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Production Systems

Operational characteristics of a machine-tractor unit for direct sowing of barley using the JD LINK telematics system

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Abstract. *A study has been conducted for some operational indicators of a machine-tractor unit (MTU) for direct sowing of barley. The data for this study has been collected and retrieved by using the JD Link telematics system from two different fields sown with barley: field A with irregular shape and area of 13.75 ha and field B with rectangular shape and area of 16.26 ha. It was found that for both fields the values for the most monitored parameters were very close as follows: for the engine speed of the sowing unit during working stroke - 1553.65 min^{-1} (A) and 1586.11 min^{-1} (B) (the difference is <2.08%); for the idle mode of the sowing unit - 900.08 min^{-1} (A) and 905.63 min^{-1} (B) (the difference is <0.62%); for the actual working speed - 9.97 km/h (A) and 10.16 km/h (B) (the difference is <1.9%), registered when the MTU is performing the technological operation "sowing"; those parameters of MTU are nor influenced by the field size and shape. Larger differences in values between the two fields were established in terms of the relative share of engine used - 19.98% (A) and 21.55% (B) (the difference is <7.3%) and for the consumed diesel fuel (in field A it was 7.2% liters higher than in field B, respectively, 11.7% higher referring to the average diesel fuel consumption - liters per hour). The actual hourly productivity in field A was 20% lower than in field B - 3.05 vs 3.81, which is due to the fact that in the field with irregular shape - A the sowing unit made more turns at the end of the levels than in the field with rectangular shape - B.*

Keywords: direct sowing, machine-tractor unit, fuel consumption, idle mode sowing time, operation speed at sowing, telematics system

Introduction

In agriculture, a universal sowing technique is applied-after plowing, after cultivation or directly on the stubble (direct sowing). The sowing units need to ensure high-precision execution of the technological processes, as the yield is dependent on two factors, the first one being complying with the sowing norm; and the second one - the even planting of the seeds in depth in the soil. In this regard, the further implementation of intelligent and automated systems, robotics, logistics, including the widespread use of electronics and precision farming systems are becoming increasingly important (Trubilin and Brusentsov, 2019). The use of these methods ensures the correct planting of the seeds under different conditions with high working speeds and low traction forces of the agricultural unit (Mitev et al., 2019).

In recent years, the direct sowing drills have been making their way into the world practice. They can perform several operations simultaneously - tillage, sowing, fertilizing and rolling. Therefore, the mechanical treatments used in conventional crop production technologies are avoided. Thus, these changes will lead to an improvement in the structure of the layers of the soil and an increase in the natural fertility of the soil. In addition, the mulched surface retains moisture better and prevents soil erosion (FAO, 2014; Drydiger, 2016). Minimizing tillage with the *No-Till* system reduces operating and labor costs for planting and crop care while there are no losses of yield, in contrast it actually increases the profitability (Kolev, 1999; Mitev et al., 2019).

The increasing number of electronic devices, for control and regulation, in the field of agricultural machinery leads to the facilitation of farmers. Through them, in addition to monitoring and optimizing the operating parameters, you can monitor the operating speed, engine characteristics, cultivated areas and fuel consumption (Mitev et al., 2019).

Ivanishin et al. (2006) established that the reduction of labor costs is also significant. According to other authors (Chervet et al., 2007), about 50% of crossings are saved and the condition of the soil is significantly improved (MTU).

Bora et al. (2012) proves that 27% of the farms that have used automatic control systems, are reducing machine time by 5.75% and fuel consumption by 5.33%. According to Muazu et al. (2015), when sowing crops, fuel consumption is 1.10 *l/h*. Other authors (Marakglu and Carman, 2012) found that in

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direct sowing of wheat fuel consumption is lower by 10.7 *l/h* compared to if the crop is sown after pre-treatment of the soil. Köller (2003) finds that direct sowing saves about 73% of fuel consumption compared to the conventional sowing method. From the studies related to the influence of electronic control and regulating devices in the field of agricultural machinery and especially in the machine-tractor units for direct sowing, it can be noted that they play an important role in precise seed sowing (Mitev et al., 2019).

The objective of this paper is to study of the operational characteristics of a machine-tractor unit (MTU) for direct sowing of barley using the *JD LINK* telematics system.

Material and methods

The study was performed by direct sowing of barley (*Tipi* variety) with a *Horsch Avatar 6.16 SD* direct seed drill, aggregated to a *John Deere 7250 R* tractor on two fields on leached resin soil type. Table 1 presents the technical characteristics of the seed driller.

Table 1. Technical characteristics of the driller *Horsch Avatar 6.16 SD*

Basic technical characteristics	Value
Working width, *m*	6.00
Transport width, *m*	2.98
Transport height, *m*	3.36
Length, *m*	6.64
Weight, *kg*	9300
The capacity of the seedbox, *l*	5000
Height of filling of the seedbox, *m*	3.32
Number of sowing boots, *pcs.*	36
Sowing section pressure, *kg*	250
Sowing boots, *pcs.*	48
Closing rollers, *cm*	33
Depth guide rollers, *cm*	40
Line spacing, *cm*	16.7
Tire size	600 55 ÷ 26.5
Range at speed for work, *km/h*	6 ÷ 15

For the purpose of the study two fields - *A* with irregular shape and area of 13.75 *ha* and *B* with rectangular shape and area of 16.26 *ha* were used (Figures 1 and 2). Both fields were sown with winter barley of the *Tipi* variety with equal sowing rate of 200 *kg/ha*.

Figure 1. Map and agronomic data for field *A* - 13.75 *ha*

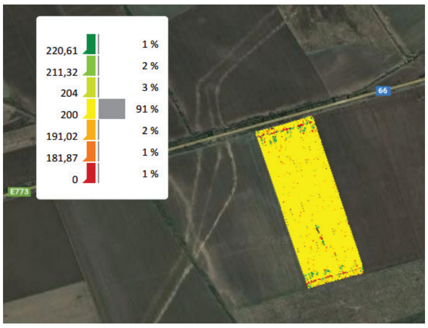

Figure 2. Map and agronomic data for field *B* - 16.26 *ha*

The study of field characteristics, agronomic data and barley sowing performance were taken from the *JD Link* telematics system.

The actual hourly productivity when using the total sowing time for both fields is determined by the dependence:

$W = S / T_o$, *ha/h*,

Where: *S* is the sown area, *ha*;

T_o - total sowing time, *h*.

Results and discussion

On Figures 1 and 2 are given the maps with the agronomic data for the two experimental fields (*A* and *B*) in the direct sowing of barley. The analysis of the data obtained shows that 89% of the area in field *A* and 91% in field *B* are sown with the set sowing rate of 200 *kg/ha*. It is evident that the deviation from the sowing norm in field *A* is 11%, and in field *B* is 10%. In both fields 6% of the area is sown with a higher sowing rate (>200 *kg/ha*), which is due to replanting at the end of the levels. These results show that regardless of the different shape of the two fields - irregular for field *A* and rectangular for field *B*, the area to be replanted is the same. Therefore, the field shape as a factor does not affect the area size which needs to be replanted.

The size of the areas with lower sowing rate than the norm (<200 *kg/ha*) - 5% of the total area of field *A* and 4% of the total area of field *B* is due to the places where the sowing unit makes turns at the end of the levels which is accompanied by switching on and off the pneumatic seed drill. The irregularly shaped field *A* has sowing rate 1% higher compared to the rectangular field *B*. Although the values difference on this indicator between the two fields is insignificant, it can be assumed that in the case of irregularly shaped fields the deviation from the sowing rate will be greater than in the case of correctly shaped fields. Future research would confirm or refute this assumption.

Table 2 presents some agronomic data and indicators for direct sowing of barley in both fields. The data shows that the actual sown amount of seeds in the two fields are almost equal - 198.59 *kg/ha* in field *A* 198.80 *kg/ha* in field *B*. The sowing rate of the two fields were by about 1% less than the set norm (200 *kg/ha*). Based on that, it can be concluded that the size and shape of the field do not affect the sowing rate. Arifa and Oleh (2018) established deviation of the practical seed sowing from a given norm ranged from 1.9% to 2.9%, which does not exceed the allowable values of agrotechnical requirements (3.0%).

Table 2. Agronomic data and indicators for direct sowing of barley of variety *Tipi*

Agronomic data and parameters	Field	
	A	*B*
Mean input rate, *kg/ha*	198.59	198.84
Total amount used, *kg*	2730.66	3232.59
Planned rate, *kg/ha*	200	200
Planned final amount, *kg*	2750.06	3251.52
Cultivated area, *ha*	13.75	16.26

Table 3 presents the results for some operational characteristics and indicators of the sowing unit in different modes of operation of the engine. The engine speed of the sowing unit during working stroke is almost equal for both fields - 1553.65 min^{-1} (*A*) and 1586.11 min^{-1} (*B*) (the difference is <2.08%). Very similar results were established and for the speed of the engine at idle mode - 900.08 min^{-1} (*A*) and 905.63 min^{-1} (*B*) (the difference is <0.62%), as well as and for the relative share of engine use - 19.98% and 21.55%, respectively (the difference is <7.3%). Therefore, it can be concluded that the quoted engine parameters at idle mode are not affected by the shape and size of the cultivated field.

A larger difference in values was observed at the relative share of engine use (when the drill is in operation) - 52.36% for field *A* and 57.74% for field *B*. Similar results were obtained in previous studies by Tihanov (2020), who investigated the modes of operation of the engine and the performance characteristics of the machine-tractor unit in direct sowing of wheat.

From the results in Table 3 it can be seen that the actual working speed of the sowing unit during the process is also very close for both fields - 9.97 *km/h* for field *A* and 10.16 *km/h* for field *B*. Tihanov (2020) found that at direct sowing of wheat with the same MTU, the actual working speed is similar - 10.06 *km/h*.

Table 3. Performance characteristics and indicators of the sowing unit for direct sowing of barley

Operation parameters	Field *A*		Field *B*	
	in idle mode	in work mode	in idle mode	in workmode
Engine rotations, min^{-1}	900.08	1553.65	905.63	1586.11
The relative share of engine use, %	19.98	52.36	21.55	57.74
Working speed of the sowing unit, *km/h*	-	9.97	-	10.16

Figure 3 shows a graphical representation of the actual working speed of the sowing unit in field *A*. It can be seen that the actual speed varies from 6 *km/h* to 12 *km/h*. The lower speed is observed at the end of the field, where the sowing unit makes turns, and the higher working speed is when the sowing unit sows in the rest of the field.

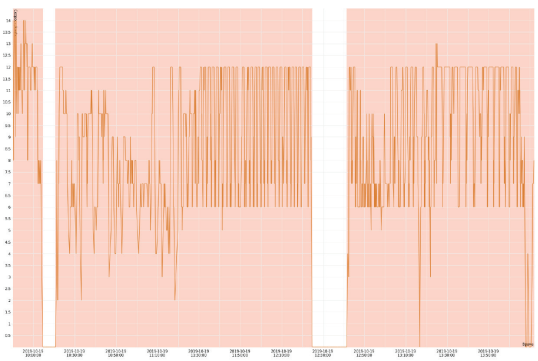

Figure 3. Working speed of the sowing unit in field *A*

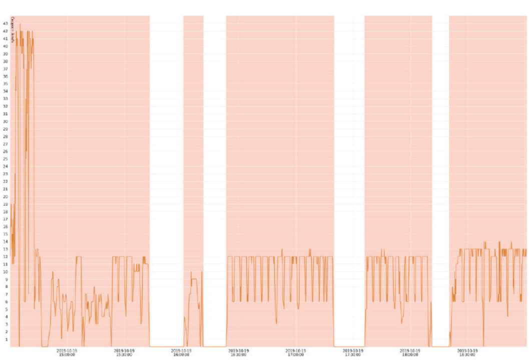

Figure 4. Working speed of the sowing unit in field *B*

Figure 4 graphically presents the actual working speed of the sowing unit in field *B*. The figure shows that the actual speed varies in the range from 6 *km/h* to 12 *km/h*, with the lower speed again at the end of the field and the higher working speed of 12 *km/h* in the rest of the field.

Therefore, the data from Figures 3 and 4 revealed that the actual operating speed in both fields varies in the same range - from 6 *km/h* to 12 *km/h*. Furthermore, from the two figures it can be seen that the speed change function is not typical, but random, and the only way to determine the effective or so-called actual operating speed is by integrating this function in the specified time range, through a certain integral in case of neglect of the initial and final technological processes.

Table 4 presents a summary of the results of the measurements of the fuel consumption of the sowing unit in the two modes of operation of the engine: at idle mode and with the engine running. Based on the results obtained we can summarize that the consumed diesel fuel in field *A* is 7.2% liters higher than in field *B*, respectively, 11.7% higher referring to the average diesel fuel consumption (liters per hour). These data clearly show that in the case of an irregularly shaped field, the fuel consumption - total liters and liters per hour - is higher than in a rectangular-shaped field. Tihanov and Ivanov (2021) found the lower average consumption of diesel fuel for direct sowing of wheat - 23.08 *l/h*, at a distance of 63 *km*.

Table 5 summarizes the results for the duration of the time for performing the technological operation "sowing" and the time for stay of the MTU. The last column of the table calculates the actual hourly productivity of the sowing unit using the total sowing time. The table also presents data for the actual hourly productivity of the sowing unit, which in field *A* is 3.05 *ha/h*, and for field *B* is 3.81 *ha/h*. It can be seen that productivity in field *A* is 20% lower than in field *B*. The higher productivity in field *B* (3.81 *ha/h*) compared to that in field *A* (3.05 *ha/h*) is due to the fact that in field *A* with irregular shape, the sowing unit makes more turns at the end of the field, loses more time for additional operations and the engine idle mode is longer than in field *B*.

One contradiction is also observed, in field *A*, with an irregular shape, the engine idle mode is 47% less than in field *B* with a rectangular shape (0.45 *h* vs 0.95 *h*). The logic suggests that the results must be with replaced position, because in the rectangular-shaped field (*B*) the stay of the MTU, respectively the speed of the engine at idle should be less than in the irregular-shaped field (*A*). We can assume that this contradiction is due to the different qualifications of the operators of the two MTU. Since this factor is not an object of this study a final conclusion cannot be made.

Table 4. Fuel consumption of the sowing unit at different operating modes of the engine

Exploitation indicators	Field *A*		Field *B*	
	in idle mode	in work mode	in idle mode	in work mode
Use of the sowing unit, *h*	0.45	4.05	0.95	3.32
Consumed amount of diesel fuel, *l*	1.79	95.37	4.16	88.51
Average diesel fuel consumption, *l/h*	3.97	23.54	4.37	26.66

Table 5. Operational parameters of the sowing unit for direct sowing of barley

Field	Cultivated area, *ha*	Duration of the sowing unit, *h*		Total sowing time, *h*	Actual productivity for total time, *ha/h*
		in work mode *T1*	in idle mode *T2*	T_O	
A	13.75	4.05	0.45	4.5	3.05
B	16.26	3.32	0.95	4.27	3.81

Conclusion

In accordance with the received data it can be concluded that: (i) 89% of the area in field *A* (13.75 *ha* with irregular shape) and 91% in field *B* (16.26 *ha* with rectangular shape) is sown with the set sowing rate of 200 *kg/ha*; (ii) for both fields (*A* and *B*), the following parameters were almost equal: the engine speed of the sowing unit during working stroke - 1553.65 min^{-1} and 1586.11 min^{-1} (the difference is <2.08%), the speed of the engine at idle - 900.08 min^{-1} and 905.63 min^{-1} (the difference is <0.62%), and the actual working speed of the sowing unit during sowing - 9.97 *km/h* and 10.16 *km/h* (the difference is <1.9%); the quoted engine parameters are not affected by the shape and size of the cultivated field; (iii) the relative share of engine use was 19.98% for field *A* and 21.55% for field *B* (the difference is <7.3%); (iv) the consumed diesel fuel in field *A* was 7.2% liters higher than in field *B*, respectively 11.7% higher referring to the average diesel fuel consumption (liters per hour); (v) the actual hourly productivity of the sowing unit was 3.05 ha/h for field *A* and 3.81 ha/h for field *B*, i.e. 20% lower; the higher productivity of field *B* compared to that of field *A* is due to the fact that in the field with irregular shape - *A,* the sowing unit made more turns at the end of the field compared with the field with rectangular shape - *B*.

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