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ON THE SYSTEM OF GENERATION OF THE TECHNOLOGICAL MAP FOR AGRICULTURAL CULTIVATION

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Introduction. The present paper is devoted to the description of tasks and ways of realization of problems arising at developing of the computer system "Cultivation Process Management".

The definition techniques of acceptable ways of cultivation, norms of fertilizers, depending on the various factors, are investigated by the numerous scientists. These knowledges are in the scientific publications, are assembled in the methodical manuals are addressed to the agriculturists. On the basis of these sources it is developed the technological schemes of cultivation of various cultures that include:

- a sequence and terms of performance agro-technical operations
- features of operations, depending on concrete conditions and choice of culture
- norms of using fertilizers, requirement on water and other vitally necessary factors.

The methods of information technologies allow applying the system approach in preparation of the technological map growing of crop. Taking into the account above mentioned reasons it was developed the program system which allowed automatically generating the technological scheme on a basis of chosen culture, agro-climatic conditions of region and state of the soil.

On developing of the software were put and were solved the following tasks: consideration of features of facilities, choice of the crop, description of the cultivation technology, the computation tasks, and definition of a sequence and terms of technological operations. Let's in detail describe each of these tasks separately.

1. *The consideration of features of facilities*. The data on the characteristic of facilities, that is filling by the user (farmer) are the followings:

- structure of the sowing areas
- system of tillage
- system of fertilizers
- system of weed control
- system of combating agricultural pests
- hydraulic engineering and water conservation actions.

In the program system the sowing area is identified by the name of the facilities and area, region of an arrangement and an economic year.

The soil, as a natural body, is function of a relief, soil-forming rock, climate and growth. From the point of view of an agronomical science the parameters influencing on potentially possible productivity of crop are *photosynthetic active radiation*, *daily average temperature in the vegetation period of the plant*, *susceptibility of soil of erosion*, *thickness of humus horizon*, *predecessor crop* and *rest of fertilizers using in under the predecessor crop*, *degree of a weed* etc. It is obvious that these parameters are changes in time. Therefore in the program the opportunity of introduction the renewed parameters, and automatic definition those on the data of the previous economic year are stipulated.

In the database of the program also is stipulated preservation of the average data of region entered on the basis of knowledge of the experts - agrochemistry and soil science. It allows carry out account of expected productivity and charges under the information by available information in the database, when the specific data of the considered facilities is absence.

2. *Choice of crop*. In the database of the program is stipulated the table that is containing the information on biological features of the basic cultivated crop, i.e. their requirement to heat, light, moisture, soil, predecessor etc. Here also is given the parameters list, as coefficient of using *photosynthetic active radiation*, *minimal temperature of growth of a plant*, *operating ratio of elements of a feed from fertilizers, from soil* etc. It is given the list of not recommended cultures depending on the predecessor. It is separated the grades and seeds which are characterized by a seed class, calibration, weights and germinating power.

The mechanism of a choice of culture is based on the following algorithm.

a) an admissibility of a choice on the predecessor;

b) provision of requirements of a plant at cultivation in concrete soil-climatic conditions.

3. *Description of cultivation technology*. The system includes a description of growing technology and business processes: system of tillage, sowing methods, care for crops, condition for protect crops from pests, diseases, weeds, harvesting. All-agricultural activities are selected on the basis of the system requirements of crops and varieties. The process of growth implies a certain sequence of agricultural operations. For example, such operations are *lushenie plowing*, *deep plowing*, *harrowing*, *seed treatment*, *heating of seeds*, *sowing*, *irrigation*, etc. The execution of each of these operations requires a certain amount of financial costs (rental of agricultural machinery, seeds, purchase of fertilizers, pesticides, etc.). Obviously, the price works for agronomic operations, fertilizers, pestetsidy and others may vary from year to year. The database system provides for the preservation of relevant indicators. They are entered and updated by the user of the system.

4. *Computation tasks*. Computation tasks produced by the system include the determination of the level of crop productivity on the coefficients of photosynthetically active radiation; calculation rules of organic and mineral fertilizers in view of the effective fertility of the soil and the plants' requirement for nutrients, the calculation of flow of seeds for planting. The system is also carried out the calculation of norms of irrigation, based on the needs of plants in the water in optimum amounts. In rainfed conditions, the productivity level is determined on the prevailing climatic conditions. As described above, the flow chart is composed of a sequence of farming operations, with their features. Talking about features, we mean the following.

For operations, such as shallow plowing, deep plowing, sowing, tilling soil in between rows, etc. one of the features is the depth. For different plants, it is different.

The operation "fertilizer" must be determined by different rate of fertilizer (mainly nitrogen, phosphorus and potassium). Let's describe an algorithm to determine fertilizer rates.

First we define the maximum possible yield (*kg/ha*) [1]

$$Y_{\max} = \frac{\Sigma R \cdot K_c}{400000\ кДж / Ц},$$

where ΣR is photosynthetic active radiation at this area (region), and K_c is the coefficient of photosynthetic active radiation plant.

Then based on the resources of heat in the region, is computing the possible real yield (*kg/ha*) by the formula [1]

$$U_p = \frac{Y_{\max} \cdot (t - \tau)}{t_{opt} - \tau},$$

where t is the average daily temperature during the growing season, t_{opt} is plant-average optimum temperature for growth of selected plants, and τ is the minimum temperature for its growth.

The norm of organic fertilizers for positive humus balance is determined on the need to achieve and maintain optimal level it in the soil. Rate of manure is calculated using the following formula proposed Chuyan [2]:

$$D_{\text{orq}} = \frac{\Gamma_c \cdot a \cdot \Delta t + (\Gamma_n - \Gamma_c) - A \cdot b \cdot \Delta t}{C \cdot \Delta t},$$

where Γ_c is the reserve of humus in the soil (*t/ha*), Γ_n is the planned (optimal) reserve of humus (*t/ha*), a is the coefficient of mineralization of humus; Δt is the time during that planned to raise the stock of humus (*year*), C is the amount of humus formed from 1 ton humification of manure, b is the crop coefficient and root residues, A is the annual amount of stubble, root residues in soil (*t/ha*).

It is determined the amount of mineral elements, which can be assimilate from a unit area (*kg/ha*) on the m amount nutrition contained in the soil (*mg/kg*),

$$P' = 30 \cdot m' \cdot \rho,$$

where ρ is the density of soil (g/cm^3).

Here and below the sign $'$ (stroke) indicates that the written formula should be applied to each subject nutrients (nitrogen, phosphorus, potassium).

Further is defined the norm of nutrition (*kg/ha*):

$$D'_n = \frac{U_p \cdot B' - \left(P' \cdot K'_{\text{p}} + D_{\text{orq}} \cdot C'_{\text{orq}} \cdot K'_{\text{orq}} + D'_{\text{os}} \cdot K'_{\text{os}}\right)}{K'_{\text{u}}},$$

where B is the amount of assimilable fertilization of soil with unit yield (*0.1 kg/s*), K_{p} is the coefficient of digestibility of fertilizers from the soil, D_{orq} is the number of organic fertilizers, making each hectare of land (*tons*), K_{orq} is digestibility coefficient of the considered organic fertilizers (mineral fertilizer), K_{u} is the coefficient of digestibility of given mineral elements of fertilizer (*%*), C_{orq} is nutrient content of the given organic fertilizer (*%*), K_{os} is the coefficient of the considered residual nutrient from the fertilizer used for a predecessor, D_{os} is the residual amount of a nutrient in the soil (*kg/ha*).

Here D_{os} is determined by the formula [3] $D'_{\text{os}} = K'_i \cdot D'_{pq}$, where D_{pq} is the amount of nutrient used in the previous year, K_i is the coefficient of digestibility of nutrients from fertilizers used in the previous year.

Finally, based on the value D'_{n} and according to the expert knowledge of specialists, is determining the dose of mineral elements for each case of use (fertilization).

The operation "irrigation" should be determined by irrigation rate. Irrigation rate M_{or} is expressed in (m^3/ha) and is defined as follows [4]:

$$M_{or} = K_{spv} \cdot U_p - e \cdot K_y \cdot \alpha - W_n \cdot n - \left(W_b - W_s\right),$$

where K_{spv} is the coefficient of water consumption of primary products of crop (m^3 /*ton)*, K_y is the coefficient of precipitation, α is the amount of rainfall during the growing season of crops (*mm*), $e = 10\,\frac{м^3}{га \cdot мм}$ is conversion factor, W_n is the amount of moisture coming for one day in the root layer of groundwater (m^3/ha), n is the vegetation period of crops (*days*), W_b and W_s respectively are moisture reserves in the root zone of soil in the early and late vegetative of crop, (m^3/ha). The difference $W_b - W_s$ is called the reserve of soil moisture and can be determined by the following formula:

$$W_b - W_s = 100 \cdot \left(H_b \times D_b \times Y_b - H_s \times D_s \times Y_s\right),$$

where H_b and H_s are the depth of the active layer of soil at the beginning and end of vegetation (*m*), D_b and D_s are the average density of the layer of soil at the beginning and end of growing season (t/m^3), Y_b and Y_s are the moisture of the soil at the beginning and end of growing season crops (*%*).

As the need of crops in water by growing phase varies, the irrigation rate serves no one watering, and frequently during the greatest needs of plants in moisture. The amount of water at the each irrigation is determining by the formula [1]:

$$M_v = \frac{M_{or}}{N},$$

where N is the number of vegetative watering.

Note that the calculation of the amount of fertilizer needed to ensure the right amount of mineral elements is a separate task and is implemented as a separate module of the program. This algorithm described in [5].

In the operation "seeding" the depth of seeding is determined by the following algorithm: If the mechanical structure of the soil is "easy", and the caliber of seeds is the "big", then the depth should be 4-5 *cm*, otherwise the depth should be 2-3 *cm*.

Weight of seeds for planting one hectare is determined as follows:

$$H = \frac{K \cdot M \cdot B_m}{1000} \ (kg),$$

where B_m is the mass of 1000 seeds in grams, the coefficient

$$K = \begin{cases} 22.5, & r = 45\,cm, \\ 16.7, & r = 60\,cm, \end{cases}$$

is determined on the basis of r presumed distance between the rows, and the coefficient

$$M = \begin{cases} 15 \div 20, & a_z = weak\ or\ medium, \\ 25 \div 30, & a_z = strong, \end{cases}$$

based on a_z grade weed of crops.

5. Definition of a sequence and terms of technological operations. Principal part of the technological scheme includes information about the sequence and characteristics of the farming operations. Generation of this part is based on the expertise of specialists represented in the form of a set of agricultural operations. Note that some operations (e.g., the deep plowing and fertilizer) are carrying out simultaneously, so they are merged into one group.

To determine the location and sequence of farming operations in the technological chart, is prescribes special conditions of ranking for each operation. As the condition favor the set of following elements:

- This operation may be only the first
- After which operations may follow this operation
- What operations may follow after this operation
- How often can be repeated this operation (the minimum allowable time interval)
- This operation can only be the last.

These conditions are imposed by the experts through a special interface. The correctness condition is verified the system of automatic tests. If the imposed conditions does not provide an unambiguous description of the technological chart, the system offers the expert to clarify or supplement them. Later, these conditions make it possible to automatically generate a flow chart, without the intervention of experts and system developers.

Conclusion. The proposed system includes guidance on the cultivation of crops. It describes the technology and business processes in real soil and climatic conditions in accordance with economic conditions. The system was created to help farmers.

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