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METHODICAL PREREQUISITES FOR SYSTEMIC ANALYSIS OF TECHNOLOGICAL VARIANTS FOR GRAPE PRODUCTION

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Abstract

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The obtained assessment of the efficiency of a given activity has concrete purposefulness and is very sensitive to the change of both external and internal environmental disturbances. The random parameters of natural climatic environmental conditions, organization and structure of the farm and random values of the parameters of the used aggregates presuppose a complex assessment to determine the extent of effect of the different factors. The objective of this work was to suggest a methodical approach and to justify a formalized relation between the parameters of grapevine plantations and the technological complex of machines and the conditions of their cultivation.

A methodical approach and a well-founded formalized relation between the parameters of the grapevine plantations and the technological complex of machines and the conditions of their cultivation are suggested. Relations are suggested for determining the productivity during basic technological operations, their material provision, costs of FLM and transport. It was found that the sensitivity of the variable costs decreased over 32 ha. A criterion of assessment of the extent of effect of the factors influencing the costs in wine grape growing is suggested on this basis.

Key words: grapevine growing, technology, criterion of assessment, systemic analysis

Abbreviations:

W_p – productivity of conducting the selective pruning, *ha/h*
N – average rate per shift in grapevine number
T_p – average duration of the working day in the period of conducting the selective pruning
$N_л$ – average grapevine number per hectare for the all analyzed farm
$W_{Пр}$ – shift performance of the sprayer, *ha/h*
T_{CM} - shift duration, *h*
q – consumption rate of working liquid, dm^3/ha
Q_n – reservoir capacity of the sprayer, dm^3
$W_{пр}^{в}$ - performance of the transport means, *ha/h*

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Q_p – loading capacity of water carrier, dm^3
D_n – debit of the system for filling of the trailer with water, dm^3/min
V_{ek} – average operating speed, km/h
τ – coefficient of use of working time
S – average distance from the plantation to the place of filling with water, loading or unloading, km
Q_p – loading capacity of trailer, kg
W^n_{mp} - performance of transportation of packaged loads, ha/h
W_t – productivity of the loaders of the trailer, kg/h
V_{ek} – average operating speed, km/h
n – loader number
q_p – consumption rate of fertilizer, kg/ha
W^m_{mp} - performance of the transport means during in bulk grape transportation, ha/h
D – average grape yield per hectare, kg/ha
N_{k_i} - necessary number of courses for definite operation
n_i - number of travelers
F - plantation area, ha
$W_{см i}$ – shift productivity during the respective operation, ha/h
$T_{см i}$ – shift duration, h
m - bucket number per grape-gatherer
R_b - annual amount of the costs of buckets, lv/ha
A_0 – depreciation allowances, %
C_b – price per bucket, lv
R_s - annual amount of the costs of sacks in the case of single use, lv/ha
C_s – is price per sack, lv
Q_s – capacity per sack, kg
R_{sm} - annual amount of the costs of sacks in the case of multiple use, lv/ha
S_p - row length in m
$T_з$ – time of making a turn, s
V_p – speed of movement of the aggregate, m/s

Introduction

The decision that a farmer will make in his choice of one or another technological or technical decision depends on many factors. These are the various farms in form and size, different soil-climatic conditions, distance to settlements and sale places for produce. On the other hand, the wide ranges of tractor makes and models and working machines that can be used in viticulture give additional indefiniteness in the system. Under such prerequisites the systemic analysis proved to be a promising form of formulation and solution of a given task. It allows working out alternative variants of solution of the problem with a possibility for comparison of the presumable costs and expected efficiency of each of the variants. Therefore, different models are developed, which reflect the conditions and interrelations in different real situations with sufficient accuracy.

Efficiency of agricultural production depends on many variables. These factors include the loss of time to overcome environmental disturbances and disturbances in the work of the aggregate. The latter depend on functional state and maneuverability of the aggregate, power capacity of technological process, tractive-hitching characteristics of the tractor. These values change continuously in the time. The external disturbances and tractive-hitching characteristics of the tractor proved to be random variables.

Agricultural machinery works under most various conditions,. For instance, the slopes of the fields change within a broad range, as well as in a macro- and micro-plan. Specific soil resistance is in a similar state. The obtained assessment of the efficiency of a given activity has concrete purposefulness and is very sensitive to the change of both external and internal environmental disturbances.

The random parameters of natural climatic environmental conditions, organization and structure of the farm and random values of the parameters of the used aggregates presuppose a complex assessment to determine the extent of effect of the different factors. The objective of this work was to suggest a methodical approach and to justify a formalized relation between the parameters of grapevine plantations and the technological complex of machines and the conditions of their cultivation.

Methods

The multi-variant technological complex of machines (TCM) for wine grape production has been worked out on the basis of the traditional technology for vineyard cultivation in our country and the TCM worked out before (Kostadinov, 1989; Marinov et al.,1998; Panayotov et al., 1998; Panayotov, 1998).

The technological complex of machines represents (Wahl, 2006) a set of power means, working machines and implements and transport means related by the working processes, main parameters and characteristics of work and intended for complex mechanization of agricultural production. It is a technical base for introduction of any technology and reflects a definite conception for mechanization of the different operations. In the last 12-15 years of the transition we are the witnesses of continuous increase of the kinds of tractors and machines imported by a great number of companies. In this connection the choice by the farmer to buy one or another power or working machine is difficult. He must perform an analysis in order to judge economic expedience of every new purchase. A prerequisite for that is the formalization of the different calculating operations.

Results and Discussion

Determination of productivity of conducting the selective pruning

The productivity of conducting the selective pruning is determined on the basis of the following expression:

$$W_p = \frac{N}{T_p N_л}$$

The average rate per shift in grapevine number is obtained as an average value from the rates for the different grape varieties cultivated by a given farmer.

Condition for transport of water to prepare working liquid

When conducting the plant protection measures under definite conditions depending on plantation size, consumption rate of working liquid, performance and reservoir capacity of the sprayer, water can be delivered to the field to prepare the working liquid or during the lunch rest the sprayer could fulfill also that function. The delivery of water to the field by other transport means is necessary under the following condition:

$$W_{pr} T_{cm} q < 2Q_n$$

Determination of performance of the transport means during water transport

When the condition for need of water delivery to the field is met, the performance of the transport means is determined by the following expression:

$$W^{в}_{тр} = \frac{60 Q_p D_n V_{ek} \tau}{(120 D_n S + Q_p V_{ek}) q}$$

The performance of the transport means in this case is related to the size of the area concerned, i.e. the quantity of needed water, loading capacity of the trailer and distance to the plantation, speed of movement and debit of the filling system.

Determination of performance of the transport means during transportation of packaged loads

In order to conduct additional and reserve fertilizing, the used mineral fertilizer is in sacks and is transported to the field by trailers. In the same way other packaged loads are also transported. Their performance is determined in a way analogous to the water transport and in this case the productivity of loading of the transport means is also taken into consideration. The performance of transportation of packaged loads, the quantitative use of which in the field depends on the performance of the working machine, is determined on the basis of the following expression:

$$W_{mp}^{n} = \frac{Q_p W_t V_{ek} n\tau}{(2nSW_t + Q_p V_{ek}) q_p}$$

Determination of performance of the transport means during grape transportation

At present the common practice of grape gathering is by hand. Grapes are taken out of the grapevine plantation and transported to the consumer by trailers. Their performance in this operation is limited by loading capacity of the trailer, productivity of the loaders and their number, the distance of transportation, operating speed and grape yield. This performance can be determined by the following formula:

$$W_{mp}^{m} = \frac{Q_p W_t V_{ek} n\tau}{(2nSW_t + Q_p V_{ek}) D}$$

Determination of costs of transportation of workers to the field

The costs of transportation of workers to the field depend on the amount of manual work needed to be performed. This amount determines the necessary number of workers and the transport means, by which that transportation will be conducted. On this basis the necessary number of courses is determined in order to cover the area concerned during a definite operation and productivity of the workers.

$$N_{k_i} = \frac{F}{W_{см_i} T_{см_i} n_i}$$

In case when the selective pruning is conducted at the same time by mechanical and pneumatic scissors, the productivity for the operation is determined as an average weighted value of the two kinds of productivity.

If the necessary number of courses for transportation of workers is one, wage fund for a driver is not calculated, because it is supposed that then the owner or the person in charge of the plantation will transport the group.

Costs of provision of the grape gatherers with materials

Costs of plastic buckets and polyethylene sacks are considered. A 20% annual depreciation of these is considered. Each grape-gatherer has 10 buckets at his disposal. The annual amount of the costs of buckets is determined by the following expression:

$$R_b = \frac{DC_b A_o}{100 Q_b}$$

The costs of polyethylene sacks in the case of single use are determined by the following expression:

$$R_s = \frac{DC_s}{Q_s}$$

and in case of multiple use by the following expression

$$R_{sm} = \frac{DC_s A_o}{100 Q_s}$$

Determination of fuel consumption

Hour consumption of fuel in principle is determined on the basis of preliminary information about the values of the coefficient of use of nominal power of engine of the tractor for the concrete aggregate. When conducting soil tillage, the coefficient of use depends on specific resistance of the soil type. Under the conditions of our country and the soil types on which the grapevine plantations are cultivated, the maximum value of soil resistance is taken, as follows:

$f_{max} = 10$ *N/cm²*. On this basis, the coefficient of use of the power of the concrete aggregate under the given regional conditions is determined by the following expression:

$\eta = \frac{f}{f_{max}}$,where *f, N/cm²* is soil resistance for the concrete soil type.

The hour consumption of fuel (R_z) is determined by the following expression:

$$R_z = N_n q \eta$$

where N_n is nominal power of tractor engine, *hp* and *q* is specific fuel consumption in *kg/hp.h*.

Determination of costs of wage fund

The costs of wage fund are on the basis of the average wages for our country. Correction coefficients are considered according to the nature of the performed work. The workers are divided into two main groups – field workers and tractor-operators (drivers). The field workers are divided into laborers and specialist workers. The rate of pay of the drivers of transport means engaged in the production is the same as that of the tractor-drivers. The following ratios of the rates of pay of the laborers to specialist workers and to tractor drivers are accepted – 0.8:1.2:1.5.

Correction of productivity depending on plantation size

Shift productivity from literature sources is used. The productivity in them is determined for work in industrial plantations. During the work in them, the coefficient of use of the time in movement for work is not lower than 0.95. On this basis, accepting that the aggregate works in an endless row we idealize the productivity and we can write for the shift productivity, as follows: $W_i = 1.05W$. The so corrected productivity is used as a basis to specify the shift productivity for a concrete size of the plantation:

$W_{см} = W_i \tau_m$ where τ_m is coefficient of use of the time in movement of the aggregate. It is determined by assuming that the aggregate moves at the same speed when working and when making a turn:

$$\tau_m = \frac{S_p}{S_p + T_з V_p}$$

Figure 1 presents the effect of row length on the coefficient of use of the time in movement. Its considerable effect on the coefficient is evident, particularly in the shorter rows. The effect of the speed of movement of the aggregate is considerably smaller.

In this context, the effect of the plantation area *F, ha* on this coefficient is of interest.

$$\tau_m = \frac{\sqrt{10^4 mF}}{\sqrt{10^4 mF} + T_з V_p}$$ where *m* is ratio of the length to the width of the plantation.

It is evident from the graph in Figure 2 that when the ratio of plantation length to width (***m***) is lower or when it is closer to square and its area is smaller, then this effect is stronger. But this effect also decreases considerably in plantations over 25 *ha*.

The coefficient of use of the time of movement has a higher value during work at lower working speed and in a plantation of a greater area (Figure 3). A sec-

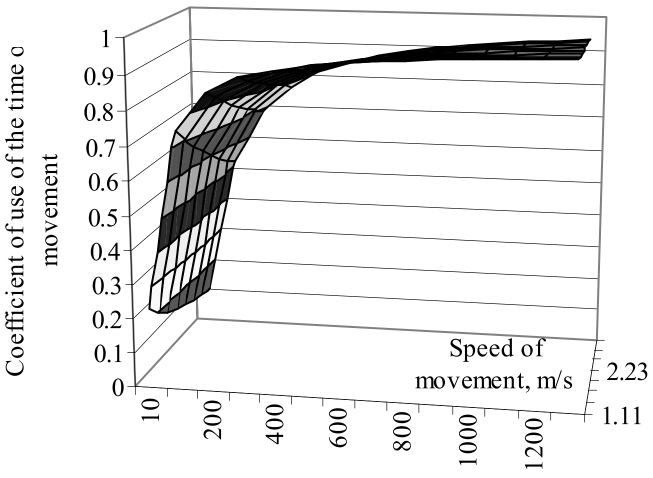

Fig. 1. Effect of movement speed of the aggregate and row length on the coefficient of use of the time of movement

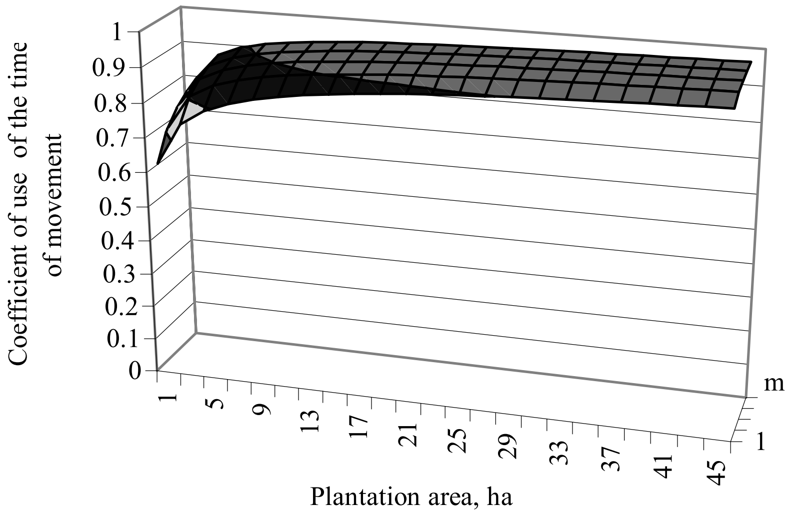

Fig. 2. Effect of ratio of plantation length to width and plantation area on the coefficient of use of the time of movement

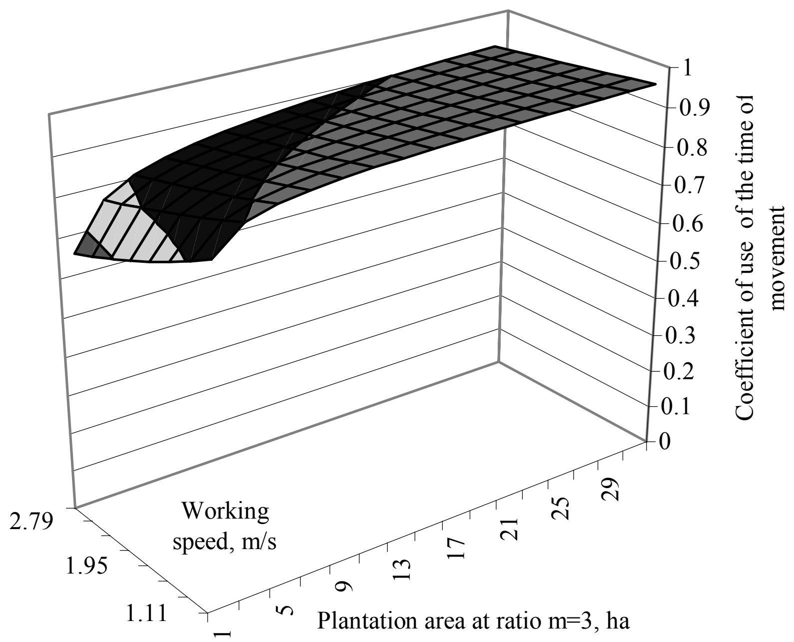

Fig. 3. Effect of movement speed of the aggregate and plantation area at ratio m=3 on the coefficient of use of the time of movement

tion of this surface at working speed of 1.95 *m/s* is shown in Figure 4.

The performed analysis confirmed the need of consideration of the effect of the factors on the coefficient of use of the time of movement of the aggregate and hence on the realized productivity.

Assessment of the extent of effect of the factors

On the basis of preliminary studies and analyses it was found that plantations of an area of over 0.5 hectares have economic importance. On the other hand, the sensitivity of variation of the variable costs decreases in plantations of an area over 32 hectares.

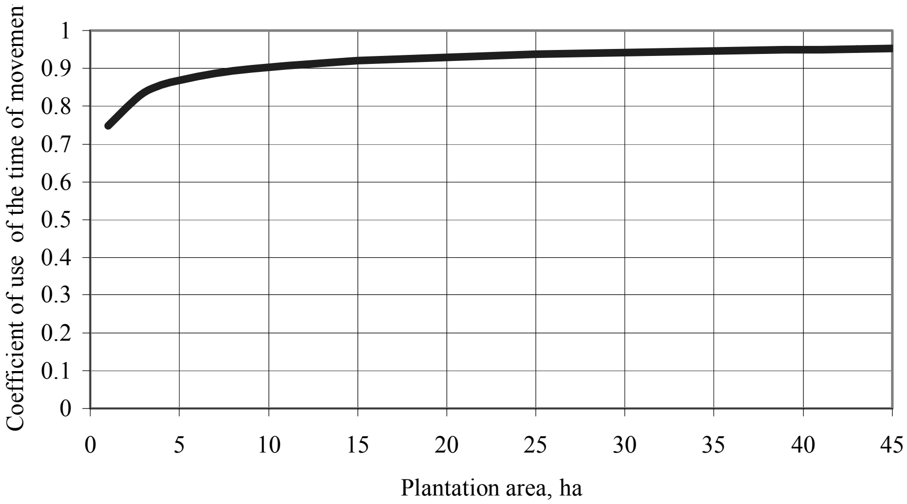

Fig. 4. Relation of coefficient of use of the time of movement to plantation area at ratio 3 of plantation length to width and working speed of 1.95 m/s

Proceeding from these prerequisites, the criterion G_f is introduced as a criterion for assessment of the extent of effect of the area:

$$G_f = \frac{R_{05} - R_{32}}{R_{32}} 100$$

For assessment of the effect of the other factors: an analogous criterion calculated at a plantation area of 32 *ha* and average level of the other factors is introduced:

$$G_i = \frac{R_{max} - R_{min}}{R_{min}} 100$$

Conclusion

A methodical approach and a well-founded formalized relation between the parameters of the grapevine plantations and the technological complex of machines and the conditions of their cultivation are suggested.Relations are suggested for determining the productivity during basic technological operations, their material provision, costs of fuel consumption and transport. It was found that the sensitivity of the variable costs decreased over 32 ha. A criterion of assessment of the extent of effect of the factors influencing the costs in wine grape cultivation is suggested on this basis.

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