Intelligent System Analyzing Quality of Land Plots

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Abstract: **Products grown on the territory of Ukraine or goods obtained from the processing of the crops concerned are attractive in many countries of the world. It is advisable to focus on improving the cultivation of crops to increase the export of our goods abroad. The development of an appropriate software complex that would combine the interests of the state and farmers to increase the yield of crops and, accordingly, increase the amount of crop, is an integral part of improving the work of the agricultural sector of the state. Introduction a crop rotation is the main idea of developing a software system. This will lessen the drying of the soil and increase yield.**

Keywords: **mathematical model, forecasted yield, crop rotation, land plot, agrarian.**

I. Introduction

Each year the state must sell the tender for the planting of certain crops for a certain period of time. The most effective distribution of orders for planting between farmers is the main issue of study. There is a problem in absence of a database of agrarians and information's about tenders at the first stage. In the work, we will use a simulated bidding scheme based on input data that is as close as possible to the actual data.

Only a few hundred species of plants are used in agriculture. Most of the agricultural products are provided at best twenty species of plants. For thousands of years, people have been trying to improve their yields, using the remains of fauna and flora. However, it was a natural way to improve yields. Today we see a completely different picture. On the one hand it increases yields but on the other hand the quality of crops and also the ecological condition of soils and groundwater deteriorate [1].

Considering all the above problems, the creation of an intelligent system analyzing quality of land plots will be a major breakthrough in the field of agronomy. It will allow maximize profits for both the state and agrarians by efficient cultivation of different crop.

II. Modeling the Process of Yield of Culture

The main idea of developing a software system for planting land is to improve soil fertility through such a crop rotation of crops. This will allow to reduce drying soil, increase the yield of the crop and will require less use of various types of herbicides, pesticides, supplements, growth

stimulants, etc. At the end, it will still have a positive impact on the environment, because less chemicals will fall into the soil and, accordingly, to the reservoirs.

Another positive aspect is that such a system does not exist in Ukraine today. The main emphasis of the state's provision of export goods in the field of agrarian industry is focused on agrarians-monopolists. They conclude with state the main tendering agreements. Within these agreements, the main focus is on obtaining a stable yield, resulting in a soil deterioration. It leads to extensive use of a large amount of inorganic fertilizers in order to improve soils quality which in run adversely affects the environmental state or condition.

The main crops grown in the Ternopil region are sunflowers, corn, rape, sugar beet and winter crops - wheat and barley. These crops are an export commodity within our state, and some of them, including sunflowers and wheat, are part of the exported goods abroad.

The average yield index of the described crops for Ternopil region in 2016 was:

- 3.8 t from 1 ha for wheat;
- 2.4 t from 1 ha for sunflowers;
- 30 t from 1 ha for sugar beet;
- 4.7 t from 1 ha for corn;
- 3.6 t from 1 ha for barley;
- 1.8 t from 1 ha for rape.

Let's take these indicators as etalon for standard crop yields to determine which crop on which area is better to plant to obtain the best possible yield without excess fertilizer. The planting of a culture will then influence what culture was planted in this field last year and how many years the proposed culture was not grown in this area.

The most depleting for soil, from the crops grown in the Ternopil region are sunflowers and corn. The land should reset for seven years to recapture the previous fertilizing power and inspiration after the sunflowers, after the corn only three years. This term agricultural producers do not always stand, or do not stand at all. This is especially true for sunflower. So in the system is proposed to consider planting a plot sunflower at least after 4 years.

Table 1 summarizes the planting rates of crops. It is including the last year of landing and crop rotation, as well as the obtained average yield of a crop from 1 ha of land. Let's enter some variables:

- y – the maximum number of years the culture should not be grown on the site;
- v_{pr_i} - average yield of the crop that was last planted on the plot within the proposed area for the last landing;
- v_i - the average yield of a crop that is being prepared for planting on a plot within the proposed area for the last landing;

- v_{res_i} - average yield of cultivated crop.

TABLE 1. INDICATORS OF AVERAGE CROP YIELDS ACCORDING TO THE PREVIOUS CROP ROTATION AND LAST YEAR OF CULTIVATION

Culture type	y	v_{pr_i}	v_i	v_{res_i}
Sunflower	3	4.7	2.4	2.2
	3	3.6	2.4	2.4
	3	1.8	2.4	2.5
	3	3.8	2.4	2.3
	3	30	2.4	2.6
Corn	2	3.4	4.7	4.4
	2	3.6	4.7	4.7
	2	1.8	4.7	4.8
	2	3.8	4.7	4.7
	2	30	4.7	4.8
Barley	1	4.7	3.6	3.5
	1	2.4	3.6	3.4
	1	1.8	3.6	3.7
	1	3.8	3.6	3.6
	1	30	3.6	3.7
Rape	1	4.7	1.8	1.7
	1	2.4	1.8	1.6
	1	3.6	1.8	1.8
	1	3.8	1.8	1.8
	1	30	1.8	1.9
Wheat	1	4.7	3.8	3.7
	1	2.4	3.8	3.6
	1	3.6	3.8	3.8
	1	1.8	3.8	3.9
	1	30	3.8	4
Sugar beet	1	4.7	30	28
	1	2.4	30	27
	1	3.6	30	30
	1	1.8	30	32
	1	3.8	30	31

It is advisable to construct a model of the dependence of the yield of the crop from its crop rotation within a specific area. At the initial stage, we will choose the linear structure of the model of the species:

$$v_{res_i} = k_1 \cdot y_i + k_2 \cdot v_{pr_i} + k_3 \cdot v_i + k_4 \qquad (1)$$

where k_i , $i = \overline{1 .. 4}$ - unknown coefficients, the values of which need to be evaluated on the basis of the analysis of the data presented in Table 1.

According to tabular data we will make a system of linear algebraic equations in this form:

$$\begin{cases} k_1 * y_i + k_2 * v_{pr1} + k_3 * v_1 + k_4 = v_{res1} \\ \dots \\ k_1 * y_i + k_2 * v_{pri} + k_3 * v_i + k_4 = v_{resi} \\ \dots \\ k_1 * y_{30} + k_2 * v_{pr30} + k_3 * v_{30} + k_4 = v_{res30} \end{cases} \qquad (2)$$

The solution of the system (2) is the region of coefficients of the model [2,3]. Using the least squares method to find the estimates of the coefficients of the model from SLR (2), we obtain the following model:

$$v_{resi} = 0{,}008 * y_i + 0.006 * v_{pri} + 0.99 * v_i - 0.04 \qquad (3)$$

Obtained value from the formula (3) is reflects the average yield of the proposed landing in the specified section of the crop with regard to the history of the planting. However, for a more adequate construction of the planting strategy, it is necessary to take into account the risks that can reduce this indicator.

Let's establish a 5% deviation from the predicted yield index for the possibility of taking into account the various risks of deteriorating crop yields. As a result, the forecast yield of the crop will be in the range [3]:

$$[v^-_{res_i}; v^+_{res_i}] = [v_{res_i} - 0{,}05 \cdot v_{res_i}; v_{res_i}] \qquad (4)$$

The order of the state to a certain culture appears in the interval:

$$[V^-_{con_i}; V^+_{con_i}] \qquad (5)$$

where $V^-_{con_i}$ - the minimum amount of crop yield required by the state to cover the domestic needs and export needs of the overseas; $V^+_{con_i}$ - the maximum amount of crop yield that the state may buy overtime from agrarians.

The function of the distribution of planting the culture between the plots within a single order (2.5) is represented by the expression:

$$[f(V_i)] = \sum_{i=1} (S_i \cdot [v^-_{res_i}; v^+_{res_i}]), \qquad (6)$$

where S_i - the area of the field selected for planting the selected culture on the i-th iteration.

The number of iterations is determined in accordance with the improvement of the goal function F_i, the value of which is determined by the formula:

$$F_i = \min_{i=1,..,N} \left\{ mid([V^-_{con_i}; V^+_{con_i}]) - mid([f(V_i)]) \right\}, \qquad (7)$$

where $F_i \geq 0$.

That is, the choice of the optimal field for planting will be selected as long as the function F_i will accept positive values from a set of possible values [4].

III. Software Realization

Figure 3.1 depicts a general block diagram of the system [5,6].

Basically you can highlight three main stages of the program system:

1) Formation of an order by the state. This process includes selecting the necessary crops, sorting them by priority and indicating the interval of the yield. Flow chart of this process depicted in Fig 3.

2) Planting cost estimation. The software system analyzes the history of the planting of all available fields of the agrarians on which it is planned to plant the corresponding crop and publish a list of fields with the most effective way of planting, that is, those fields that will result in the best crop yields taking into account crop rotation. Flow chart of this process depicted in Fig 2.

3) Giving of a result. The last step will be the window with the formed fields for planting each crop. At this stage, you can review the forecast average yield, previous yields in this field and other indicators. Flow chart [7] of this process depicted in Fig 4.

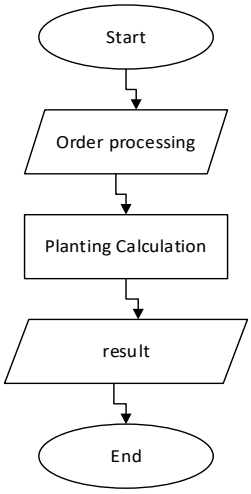

Fig. 1. Flow chart diagram

A detailed flowchart of the "Planting Calculation" process is shown in Fig. 2. Consider the step-by-step description of the process:

1. System choose the culture from order. The culture was sorted by priority.
2. Retrieve information about all available fields on which can be planted the culture, selected in step 1.
3. Calculating for each field the estimated yield of the selected crop depending on the history of planting and the average yield in this field by the formula 4.
4. Select the field with the largest interval of the forecast yield according to the formula 6.
5. Connecting the field to the chosen culture.
6. This field will be marked as selected and will not appear in field list by the end of calculation.
7. Check whether there any culture that does not connected to any of fields;

7.1. If fields are selected for all cultures, then proceed to the next stage;

7.2. If there are cultures for which the fields are not yet selected, then choose the culture that follows the priority and proceed to step 2.

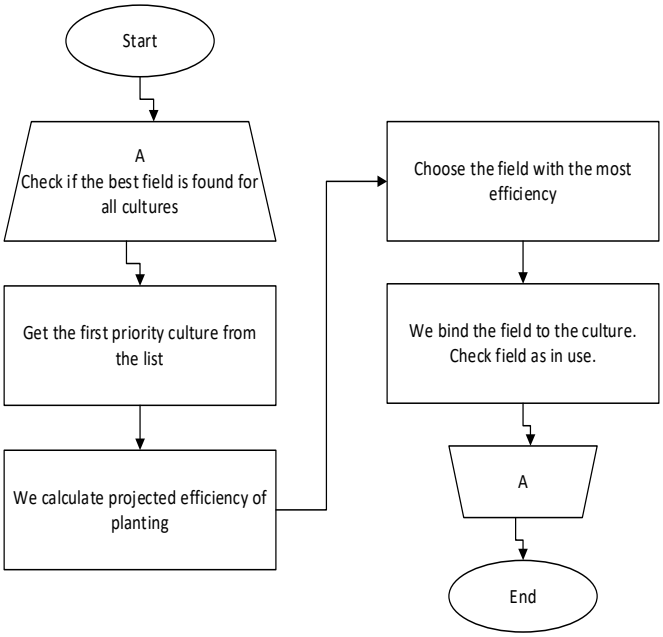

Fig. 2. Flow chart of the «Planting Calculation» process

In order to get started with the system, it is necessary to form orders. We should choose the culture, their priority and indicate the minimum and maximum crop yields for the state. The form of this process is depicted in Fig. 3. [7]

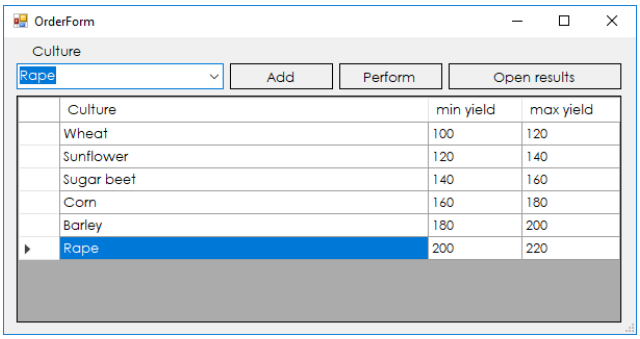

Fig. 3. Purchase Order Form

Once the system has selected the most effective options for planting fields, you can open the resulting form for viewing detailed information on the results of calculations, namely:

- description of the data on the agrarian who owns the field with the planted crop;
- field area;
- a culture that will be planted in the chosen field;
- current year of planting.

The prototype of the shape is depicted in Fig. 4.

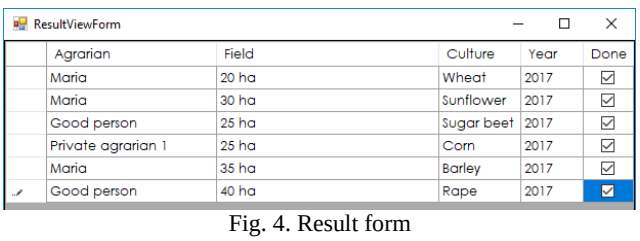

Fig. 4. Result form

In general, this form depicts a compiled information about agrarian and field, which will effectively be used when planting a certain culture. Double-clicking on a culture will open a dialog box that displays detailed information about the field and the owner. The prototype of the shape is depicted in Fig. 5.

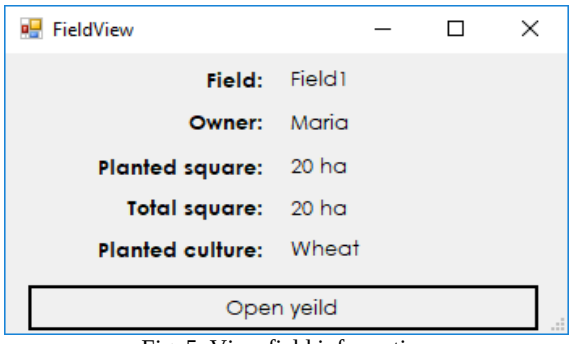

Fig. 5. View field information

Clicking on the "View yield" button will open a window that displays information about how much culture of the whole field was collected, how much was forecasted for collection, the average yield of actual and average yields is projected in the range from the minimum to the maximum value. The prototype of the shape is depicted in Fig. 6.

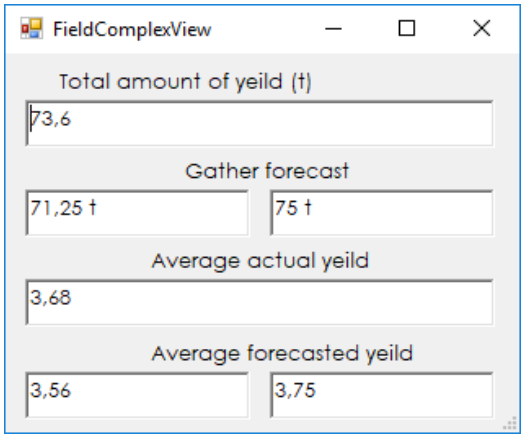

Fig. 6. Display detailed information on crop yields at a particular site

IV. Conclusion

In the scientific work the actual scientific research task of analyzing the quality of land plot planting has been solved. The following scientific and practical results were obtained.

During the analysis of the subject area it was discovered that today the main emphasis of the state's provision of export goods in the field of agrarian industry is focused on agrarians of the monopolists. Between them and the state, the main tendering agreements are concluded. Within these agreements, the main focus is on obtaining a maximum yield, which leads to a deterioration of the soil, which is trying to improve with the use of a large amount of fertilizers of inorganic origin, which in turn adversely affects the environmental state of the environment.

In order to improve crop yields and reduce the amount of inorganic fertilizers, it is proposed to take into account the previous crop rotation when planting the crop, which can significantly improve the yields of the proposed crop.

In the framework of the proposed approach, a mathematical model of the dependence of the crop yield from the previous crop rotation within a specific area is developed.

The method of planting of plots on the basis of the developed model of crop rotation is developed, which will allow covering the minimum amount of crop yield required for the state for crops and improve the quality of soil application and, as a result, average yields of crops.

The program complex of quality of planting of land plots has been developed, which will improve the connection between "state-agrarian state". Provide the opportunity for private entrepreneurs to enter a large market of sales and as a result, with the correct and lawful application of the software complex to improve the quality of land and the ecological state of the country.

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