Theoretical preconditions for determining the utilization coefficient of shift time when using planning machines

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Abstract. This article presents a set of works that must be performed to maintain the ecology of the soil in the process of planning by planning machines. The smoothness of the movement of agricultural machines is ensured by reducing the unevenness of the surface of the cultivated field. In these studies, it was noted that the utilization rate of the planning machine depends on the speed of the unit, the length of the field section, the time spent on eliminating technical malfunctions, etc. Taking into account the mathematical dependencies, the coefficient of utilization of the shift time in function depends on movement speed, working width and specific working conditions and the value of the actual productivity of the planner per hour of shift time. The capacity of the planner was calculated according to the equation proposed by the researchers of this article, and does not differ much from the unit performance obtained during field tests, and the percentage of difference is 5 ... 6%. Therefore, the results of this work can be used for preliminary design and kitting-up of machine-tractor units for planning works of pre-sowing background of irrigation agriculture.

1 Introduction

Careful planning of great importance on saline lands [1]. High efficiency is achieved when washing irrigation on planned saline lands. Due to the equal distribution of the rinsing water on the leveled surface of the sites, the identical effect of washing the soil over the entire area of the field is ensured. Approximately half the amount of rinsing water is used on soil washing in such areas, while labor costs for cutting and leveling the rollers are reduced by two times due to an increase in cotters and a significant decrease in the height of the rollers. At the planned sites, the cost of installing a temporary irrigation network is reduced by 1.9 times, the usable area is freed up to 4.6% and the productivity of tractor units is increased.

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2 Materials and methods

The article mentions the method of theoretical research to determine the optimal values of the coefficients depending on the working time of the shift of earth-moving machines by the method of mathematical planning of experiments [2, 3].

As shown by an experimental field test of the planner on the fields of the farm "Rakhim bobo" of Gijduvan area of Bukhara region, their real operational actual productivity differs by 10....20% from the earlier derived equation of theoretical productivity. Therefore, the researchers of "Irrigation and mechanization of agricultural production" Department made an attempt below to determine the theoretically actual productivity taking into account the coefficient of utilization of shift time (τ)from the previously derived equation for the theoretical performance of the planning machine

The coefficient of utilization of the shift time is influenced by many factors, the main of which are:

- the movement speed of the unit, the length of the working sections of the field, the time spent on troubleshooting technical malfunctions, etc.

To consider the influence of these factors, we express the coefficient of utilization of shift time through the network time T_p and the total time T_{ha} per hectare of processed area, i.e. [4-7].

$$\tau = \frac{T_{pha}}{T_{ha}} \tag{1}$$

Working time for the planning machine is determined

$$T_{pha} = \frac{1}{W_m}; \tag{2}$$

where, W_m- theoretical productivity per hour of net work, per / hour.

The total processing time of one ha (T_{ha}) can be expressed as:

$$T_{ha} = T_{opha} \frac{T_{cm}}{T_{op}} \tag{3}$$

where $T_{op\,ra}$ - operational time for processing 1 ha / hour:

T_{cm} – shift time, hour;

T_{op} - operational shift time, hour.

Time T_{opha} is determined as:

$$T_{opha} = T_{p\,ha} + T_{ha} + T_{per\,ha} + T_{ro\,ha} \tag{4}$$

Here T_p, T_{pov}, T_{per} accordingly, the elements of the time spent on processing 1 ha of working time are turnaround time, travel time and maintenance time. The operational shift time is determined as:

$$T_{pov} = T_{cm} - (T_{mo} + T_{wiz}) \tag{5}$$

where T_{mo}, T_{wiz} - time spent during a shift for maintenance and physiological needs that are not directly dependent on the area being processed [8, 9].

After substituting into equation (1) the values of the input quantities from equation (2) and (3) we obtain:

$$\tau = \frac{T_{op}}{W_m \cdot T_{opha} \cdot T_{cm}}$$

Having replaced the input quantities by their values from equations (4) and (5), we have:

$$\tau = \frac{T_{cm} - (T_{mo} + T_{wiz})}{W_m (T_{pha} + T_{povha} + T_{perha}) T_{cm}} \tag{6}$$

In the resulting equation, the time $T_{p\,ha}$ is determined by equation (2), and the turnaround time $T_{пов\,ra}$ per one ha can be expressed in terms of the time of one turn t_{pov}, the working width B and the length of the working working stroke L with the following dependence:

$$T_{pov} = \frac{t_{pov}}{0.36 \cdot B \cdot L},$$

In this case, equation (6) takes the form:

$$\tau = \frac{T_{cm} - (T_{mo} + T_{wiz})}{W_m \left(\frac{1}{w_m} + \frac{t_{pov}}{0.36 \cdot B \cdot L} + T_{perha} \right) T_{cm}}$$

After the conversion, the resulting equation will slightly change:

$$\tau = \frac{1 - K_{mo} - K_{wiz}}{1 + V\left[\frac{t_{pov}}{3.6L} + 0.1B(T_{per})\right]} \qquad (7)$$

where $K_{mo} = \frac{T_{mo}}{T_{cm}}$; $K_{wiz} = \frac{T_{wiz}}{T_{cm}}$ coefficients taking into account the time spent on shift maintenance and physiological needs.

T_{mo} and T_{wiz} – proportional shift duration.

V - progressive working speed of the planning unit, km/h;

T_{pov} - duration of one turn, sec;

L, B- working stroke length and working width, m;

T_{perha} - travel time per 1 ha, sec.

The turn time of the unit depends on the movement speed at turn and the length of the path:

$$t_{pov} = \frac{3.6 \cdot l_n}{V_n}, \qquad (8)$$

where l_n - the length of the turn, taking into account the exit and arrival of the unit, m;

V_n - progressive movement speed at turn, km/h.

The length of the path at turn depends on the radius of turn of the unit, the value of which is affected by the speed of movement, working width, surface conditions of the turn patch, etc. and can be represented by an equation of type [10]:

$$l_n = a_1 + b_1 V_n + c_1 V_n^{d-1}, \qquad (9)$$

where a_1, b_1,c_1, - coefficients determined by experimental material.

After substituting in equation (8) the values from equation (10), the time of turn of the unit is expressed:

$$t_{pov} = 3.6 \left(\frac{a_1}{V_n} + b_1 + c_1 V_n^d \right),$$

Investigating the obtained function to an extreme, using the known method of differentiation we obtain the optimal speed of the long-base planner at the turn from the condition of minimum time consumption at the turn

$$V_{nonm} = \sqrt[d]{\frac{a_1}{c_1(d-1)}} \qquad (10)$$

If V_{nonm} significantly different from V, then the additional time spent shifting gears should be taken into account and the expediency of switching to the optimal turning speed should be determined.

The total travel time of the long-base planner-perga includes the time spent on moving the perga and transferring the unit to the transport position and vice versa, i.e. preparatory-final time. Travel time per 1 ha may be presented as:

$$t_{perha} = \frac{10^4 \cdot t_{per}}{c \cdot L \cdot 60} = \frac{\frac{l_{per} \cdot 10^4 \cdot 60}{V_{per} \cdot 10^3}}{K_c \cdot L^2 \cdot 60} = \frac{10 \cdot Kn}{Kc \cdot L \cdot V_{per}},$$

where $K_c = \frac{c}{L}$; $K_n = \frac{l_{per}}{L}$ - proportionality coefficients, which are independent of the working width and the movement speed of the unit;

t_{per} - the duration of one move, min;

B, L - width and length of working site of the field, m;

l_{per} - length of the unit moving path from site to site of the field, m;

V_{per}- constant speed of the unit when moving, km / h. Similarly, preparatory - final time can be expressed:

$$t_{pzha} = \frac{10^4 \cdot t_{pz}}{60 \cdot C \cdot L} = \frac{10^4 \cdot t_{pz}}{60 \cdot Kc \cdot L^2}, \text{hour/ha}$$

where t_{pzha} - time spent on transferring the unit to the transport position and back, min.

Finally, the total travel time of the planning unit relating to one ha, taking into account the obtained dependencies, will be expressed:

$$T_{perha} = \frac{10 \cdot Kn}{Kc \cdot L \cdot Vnep} + \frac{10^3 \cdot t_{n3}}{6 \cdot Kc \cdot L^2} = \frac{10}{Kc \cdot L}\left(\frac{Kn}{Vnep} + \frac{10^2 \cdot t_{n3}}{6 \cdot L}\right), \text{hour/ha} \qquad (11)$$

For the fully calculation for the possible elements of the cost of the shift time, it is necessary to introduce into equation (6) and (7) the time spent on eliminating technical malfunctions $T_{mнha}$ per one ha, which can be determined from the equation of the operational reliability coefficient:

$$K_{ен} = \frac{T_p}{T_p + T_{mнha}}$$

To do this, we present the total time for eliminating technical malfunctions during the shift of $T_{mн}$ in the following form:

$$T_{mн} = T_{mнha} \cdot w_m \cdot Tp = T_{mнha} \cdot 0{,}1VBTp$$

when

$$K_{эн} = \frac{Tp}{Tp + T_{mнha} \cdot 0{,}1BVTp} = \frac{1}{1 + 0.1BVT_{mнha}}$$

Solving the obtained equation with respect to $T_{mн\,ha}$, we find

$$T_{mнha} = \frac{1 - K_{ен}}{0{,}1BVK_{ен}}, \text{hour/ha}$$

where, $K_{ен}$ – coefficient of operational reliability of the unit, for our case can be represented

$$K_{ен} = K_{енm} \cdot K_{енn}$$

$K_{енm}$, $K_{енn}$ - accordingly, the coefficients of operating reliability of the tractor and the planner.

Depending on the speed of translational movement of the planning unit (up to 10 km/h) [11], these coefficients, as shown by our studies and analysis of works, vary slightly and with some approximation can be taken constant.

Taking into account the above mathematical dependencies, the coefficient of utilization of shift time in function of the movement speed, working width and specific working conditions can be presented in the following form:

$$\tau = \frac{1 - K_{my} - Kf}{1 + v\left\{\frac{tpov}{3,6L} + 0.1B\left[\frac{10}{KcL}\left(\frac{Kn}{V_{per}} + \frac{10^3 t_{nz}}{L}\right) + \frac{1 + K_{ен}}{0,1BVK_{ен}}\right]\right\}} \qquad (12)$$

Multiplying the expression of theoretical productivity (w_m) derived in article [1] by expression (12) we obtain the value of the actual productivity of the planning unit in an hour of shift time:

$$Wч(v) = Wm(v) \cdot \tau = w_t \cdot x \frac{1 - K_{my} - Kf}{1 + V\left\{\frac{tpov}{3,6L} + 0.1B\left[\frac{10}{KcL}\left(\frac{Kn}{V_{per}} + \frac{10^3 t_{nz}}{L}\right) + \frac{1 + Ke_{н}}{0,1Bе_{н}}\right]\right\}} \qquad (13)$$

3 Results and discussion

The obtained dependences allow us to determine the actual hourly productivity of the planned unit.

The calculated capacity of the planning unit according to the proposed expression (13) almost does not differ from the capacity of the unit obtained during operation-field tests; the difference in percentage is 5÷6% [12, 13].

According to the obtained equation, the dependences of the coefficient of utilization of shift time as a function of the movement speed of the planner and the length of the rut with different working widths are formed up (Figures 1 and 2).

Analysis of the graphs (Figures 1 and 2) shows that with an increase in the movement speed of the planning unit τ decreases in the direction of parabolic dependence, and with an increase in the length of the rut τ increases. An increase in the working width as seen from the graphs (Figures 1 and 2) decreases τ.

Knowing the influence of considered factors on the change of coefficient of utilization of shift time, we can determine the shift hourly productivity of the planner at different rut lengths depending on the working width and movement speed [14].
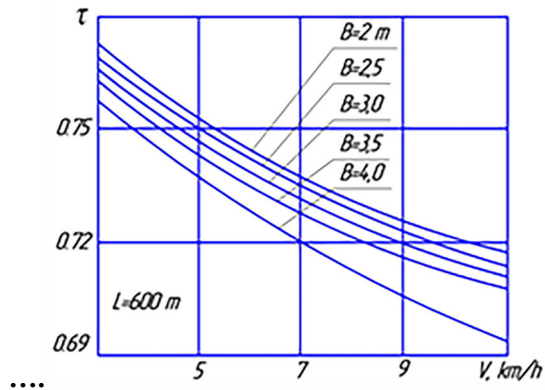

Fig. 1. Change in the coefficient of utilization of shift time depending on the movement speed of the grasp width.
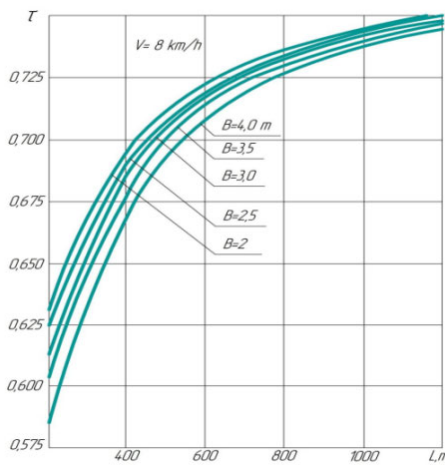

Fig. 2. Change in the coefficient of utilization of shift time τ depending on the length of the rut and the grasp width B.
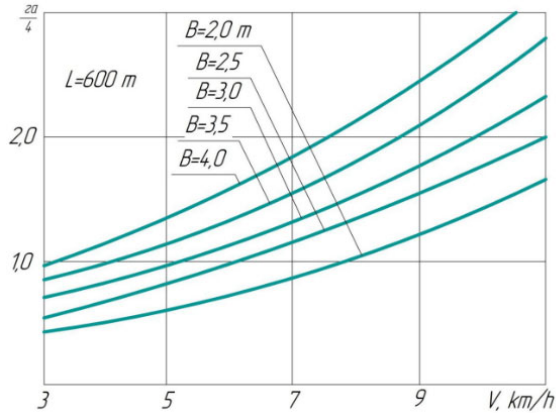
Fig. 3. Change in productivity depending on the movement speed of the grasp width B.
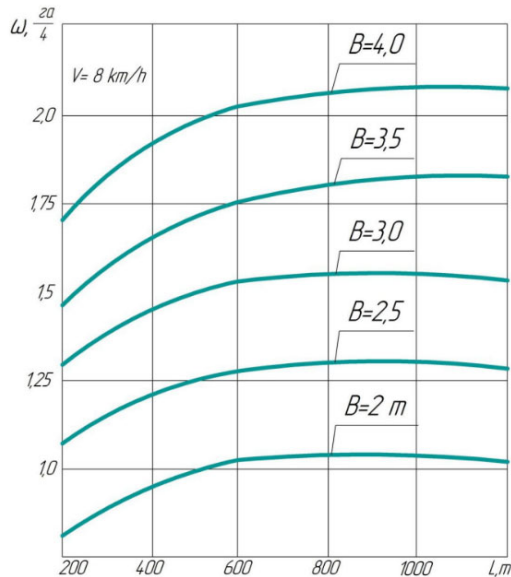

Fig. 4. Graph of the dependence of the width of the grip and the length of the head of the planer on productivity.

4 Conclusions

Analysis of the graph (Figure 3) shows that with an increase in the grasp width and the movement speed, the productivity of the unit increases. In addition, according to the graph (Figure 4), it can be seen that increasing the length of the rut to 600 meters increases the productivity of the unit. At L=600-100 m, productivity is almost unchanged. With a further increase in L, a decrease in productivity is observed.

According to the results of the research, the performance of the planning machine makes it possible to increase the efficiency of work performed throughout the year. The smaller the working width of the planning unit, the lower the productivity. The use of planning machines on large areas ensures high economic efficiency.

References

1. I. Khudaev, J. Fazliev, Modern Innovations, Systems and Technologies **2(2)**, 0301-0309 (2022). https://doi.org/10.47813/2782-2818-2022-2-2-0301-0309

2. O. Akramova, Informatics. Economics. Management **1(2)**, 0208-0216 (2022). https://doi.org/10.47813/2782-5280-2022-1-2-0208-0216

3. D. Kovalev, M. Kozlova, O. Olshevskaya, T. Mansurova, Modern Innovations, Systems and Technologies **1(3)**, 1-21 (2021). https://doi.org/10.47813/2782-2818-2021-1-3-1-21

4. S. N. Norov, A. S. Abrorov, M. F. Hamroeva, S. F. Muxamedjanova, G. B. Zaripov, Journal of Physics: Conference Series, **1515(4)**, 042016 (2020)

5. I. Hasanov, P. Khikmatov, News of Tashkent State Technical University **2**, 80-83 (2006)

6. I. Hasanov, *Justification of the main parameters of the scheduler for working in small areas* (Yangiyul, 1994)

7. I. Hasanov et al, *Theoretical preconditions for determining the maximum productivity of planning machines,* Materials of the international scientific and practical conference, May 26-28, Ulyanovsk, 121-125 (2009)

8. A. Tukhtakuziev, *Research and justification of the parameters of the tooth harrow for working at high speeds in the cotton growing zone* (Tashkent, 1979)

9. B. A. Lintvarev, *The scientific basis for increasing the productivity of agricultural units* (Moscow, 1962), pp. 131-150

10. A. Teshabaev, *Substantiation of the operating mode and operating time parameters of the ripper of the combined planning unit* (Yangiyul, 1993)

11. M. Akhmedzhanov, Yu. Shalyagin, Issues of mechanization and electrification of agriculture **6**, 185 (1989)

12. D. Abduvakhabov, *Development and parameterization of gear harrow adapted to field terrain* (New Year, 2018)

13. H. Gaffarov, Sh. Sadullaev, Galaxy international interdisciplinary research journal **(9(12)**, 2347-6915 (2021)

14. P. Hikmatov, *Research of qualitative and technological indicators of the work of a long-base planner in order to substantiate the optimal capture width and movement speed* (Tashkent, 1978)

15. B. Vasiliev et al, *Ameliorative machines* (Kolos, Moscow, 1980)