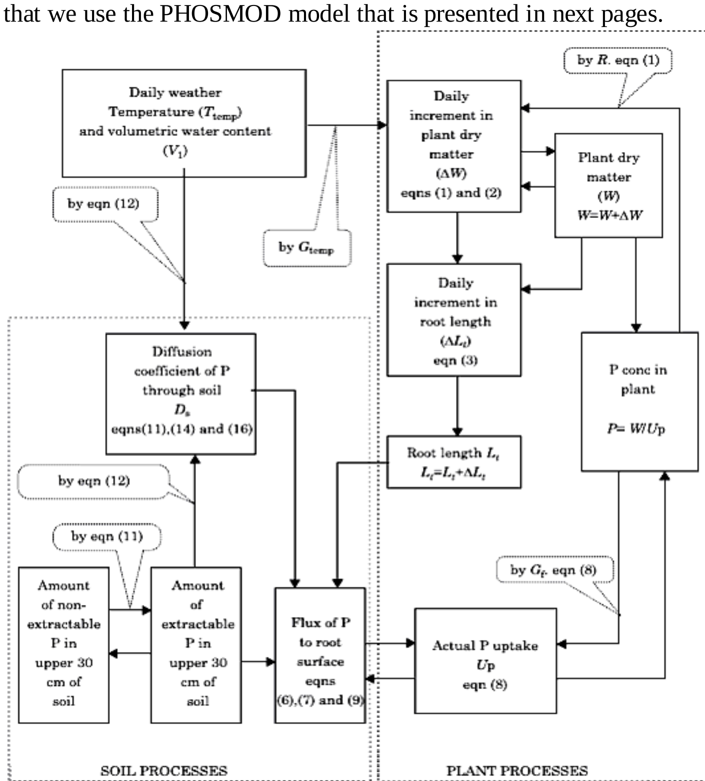

Figure 1. The schematic flow of PHOSMOD

The flow diagram represents a simplification of the PHOSMOD model. In these, soil phosphate is very immobile and moves only short distances. The model assumes that root absorption of phosphate is from the upper 30 cm of soil and there is no leaching [2]. The different components of weather are represented by a single box on the right hand side of the diagram and the various soil properties by a single box at the top of the diagram. The different types of fertilizer-phosphate are also represented by another single box at the top of the diagram. The various below ground processes are presented in the upper section of the diagram and the above ground processes in the lower section.

The numerous processes in the model are represented by equations. These are solved for each day of the simulation and the variables updated accordingly. The main inputs to the equations used for calculating each variable are given by the sources of the arrows in the diagram, For example, the % P in the plant is calculated from the total P in the plant and plant dry weight [3].

Moving from the top of the diagram downwards, the model calculates for each day new values for the increment in root length, the soil water content, the diffusion coefficient and the different forms of soil-P. From this information and the weather conditions it calculates the maximum possible P-uptake by the plant. This is reduced depending on the % P already in the plant to give the actual P-uptake, and a new % P in the plant which is then used with the weather conditions and the existing plant weight to calculate a new plant weight and also a new increment in root length and the cycle of calculations begins again [2].

All the equation are explain in [7].

RESULTS AND DISCUSSION

For each day, the PHOSMOD model calculates the increment in root growth and partitions it into segments between the regions of soil enriched with starter fertilizer, those enriched with granular fertilizer and the remainder of the soil. It calculates the maximum possible amount of P that can diffuse through soil to each root segment in each region. Using this information and the P concentration in the plant, total P uptake is calculated. The increment in plant weight and root growth is calculated from the current plant weight, plant P concentration and air temperature [2]. Subroutines calculate daily soil water content, the extractable and non-extractable soil P, and diffusion coefficients in the P-depleted zones around each root segment and in the remainder of the soil. Model simulations and sensitivity analyses indicate that extractable soil P and starter fertilizer P can lead to higher crop yields than are achieved when granular fertilizers are incorporated in soil, in the usual way, immediately before sowing [3]. They also indicate that in the long-term, levels of extractable soil P will move towards a level characteristic of the soil. These findings are in agreement with results of long-term field experiments that have been reported in the literature. All inputs to the model that have a substantial impact on P-response of a single crop are easy to obtain. They include standard soil properties, the maximum potential yield, and daily rainfall, mean air temperature and evaporation from an open water surface.

In next pages, we presented an example of PHOSMOD using to modelling the phosphate accessibility. We study a potatoes crops seeding on a sandy clay soil. The crop was seeding in 23 April 2008 and we considering that they will be reaped in 30 September 2008. The model simulation was made in 10 Julie 2008 [7].

We consider that the crop will be 10 tone/ha, the field capacity was considering to be constant in the first 100 cm of soil, the soil moisture deficit is 10 mm to the 01 January 2008.

The crop is considering having all the roots in the upper 30 cm of the soil. The soil is considering being uniform and the roots and the water content are uniform in the soil. The daily water content is daily updating. It depends of the soil moisture deficit, the soil type, the degree of soil cover with crops and the plants weight.

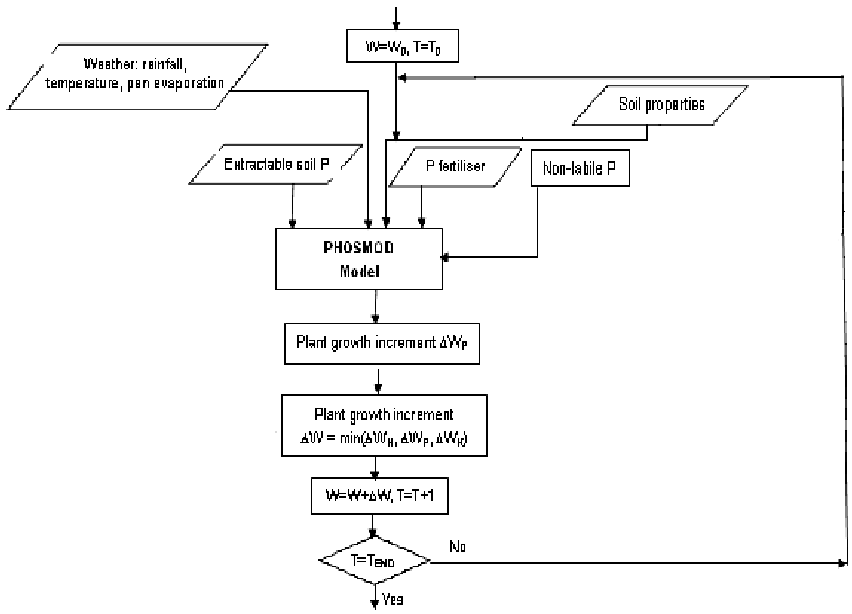

Figure 2. PHOSMOD diagram

The crop is not irrigated and the weather dates are the average value.

The simulation was made for the situation in that are not applied fertilisers ao are applied a 25, 50, 75 and 100 kg/ha of phosphorus fertilisers [7].

In next tables are presented the dates for the stat of programme simulation.

Table 1.

Crop description

Crop:	Potato late
Date of planting	23 apr 2008
Date of harvest	30 September 2008
Date when simulation cases	10 July
Max dry weight of total plant at harvest (t/ha) (0.01 ~ 25)	10
Barrier to rooting depth (cm) (1 ~ 200)	200

Table 2.

Soil description

Soil Type	Sandy clay
Clay content (%) (10 ~ 50)	45
Soil bulk density (g/cm3) (0.9 ~ 1.9)	1.4
Field capacity in 0-30cm soil layer (cm3/cm3) (0.15 ~ 0.5)	0.46
Field capacity in 30-60cm soil layer (cm3/cm3) (0.15 ~ 0.5)	0.46
Field capacity in 60-90cm soil layer (cm3/cm3) (0.15 ~ 0.5)	0.46
Date when soil moisture deficit known (MUST be earlier than any other input dates)	1 Jan current 2008
Soil moisture deficit (mm) (0 ~ 200)	10

Table 3.

Weather description

	Precipitation (mm)	Irrigation (mm)
January	43,4	0
February	24,5	0
March	26,9	0
April	57,2	0
May	73,7	0
Jun	120,9	0
July	51,6	0
August	45,3	0
September	51,2	0
October	30,3	0
November	40,8	0
December	19,7	0

Table 4.

The initial dates

Initial bicarbonate extractable P (mg/kg soil) (10 ~ 300)	20
Amount of P fertiliser (kg/ha) (0 ~ 300)	100
Conversion rate of extractable P into non-extractable soil P (1/d)	0.000637
Conversion rate of non extractable P into extractable soil P (1/d)	0.0000322

Results for the model simulation with different quantities of applied phosphorus are:

Day	DW	%P	Day	DW	%P	Day	DW	%P	Day	DW	%P	Day	DW	%P
-	t/ha'	-	-	t/ha'	-	-	t/ha'	-	-	t/ha'	-	-	t/ha'	-
0,00 kg/ha P_2O_5			25,00kg/ha P_2O_5			50,00kg/ha P_2O_5			75,00kg/ha P_2O_5			100,00kg/ha P_2O_5		
114	0.50	0.80	114	0.50	0.80	114	0.50	0.80	114	0.50	0.80	114	0.50	0.80
146	1.78	0.47	146	1.79	0.51	146	1.79	0.51	146	1.80	0.51	146	1.80	0.51
178	3.58	0.40	178	3.59	0.40	178	3.60	0.40	178	3.60	0.40	178	3.60	0.40
210	5.33	0.40	210	5.34	0.40	210	5.35	0.40	210	5.35	0.40	210	5.35	0.40
242	7.36	0.39	242	7.35	0.35	242	7.37	0.36	242	7.38	0.37	242	7.38	0.38
274	9.56	0.35	274	9.50	0.30	274	9.53	0.32	274	9.55	0.33	274	9.57	0.33

Where: the *Day* represents the number of day from the first day of the year
DW represent the plant mass
% P represents the percent of phosphorus incorporation in the plant

According to available soil phosphorus practice in the case of sandy clay type's of soil, phosphorus application rates generally range from 20 to 80 kg/ha [8]. This fact is illustrated also by the PHOSMOD simulation, when we observed that the best response of phosphorus application is in the case of 25 kg/ha of application rates.

CONCLUSIONS

The phosphate concentration in plants that is necessary to optimal growth decrease with the plant mass.

The crops are more vulnerable to the phosphorus deficiency in the first stadium of their growth. Temporary stops of the phosphate application in this initial stage are compromise all the crops although initial was an adequate quantities of phosphate in the soil.

The start fertilisers neither attenuate the phosphorus deficiency in the first stage of the crop growth, so the plants growth is nor stopped. These facts increase the final harvest.

If the phosphate are applied more than it is necessary, it will be lost. These is the case of 50 kg/ha P_2O_5, 75 kg/ha P_2O_5 and 100 kg/ha P_2O_5 of phosphate applied, when the crop production are comparatively the same with the 25 kg/ ha of P_2O_5 applied, but the economical costs are high (9.57 t/ha, to 9.50 t/ha).

So, it must be solve the compromise between the phosphorus quantities to obtain an increment in the harvest and a rational fertilisation, especially in the environmental protection context, but without to ignore the economical aspects that are involved.

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