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# ALGORITHM FOR DEFINITION OF QUANTITY OF FERTILIZERS FOR ACHIEVEMENT OF NECESSARY RATIO OF NUTRITIOUS ELEMENTS

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**Introduction**. One of main tasks of optimization of nutrition of hothouse plants is use the standard, on phases of development of plants, solutions with the appropriate balanced parities of macro- and microelements. The allowable marginal levels of elements in the water for preparation of nutrition solutions should be in limits established by long-term laboratory and field experiments. They are given as standard units for each nutritious element, or as shares of percents. Besides the allowable limiting deviations as percentage parameters are given too.

One of industrial ways of cultivation of plants is hydroponics, meaning "job with water" [1]. This method has wide application in hothouses and actually exempts from additional jobs on study of structure of soil and further updating of structure of fertilizers depending on it. Certainly, in each hothouse facility used spray water has the certain chemical structure and parameter pH, which it is necessary to take into account at definition of required quantity of nutritious elements for maintenance high (best) productivity. However, within the framework of this job, we shall consider, that required quantity of nutritious elements already are determined in view of these parameters.

It is necessary to notice, that the agriculturists first of all supervise such basic nutritious elements, as nitrogen ($NO_3$– and $NH_4$+),, phosphorus ($P_2O_5$), potassium ($K_2O$), magnesium ($Mg^{2+}$), calcium ($Ca^{2+}$), sulfur ($SO_4^{2-}$) etc. Then pay attention to a parity of microelements: Zn, Mn, Co, Se, Cu etc.

Thus, the quantitative portion of nutritious elements necessary for achievement of a desirable crop, for each cultivate plant is considered as known. However, whereas the biological systems are flexible, the optimum parities of nutritious elements can be carried out with the some approximately.

On the other hand, quantities of available nutritious elements in structure of fertilizers also are known. Now, in order to the farmer in the hothouse facilities applied method hydroponics, it is necessary to determine quantity of each accessible fertilizer for reception of required nutritious structure. Thus, it is desirable that most favorable was chosen from numerous variants of the decision with the economic point of view.

**Mathematical formulation of the problem.** Let's assume that it is required to receive structure consisting of $M$ nutritious element, nitrogen, phosphorus, potassium, magnesium, calcium, sulfur etc., accordingly in the ratio

$$\tilde{C}_0 : \tilde{C}_1 : \tilde{C}_2 : \cdots : \tilde{C}_M ,$$

where $\tilde{C}_j \geq 0,\ j = 0, 1, \ldots, M-1$. For each $j$ the equality $\tilde{C}_j = 0$ means that in the given structure is no nutrition element with the same index.

Let's denote through $a_{j,i}$ the percentage share of $j$-th nutritious element in structure of $i$-th fertilizer, where $N$ is the total of accessible fertilizers, $i = 0, 1, \ldots, N-1$. Obviously, the following natural conditions are carried out: $a_{j,i} \geq 0$ and $\sum_{j=0}^{M-1} a_{j,i} > 0$, $i = 0, 1, \ldots, N-1$. It is required to find such quantity of $i$-th fertilizer that $x_i \geq 0$ and

$$\left| \sum_{i=0}^{N-1} a_{j,i} x_i - \tilde{C}_j \right| \leq \varepsilon \tilde{C}_j, \quad j = 0, 1, \ldots, M-1, \tag{1}$$

where $0 \leq \varepsilon < 1$ is the parameter of allowable deviations from normative meanings $\tilde{C}_j \geq 0$.
Thus it is desirable, that the function

$$F(x_0, x_1, \ldots, x_{N-1}) = f_0 x_0 + f_1 x_1 + \ldots + f_{N-1} x_{N-1} \tag{2}$$

will be minimum. The coefficients $f_0, f_1, \ldots, f_{N-1} \geq 0$ are the prices of the appropriate fertilizers. The equality $f_i = 0$ for some $i$ means, that these fertilizers are got free-of-charge (for example, at the expense of the grants).

**The solving method**. Having copied inequalities (1) in the little bit modified kind, we receive a linear programming problem:

$$\sum_{i=0}^{N-1} a_{j,i} x_i \leq (1+\varepsilon) \tilde{C}_j, \quad j = 0, 1, \ldots, M-1, \tag{3a}$$

$$\sum_{i=0}^{N-1} a_{j,i} x_i \geq (1-\varepsilon) \tilde{C}_j, \quad j = 0, 1, \ldots, M-1, \tag{3b}$$

$$F(x_0, x_1, \ldots, x_{N-1}) = f_0 x_0 + f_1 x_1 + \ldots + f_{N-1} x_{N-1} \to \min, \tag{3c}$$

$$x_i \geq 0, \quad i = 0, 1, \ldots, N-1.$$

The given problem we shall solve by the simplex method [2]. First of all by introduction fictitious variable $x_i \geq 0$, $i = N, N+1, \ldots, N+3M-1$, we shall write (3a) and (3b) in the following standard form:

$$\sum_{i=0}^{N-1} a_{j,i} x_i + \sum_{i=N}^{N+M-1} a_{j,i} x_i + \sum_{i=N+M}^{N+2M-1} a_{j,i} x_i + \sum_{i=N+2M}^{N+3M-1} a_{j,i} x_i = C_j, \quad j = 0, 1, \ldots, 2M-1, \tag{3}$$

$$x_i \geq 0, \qquad i = 0, 1, \ldots, N-1,$$

where

$$C_j = \begin{cases} \tilde{C}_j (1+\varepsilon), & j = 0, 1, \ldots, M-1, \\ \tilde{C}_{j-M} (1-\varepsilon), & j = M, M+1, \ldots, 2M-1, \end{cases}$$

$$a_{j,i}=\begin{cases} a_{j-M,i}, & j=M,M+1,\dots,2M-1;\quad i=0,1,\dots,N-1,\\ 1, & j=0,1,\dots,M-1;\quad i=N,N+1,\dots,N+M-1;\quad i=j,\\ 0, & j=0,1,\dots,M-1;\quad i=N,N+1,\dots,N+M-1;\quad i\neq j,\\ 0, & j=M,M+1,\dots,2M-1;\quad i=N,N+1,\dots,N+M-1,\\ 0, & j=0,1,\dots,M-1;\quad i=N+M,N+M+1,\dots,N+2M-1,\\ -1, & j=M,M+1,\dots,2M-1;\quad i=N+M,N+M+1,\dots,N+2M-1;\quad i=j+N,\\ 0, & j=M,M+1,\dots,2M-1;\quad i=N+M,N+M+1,\dots,N+2M-1;\quad i\neq j+N,\\ -1, & j=M,M+1,\dots,2M-1;\quad i=N+2M,N+2M+1,\dots,N+3M-1;\quad i=j+N+M,\\ 0, & j=M,M+1,\dots,2M-1;\quad i=N+2M,N+2M+1,\dots,N+3M-1;\quad i\neq j+N+M. \end{cases}$$

These dummy variables are simultaneously entered into the cost functional with some enough large coefficients $Y >> 0$

$$F\left(x_0, x_1, \dots, x_{N-1}, x_N, \dots, x_{N+3M-1}\right) \equiv$$
$$\equiv f_0 x_0 + f_1 x_1 + \dots + f_{N-1} x_{N-1} + Y \cdot \left( f_N x_N + f_{N+1} x_{N+1} + \dots + f_{N+3M-1} x_{N+3M-1} \right) \to \min . \qquad (4)$$

Thus, we receive a problem which is equivalent to (3a) - (3c) and has been written in the canonical form, that allows to apply the well known simplex-method.

It is necessary to note, that the solution (3) - (4) can not satisfy the initial agro-technical requirements. For example, in structure considered fertilizers will not appear required nutrition elements. Therefore, the process of finding of the solution is necessary for finishing by checking of satisfaction of the solution to initial conditions.

**On the calculation program**. The described above problem was realized as the program GUBRE2, on base MS Access. The initial data are saved in two tables.

The table GUBRELER contains the list of fertilizers, where the percentage parities of nutritious elements, contained in them, its availability and price are resulted. The table TELEB contains the information on required structure of nutritious elements.

The program GUBRE2 works in the interactive mode, which allows, entering new structures of nutritious elements, to correct them if necessary, to calculate quantities of fertilizers for achievement of a necessary parity of nutritious elements.

## Literature

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