EXPERIMENTAL RESEARCHES ON THE WORKING PROCESS OF A SEEDBED PREPARATION EQUIPMENT FOR HEAVY SOILS
/
CERCETĂRI EXPERIMENTALE PRIVIND PROCESUL DE LUCRU AL UNUI ECHIPAMENT DE PREGĂTIT PATUL GERMINATIV PENTRU SOLURI GRELE

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ABSTRACT

The paper presents the results obtained from experimental researches carried out under exploitation conditions in order to determinate the qualitative working indices of an equipment used for preparing the seedbed for heavy soils: the vegetal debris coverage degree and the soil crushing degree, as well as the energy indices: slipping, traction and fuel consumption, depending on the depth, soil moisture and working speed.

REZUMAT

Lucrarea prezintă rezultatele obţinute ca urmare a cercetărilor experimentale realizate în condiţîi de exploatare pentru determinarea indicilor calitativi de lucru ai unui echipament de pregătit patul germinativ pentru soluri grele: gradul de acoperire cu resturi vegetale şi gradul de mărunţire a solului, precum şi a indicilor energetici: patinarea, forţa de tracţiune şi consumul de combustibil, funcţie de adâncime, umiditatea solului şi viteza de lucru.

INTRODUCTION

Conservative soil cultivation works are an alternative to classical soil processing (ploughing) in the context of current drought-induced climate change. The use of the equipment for processing the seedbed for heavy soils is an alternative, this equipment being able to process the soils up to depths of 25-30 cm (*Budoi and Penescu, 1996; Constantin et al., 2008*).

Under the need to apply conservative tillage, it became widely used the cultivator, an equipment for conservative processing of soil that can also perform soil crumbling in a single pass (*Koloszvary*, *2008*).

The cultivator can be fitted with active bodies, type notched disks, chisel and levelling; of these types, the chisel type active bodies are subjected to an intense wear due to the shape that comes directly in contact with the soil, resulting in a high wear (*Constantin et al, 2012*). Such equipment for conservative processing of soil is designed as a complex aggregate, consisting of 4 modules with different active bodies, mounted one after another so that in a single pass to perform several operations which will ultimately lead to a high quality of soil processing (*Croitoru et al 2016; Vladuţoiu L. et al, 2017*).

This equipment must be checked and tested from the point of view of stress and strains distribution in the frame of agricultural cultivators using the finite element method (*Biriş et al, 2016*), of transportation stress of agricultural implements within laboratory (*Matache et al, 2016*), respectively of structural and kinematic analysis of the mechanism deep soil loosening (*Croitoru et al, 2017*), so that to enhance the performance of cultivators' working bodies (*Biriş et al, 2017*).

MATERIALS AND METHODS

The experimental researches for the determination of the qualitative and energetic indices with the soil processing equipment (seedbed preparation) in a conservative system, were made in the Zerind locality, Arad County (Fig. 1), about 12 km away from Chisinau Cris, on an area of about 30 ha, using a 250 HP tractor (Fig. 2). In order to determine the experimental data, a National Instruments acquisition system, tensometric marks, humidity meter, penetrometer, stopwatch, fuel consumption meter, furrowmeter, metric frame, 100 kg scale, bags and milestones were used (*Uceanu et al, 2008; Vlăduţ et al, 2012*).

Fig. 1 - Polygon 1 used for experiments (Zerind locality, Arad county)

Fig. 2 - Soil processing equipment working in a conservative system during experiments

RESULTS

- ***Soil moisture determination***

According to the working depth set for the experiments: 5 / 10 / 15 / 20 / 25 / 30 cm, the relative humidity of the soil (Fig. 3) was determined for these 6 horizons: 0 – 5 / 5 – 10 / 10 – 15 / 15 – 20 / 20 - 25 / 25 - 30 cm (Table 1).

Fig. 3 - Aspects during soil determination in the polygon used for experimentation

Table 1

Soil humidity depending on the depth of the horizons

SOIL HUMIDITY [%]											
Depth [cm]	**Sample**										***Average***
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
0 – 5	17.4	19.6	18.2	17.7	18.4	20.3	20	19	18.1	18.3	*18.7*
5 – 10	25.3	28.8	22.9	27.6	25.8	26.7	29.4	27	28.7	25.8	*26.8*
10 – 15	37.2	38.9	36.9	34.5	36.8	35.9	34.4	32.8	33.7	31.9	*35.3*
15 – 20	21.8	40.8	42.2	39.9	41.7	42.6	43.1	40.5	41.3	42.1	*39.6*
20 - 25	38.6	42.3	40.9	41.5	41.9	40.7	42.2	41.6	42.2	42.1	*41.4*
25 - 30	39.1	43	41.2	42.8	42.7	42.7	44.1	40.9	41.3	41.2	*41.9*

- ***Soil compactness determination (resistance to penetration)***

The soil compactness was determined, for the working depth of the equipment set between: 0…30 cm, (Fig. 4), Table 2.

Fig. 4 - Soil compactness determination (resistance to penetration) in polygon 1

Table 2

Compactness of the soil corresponding to the working depth of the equipment

Depth [cm]	SOIL COMPACTNESS [kPa]				
	Sample I	**Sample II**	**Sample III**	**Sample IV**	***AVERAGE***
2.5	1088	3054	1860	3025	*2256.75*
5.0	1369	2036	2212	2011	*1907.00*
7.5	1193	3265	1931	3210	*2399.75*
10.0	1334	4318	1966	4290	*2977.00*
12.5	2247	4213	1896	4280	*3159.00*
15.0	2387	3581	1899	3560	*2856.75*
17.5	1931	3511	1860	3480	*2695.5*
20.0	2071	3195	1755	3090	*2527.75*
22.5	1966	3300	1931	3281	*2619.5*
25.0	1755	2738	2001	2711	*2301.25*
27.5	1746	2685	1995	2657	*2270.75*
30.0	1723	2611	1952	2613	*2224.75*

Determination of qualitative and energetic indices

- ***Determination of the vegetal debris coverage degree***

This step has been done in order to identify the average values of the existing vegetal mass present on the soil surface per 1m^2, before (Fig. 5) and after the passing of the aggregate, and in order to check how the cultivator incorporates as much as possible of the vegetal debris into the soil (Table 3).

The existing vegetal mass on the soil surface (per 1m^2) before the passing of the aggregate

Existing soil mass on the soil surface (per 1m^2) after the cultivator-tractor aggregate has passed

Fig. 5 - Aspects on how to determine the degree of vegetal debris coverage

Table 3

Determination of vegetal debris coverage degree

A. BEFORE THE PASSING OF THE AGGREGATE						
Repetition 1 (kg/m^2)	**Repetition 2** (kg/m^2)	**Repetition 3** (kg/m^2)	**Repetition 4** (kg/m^2)	**Repetition 5** (kg/m^2)	**Repetition 6** (kg/m^2)	***AVERAGE*** (kg/m^2)
0.445	0.494	0.364	0.612	0.533	0.481	*0.488*
B: AFTER THE PASSING OF THE AGGREGATE						
Repetition 1 (kg/m^2)	**Repetition 2** (kg/m^2)	**Repetition 3** (kg/m^2)	**Repetition 4** (kg/m^2)	**Repetition 5** (kg/m^2)	**Repetition 6** (kg/m^2)	***AVERAGE*** (kg/m^2)
0.034	0.038	0.028	0.048	0.042	0.037	*0.0378*
Incorporation of plant residues degree						
92.36	92.31	92.31	92.16	92.12	92.31	**92.25**

- ***Determination of soil compactness***

  This step was done in order to determine how the working parts of the cultivator dislodge and crush the soil (Fig.6) in order to make a seedbed, as uniform as possible with the smallest bulges (Table 4).

Fig. 6 - Aspects on how to determine the degree of soil shredding

Table 4

Determination of soil compactness

Particle size [mm]	The grading degree by size [%]					
	Sample 1	**Sample 2**	**Sample 3**	**Sample 4**	**Sample 5**	***Average***
>100	8.20	5.90	6.93	8.54	6.23	*7.160*
>50	66.63	71.64	68.69	72.64	71.88	*70.296*
>20	22.66	21.02	23.01	23.15	22.88	*22.544*

- ***Determination of tractor slipping and fuel consumption***

The tractor slipping (Table 5) that occurs when the tractor is towing the cultivator while working is necessary to calculate the traction power requirement of the power source used (tractor). The average fuel consumption of the tractor, obtained by processing the 80 ha of scarified land (including double crossings at the ends of the plot and for turning at the end of the furrow, etc.), correlated with the working width of the equipment, speed and working depth, allows to determine cultivator productivity, which varies depending on working conditions: humidity, soil compactness, depth of work, etc. (*Uceanu et al, 2008*).

Table 5

Slipping of the tractor during the working process with the "DRACULA" cultivator

Slipping [%] [50 m]											
Sample 1		**Sample 2**		**Sample 3**		**Sample 4**		**Sample 5**		**AVERAGE**	
left	right	left	right	left	right	left	right	left	right	left	right
9.50	9.50	9.75	9.50	10.0	10.0	10.25	10.50	10.50	10.50	-	-
6.31%		7.54%		11.21%		14.22%		15.23%		*10.9%*	

- *Average fuel consumption: 25.81 l / ha*

In order to highlight the energetic indices according to the variation of the main working parameters: depth, speed and soil humidity, experiments were carried out following their variation: traction, slipping and fuel consumption (Table 6).

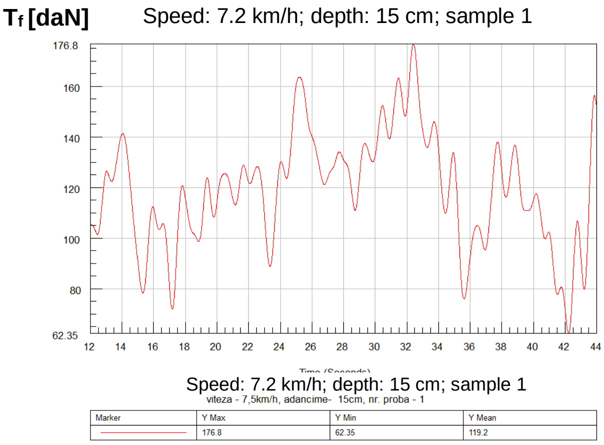
Table 6

Variation of the energetic indices depending on: depth and working speed, respectively soil humidity

Parameters		d_1 [5 cm]; S.U. = 18.7%				d_2 [10 cm]; S.U. = 26.8%				d_3 [15 cm]; S.U. = 35.3%			
		R1	R2	R3	*Average*	R1	R2	R3	*Average*	R1	R2	R3	*Average*
s_1 = 2 [m/s] 7.2 [km/h]	Slipping [%]	6.15	6.15	6.18	*6.16*	7.42	7.43	7.47	*7.44*	9.43	9.42	9.38	*9.41*
	Traction force T_r [daN]	100.3	100.8	100.1	*100.4*	108.9	101.2	105.8	*105.3*	119.2	114.3	116.7	*116.73*
	Fuel consumption [l/ha]	5.98	6.02	6.03	*6.01*	10.44	10.42	10.4	*10.42*	13.13	12.9	12.73	*12.92*
s_2=2.5 [m/s] 9 [km/h]	Slipping [%]	6.26	6.26	6.23	*6.25*	7.49	7.49	7.49	*7.49*	9.51	9.49	9.5	*9.5*
	Traction force T_r [daN]	102.48	102.89	101.96	*102.44*	110.22	105.77	107.46	*107.82*	118.95	121.35	119.24	*119.85*
	Fuel consumption [l/ha]	6.12	6.12	6.18	*6.14*	10.35	10.31	10.33	*10.33*	12.72	12.81	12.9	*12.81*
s_3 = 3 [m/s] 10.8 [km/h]	Slipping [%]	6.36	6.32	6.34	*6.34*	7.58	7.58	7.55	*7.57*	9.5	9.51	9.55	*9.52*
	Traction force T_r [daN]	103.95	104.12	103.98	*104.02*	112.87	111.56	111.21	*111.88*	122.33	124.01	121.89	*122.74*
	Fuel consumption [l/ha]	6.26	6.26	6.23	*6.25*	10.24	10.22	10.26	*10.24*	12.73	12.74	12.72	*12.73*
s_4=3.5 [m/s] 12.6 [km/h]	Slipping [%]	6.48	6.49	6.5	*6.49*	7.67	7.67	7.64	*7.66*	9.52	9.53	9.51	*9.52*
	Traction force T_r [daN]	105.21	106.03	104.32	*105.19*	114.34	114.88	113.98	*114.40*	122.33	124.01	121.89	*122.74*
	Fuel consumption [l/ha]	6.36	6.37	6.35	*6.36*	10.13	10.13	10.07	*10.11*	12.61	12.71	12.51	*12.61*

Parameters		d_4 [20 cm]; S.U. = 39.6%				d_5 [25 cm]; S.U. = 41.4%				d_6 [30 cm]; S.U. = 41.9%			
		R1	R2	R3	*Average*	R1	R2	R3	*Average*	R1	R2	R3	*Average*
s_1 = 2 [m/s] 7.2 [km/h]	Slipping [%]	11.07	11.09	11.08	*11.08*	14.3	14.1	13.9	*14.1*	15.07	15.08	15.12	*15.09*
	Traction force T_r [daN]	118.72	121.21	124.54	*121.49*	123.51	126.17	127.32	*125.67*	128.85	129.04	129.65	*129.18*
	Fuel consumption [l/ha]	25.42	25.44	25.4	*25.42*	21.67	21.67	21.64	*21.66*	26.1	26.1	26.1	*26.1*
s_2=2.5 [m/s] 9 [km/h]	Slipping [%]	11.16	11.16	11.16	*11.16*	14.19	14.19	14.16	*14.18*	15.19	15.21	15.2	*15.2*
	Traction force T_r [daN]	120.75	124.33	125.04	*123.37*	131.52	130.26	132.2	*131.33*	139.12	138.62	137.52	*138.42*
	Fuel consumption [l/ha]	17.6	17.52	17.56	*17.56*	21.42	21.42	21.45	*21.43*	25.81	25.83	25.82	*25.82*
s_3 = 3 [m/s] 10.8 [km/h]	Slipping [%]	12.27	11.27	11.24	*11.26*	14.25	14.27	14.29	*14.27*	15.28	15.27	15.29	*15.28*
	Traction force T_r [daN]	127.55	126.89	128.19	*127.54*	136.95	137.53	135.88	*136.79*	143.62	145.52	146.06	*145.07*
	Fuel consumption [l/ha]	17.49	17.5	17.45	*17.48*	21.33	21.32	21.34	*21.33*	25.69	25.69	25.72	*25.7*
s_4=3.5 [m/s] 12.6 [km/h]	Slipping [%]	11.35	11.35	11.32	*11.34*	14.33	14.33	14.33	*14.33*	15.36	15.36	15.33	*15.35*
	Traction force T_r [daN]	130.14	131.56	130.61	*130.77*	140.56	142.06	141.32	*141.31*	151.69	154.32	152.54	*152.85*
	Fuel consumption [l/ha]	14.4	14.41	14.45	*14.42*	21.28	21.27	21.223	*21.26*	25.6	25.63	25.63	*25.62*

s-speed; d-depth; S.U.-soil humidity; R-repetition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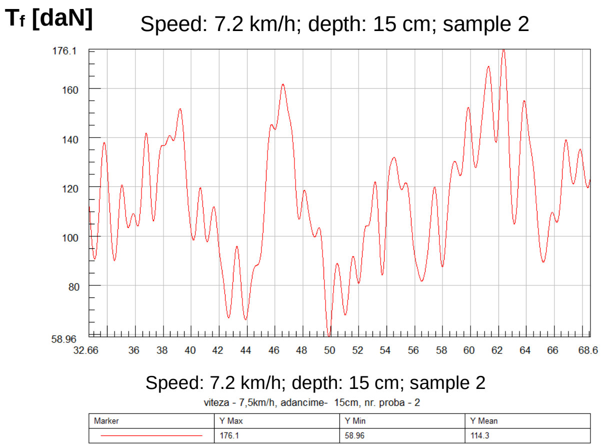
Y Mean 119.2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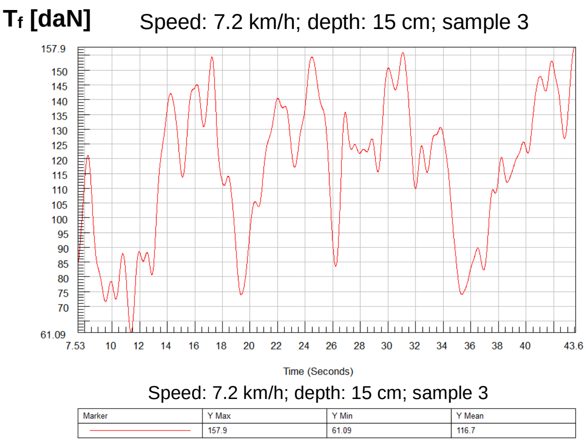
Y Mean 114.3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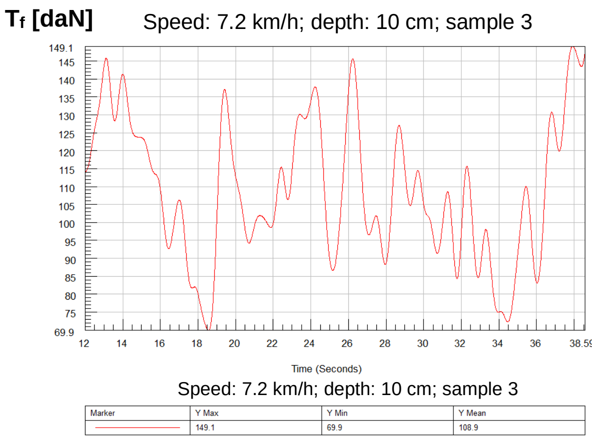
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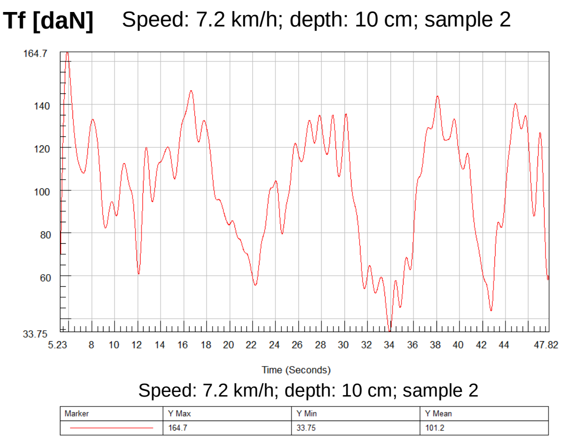
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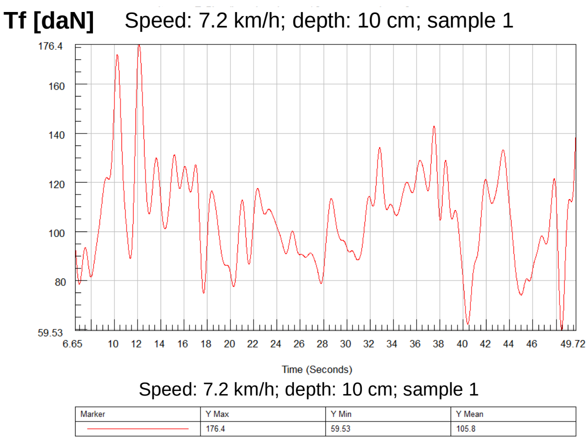
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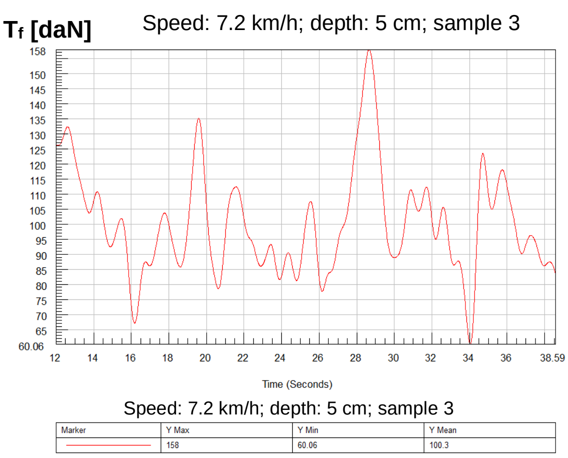
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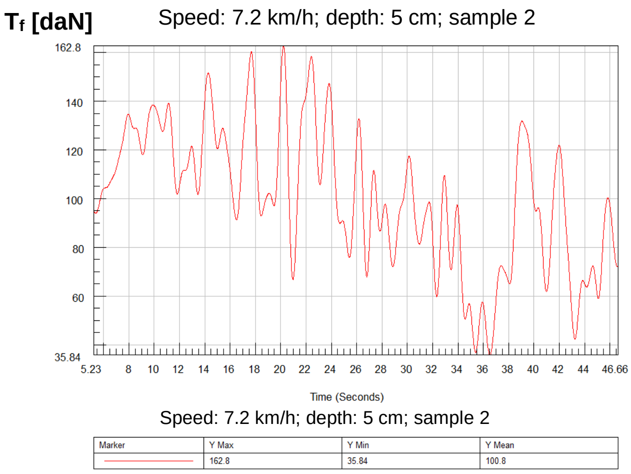
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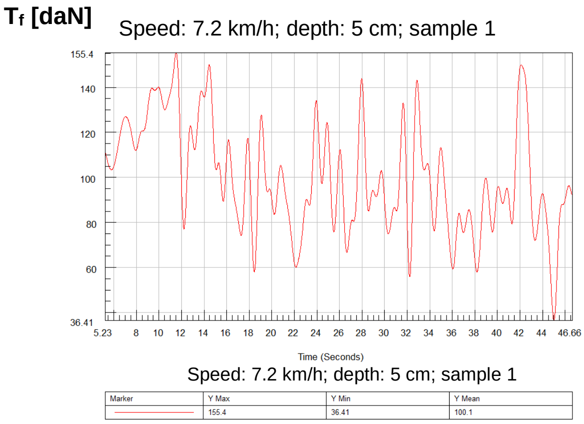

CONCLUSIONS

Soil humidity and compactness are two very important factors that have a great influence on the data obtained while determining the qualitative working or energetic indices of the “DRACULA” cultivator, because any variation of one or both of these factors leads to variations in measured data, as a result of the experimental research and implicitly of the obtained results.

That is why it is very important that the qualitative and energetic indices determined for the tractor unit + DRACULA cultivator to be accomplished within a short period of time (maximum 3-4 days) on the same site (plot), and also, during this experimental period no variations were accepted (precipitations) because they have the ability to change the input parameters (soil humidity and compactness) and therefore the measured output data will not be comparable to those measured prior to the occurrence of these improper conditions.

The experimental researches presented in this report respected these conditions and by analysing the data obtained it is observed that:

- soil humidity determined on 6 horizons (0 – 5 / 5 – 10 / 10 – 15 / 15 – 20 / 20 – 25 / 25 - 30 cm), corresponding to the working depths previously defined, varies with depth, growing with it;
- the soil compactness (penetration resistance) for the depth of 0 ÷ 30 cm (the maximum working depth of the cultivator) increases with the depth (not uniformly due to the inhomogeneity and unevenness of the soil) reaching a maximum of 12.5 cm, after that it decreases continuously, (in these horizons the humidity is higher and the soil is not as rough);
- the vegetal debris coverage degree of the soil after the passing of the aggregate (incorporation of vegetal debris into the soil) by the active parts of the "DRACULA" cultivator is very good (92.25%), since this equipment does not overturn the soil;
- the soil grinding degree made by the "DRACULA" cultivator has a comparative value with those made by the other seedbed preparation equipment (disc grabs, tines, etc.), the results obtained with this equipment were made on a land that has been unprocessed for 20 years and scarified, so under very difficult working conditions; unlike conventional bedding equipment, this cultivator is normally used directly in non-terrain (conservative soil treatment system);
- among all the determined energetic indices, the slipping and tensile strength (for different working speeds and depths, respectively humidities) had increasing values with increasing working depth and humidity, respectively working speed, but fuel consumption decreased with the increasing of the working speed and increasing of the working depth, while soil moisture had higher values.

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