Prediction of losses in agricultural production output

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Abstract. The research presents the method of predicting the output losses in the two-staged project of agricultural production which takes into consideration the volumes of production; technological requirements concerning directory temps of carrying out operations; properties of technical resources; interdependence of operations.

This method also allows to determine the expected losses of the output connected with violating directory terms of performing technological operations of the project.

Key words: project, output, losses, directory terms, method.

INTRODUCTION

Projects connected with criop production in agriculture have quite a number of specifie characteristics and, therefore, traditional network and calendar types of planning frequantly cannot be effectively employed there. In particular, such projects foresee performing of a lot of agricultural operations only within optimal agrotechnical terms because of the biological properties of crops, their specifie phases of vegetation and agrometeorogical conditions of environment.

The given terms should be considered as directory. Their violation will provoke irreversible losses in crop yields (the output of the project) and , therefore, predictions of losses at the stage of planning the project and developing the corresponding managerial decisions proved to be a serious scientifically – practical objective aimed at minimizing such losses.

RECENT RESEARCH AND PUBLICATIONS ANALYSIS

Manager's activity may be sufficiently relieved at each stage if he managed to get a model of calendar planning of performing predetermined operations and their biasing [2, 3]. In the projects connected with agrarian production any moving away of directory terms cause losses of yields (outputs).

Current methods of predicting yields losses caused by ill-timing of technological operations [4, 5, 6] are based on the biological specifications of crop vegetation. The analysts possess different views in predicting such losses . The reseach [4] suggests to employ a linear model of losses under conditions of velatively short periods of time (no more 20 days):

$$U_t = U_{\max}\left(1 - k_l t\right), \quad (1)$$

where: U_t –current value of the yielding capacity, c/ha; U_{max} – the yielding capacity of the crop which corresponds to performing operations in optimal terms, c/ha; k_l – coefficient of the yield losses when directory terms of performing an operation are prolonged in one unit of time (a day); t – duration of ill – timed operation carried out with violation of optimal moments, days.

The research [5] suggested the method of determining losses of crop yields caused by ill-timed performing of each technological operation. The given method, however, ignores the impact of neigbouring technological operations within a single project on the volumes of crops yields losses.

OBJECTIVES

The article is focused on developing the method of predicting losses of the project's output under conditions of violation of directory terms of performing operations.

MAIN PRESENTATION

Our project connected with crop growing is implemented on the single field or the group of fields. It faces, therefore, the necessity of performing major operations in one field in succession only. This approach excludes performing of different operations simultaneously there.

In addition, the results of the projects dealing with crop growing frequently face the risks of natural calamities, bad weather, etc which should be taken into consideration when making up models.

The project dealing with crop growing production can be considered as a set of well – organized operations over soils, a plant or a material in accordance with the given agrotechnical requirements:

$$P = \{O_i\}. \quad (2)$$

Each technological operation O_i, is given a finite sequence with the following attributes: type of operation VO_i, (ploughing, cultivation, chemical protection, etc.); a set of agrotechnical requirement to operations $\{AV_i\}$ (depth of procession, rate of application, etc.); directory time of starting $[\tau_i]$ and duration of fulfillment of an operation $[t_i]$:

$$O_i = \langle VO_i, \{AV_i\}, [\tau_i], [t_i] \rangle. \quad (3)$$

When performing major and additional technological operations within a single project one uses a limited number of industrial and technical resources of agrarian enterprises. We may distinguish there a set of farm machines $\{M_i\}$ and energetic instruments $\{T_i\}$ for their drive. The given resources make up the resource pool which may also be used in some other projects of the portfolio of agrarian enterprises. Because of the resources scarcity it is reasonable, therefore, to simulate these resources utilization under conditions of variable volumes of jobs Q within the project and limitation of the admissible terms of performing operations.

Calendar schedule of technological operations dealing with crop growing production is planned at three stages. The first stage foresees constructing the model of technology demonstrates orderable by time and content set of operations and vectors of directory calendar terms of their performing. The coordinate of the vector origin of the calendar terms of operation in the model of technology is given the directoty time of the operation starting $[\tau_s]$. The coordinate of completion $[\tau_{e_i}]$ is determinated by the formula:

$$[\tau_{e_i}] = [\tau_{s_i}] + [t_i]. \quad (4)$$

The model of the products output technology sets the ideal calendar schedule of the project. Performing of all technological operations within the directory calendar terms guarantees maximum output.

The second stage foresees selecting for each a-operation farm machines of the set $\{M_i\}$ of machinery available at the enterprise. The selected machines should secure the successful performing of the predetermined types of operations VO_i, and observing a set of agrotechnical requirements $\{AV_i\}$. In case with nonautomotive machines one should select specific energetic tool from the set $\{T_i\}$ of energetic means for these machines drive to secure the most efficient fulfillment of the predetermined technological operation. In this way we, thus, get the technical resource (machine and tractor aggregate) needed for performing the predetermined operation.Coming from technical characteristics of the given technological resource and environmental factors (specific resistance of the soil, the average angle of the field incline, length of the field gon and state of the object of conversion – a plant or material) we determine the veriable productivity w_v of the technical resource and its specific fuel costs g_p.

Coming from the determined variable productivity of technical resources we can determine the real duration of each technological operation O_i, taking into consideration the quality of all available technical resources:

$$t_i = \frac{q}{w_v \cdot k_v \cdot n}, \quad (5)$$

where: q – the volume of jobs, ha, t, m^3; w_v – productivity of the aggregate for a shift (standard of the aggregate output) ha/shift; k_v – coefficient of variability; n – number of aggregates involved onto the given operation from the available set $\{M_i\}$ and $\{Ti\}$.

As only a single operation may be carried out in one single field at the given time, one must determine coordinates of the vector of both origin τ_{s_i} and completion τ_{e_i} for each single technological operation. In the case with the first operation of the project coordinates of the vectors origin will be equal to its directory calendar time $[\tau_{s_1}]$, i.e. $\tau_{s1} = [\tau_{s_1}]$.

For all further 1-x operations coordinates of their vectors of starting are determined with consideration of directory time of their starting $[\tau_{s_i}]$ after finishing the previous field operation $\tau_{e_{i-1}}$, i.e:

$$\tau_{s_i} = \begin{cases} [\tau_{si}], \text{ if } [\tau_{si}] > \tau_{e_{i-1}} \\ \tau_{e_{i-1}}, \text{ if } [\tau_{si}] \le \tau_{e_{i-1}} \end{cases}. \quad (6)$$

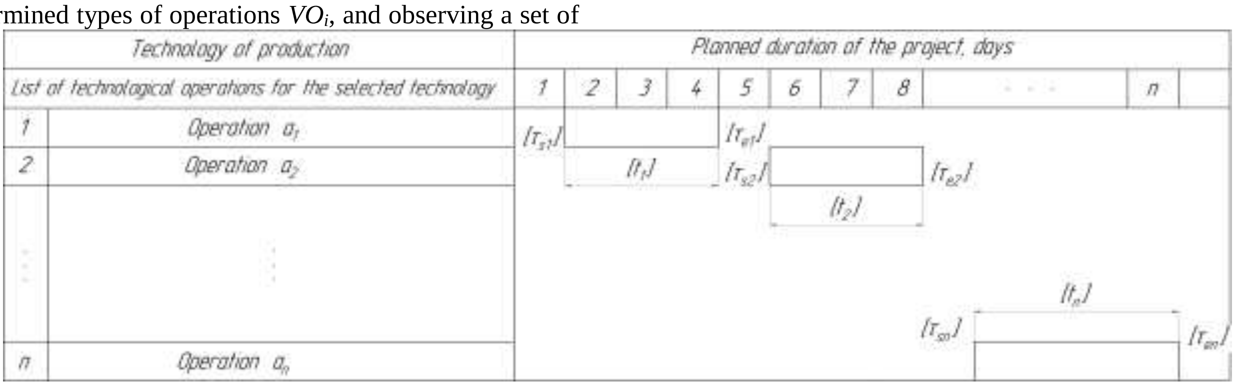

Fig. 1. Model of the crop production technology

Coordinate of completion of the vector of technological operation is determined by addition of the value of duration τ_{s_i} of the operation to the coordinate of its starting t_i:

$$\tau_{e_i} = \tau_{s_i} + t_i . \quad (7)$$

When performing technological operations in the predetermined volumes one may face the searcity of farm machines {M_i} and energetic means {T_i}, and, hence, the problems of violation of directory terms of operations may arise. The value of duration of performing operations prevailing the directory terms t_u (Fig. 2) is determined under the following condition:

$$t_u = \begin{cases} \tau_{e_i} - [\tau_{e_i}], \text{ if } \tau_{e_i} > [\tau_{e_i}] \\ 0, \text{ if } \tau_{e_i} \le [\tau_{e_i}] \end{cases} . \quad (8)$$

In case the time of completion of technological operation prevails its directory calendar time of completion $\tau_{e_i} > [\tau_{e_i}]$ (Fig. 2*b*), the problem of the losses of the output may arise.

To avoid such situations one must modify the duration of one day working time (the coefficient of variability) or the number of machine and tractor aggregates involved into jobs.

If both measures are not able to prevent the duration of operations beyond the directory terms , one must determine the value of losses caused by ill-timed performing of such operations:

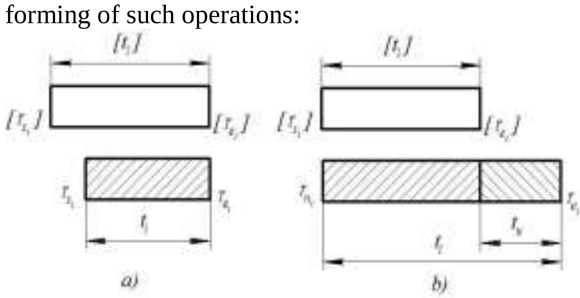

Fig. 2. The technological operation which does not prevail (*a*) and prevails (*b*) the directory terms of its carrying out

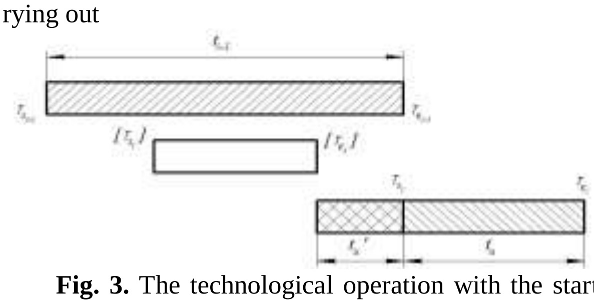

Fig. 3. The technological operation with the starting lagged behind the directory term of carrying out jobs

$$Z_i = 0{,}5 \cdot U_{\max_i} \cdot q_{u_i} \cdot t_{u_i} \cdot \kappa_l , \quad (9)$$

$$q_{u_i} = q - W_{d_i} \cdot ([\tau_{ei}] - \tau_{si}) , \quad (10)$$

where: U_{max} – maximum yielding capacity of a crop (the project output), c/ha; q_{ui} – the area of the field where the operation is performed with violations of directory terms, ha; t_u – duration of performing the operation beyond the directory terms, days; k_l – coefficient of the crop losses caused by 1 day delay of the technological operation; W_{di} – the delay standard of the aggregate output when performing the given operation, ha/day.

When field or technical resources are employed in the previous operation may, the time of starting of the next technological operation, may be lagged behind the directory terms predetermined for it (Fig. 3). The output losses caused by ill – timed starting of the operation t_n, then, are calculated by maens of the formula:

$$Z_i^{'} = q_u \cdot t_u^{'} \cdot U_{\max_i} \cdot \kappa_{l_i} , \quad (11)$$

$$t_{u^{'}} = \begin{cases} \tau_{s_i} - [\tau_{e_i}], \text{ if } \tau_{s_i} \ge [\tau_{e_i}] \\ 0, \text{ if } \tau_{s_i} < [\tau_{e_i}] \end{cases} . \quad (12)$$

The next step is determining the total output losses for each operation of the project caused by its ill – timed performing:

$$\sum Z_{Si} = Z_i^{'} + Z_i . \quad (13)$$

Coming from the construction of the calendar schedule we determine the expected losses of the output for all operations of the project *P*, and their gross expected losses of the output by means Z_{Pi} of the formula:

$$Z_{Pi} = \sum_{i=1}^{n} Z_{S_i} . \quad (14)$$

The received results give grounds for motivating organizationally technical decisions on realization of the project.

Analysis of the technical operations give the apportunity to determine the critical operations of the project causing the most dramatical output losses as well as to determine such technical resources whose scarcity provokes these losses. Managers supervising the project should constantly take into consideration the said above and feel their personal responsibilities for satisfactory supply of technical resources through cooperation, rent and additional purchase of the given type of resources.

If it is impossible or unreasonable to employ the additional resources one should think about the opportunities of diminishing the range of the project which, in its turn, will lead to diminishing demands in technical resources and, hence, minimal losses of the output.

CONCLUSIONS

1. Projects connected with agrarian production have their specific characteristics caused by limitation of calendar terms of performing operations. This phenomenon needs further developments or improvements of the current methods of constructing calendar schedules and supervision of the projects.

2. The suggested method of constructing calendar schedule considers optimal versions of interdependence of technological operations conserving both the timely realization of the project and violation of directory terms which allows to determine the expected losses of the project caused by the violation of directory terms of performing operations within the project.

3. The developed method of predicting the output losses proved to be a reason for grounding the needs in

additional resources and the change of the range of the project for preventing irreversive losses of the output.

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