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Degree of Influence of the Lid Angle over Soil Sputtering and Disintegration by a Tiller

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Abstract

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It is known that the process of soil disintegration by a tiller undergoes two stages - cutting of the cultivable soil layer by the spuds and throwing back the soil aggregates, upon which a great part of them hit the tiller lid. The degree of soil disintegration can be estimated mainly by the working mode of its working organs.

The tiller lid is used as a means for levelling the soil surface. It has been established that 30-70% of the energy in tilling is used for throwing back and additional disintegration.

The lid of the soil-cultivating tiller has a significant impact over the sputtering and disintegration of the soil. Its degree of influence is equal to the degree of influence of the advancing speed, which for the soil sputtering is from 15.70 to 30.22%, and for the soil disintegration - from 27.90 to 28.92%. This influence is bigger than the impact of the working depth and the drum rotation frequency. The form of this influence is close to the one represented by the drum rotation frequency. For this reason, it is an important characteristic feature for the improvement of the technological result.

Key words: lid angle, soil sputtering, disintegration, tiller

Introduction

It is known that the process of soil disintegration by a tiller undergoes two stages - cutting of the cultivable soil layer by the spuds and throwing back the soil aggregates (Daskalov, 1975; Mandradzhiev, 1982; Sednev, 1978), upon which a great part of them hit the tiller lid. The degree of soil disintegration can be estimated mainly by the working mode of its working organs, which is typical of the first working stage. The technological upgrading of the tillers is mainly in this direction.

The tiller lid is used as a means for levelling the soil surface. It has been established that 30-70% of the energy in tilling is used for throwing back and additional disintegration (Conoval, 1986).

The purpose of the present research is to determine the degree of influence of the sloping angle of the tiller lid, in relation to the vertical line, over the sputtering and disintegration of the soil, as well as to compare it with the impact of the basic factors connected with the working mode.

Material and Method

The research has been carried out on maroon-forest soil, using soil-cultivating tiller FN-0.76, aggregated by tractor MTZ-80.

In order to compare the degree of influence of the individual factors, the methodology of the multifactor experiment has been applied, including the following factors: advancing speed *Vm*, frequency of the tiller drum rotation *n*, sloping angle of the tiller lid, in relation to the vertical line, working depth *a*.

The quantity of the aggregates has been determined with size up to 1 mm- P_{0-1} and those with size from 1 to 10 mm - P_{1-10}. The overall appearance of the experimental site has been selected in accordance with the requirements of the methodology.

Results and Analysis

The soil dampness during the experiments for the 12 cm layer is 13.09 to 21.11% on the average, whereas it is lower for the surface layer. It is 3% higher in the afternoon than in the morning, due to the higher dampness during the last day of the experiments. Therefore, it can be taken that the dampness was constant during the experiments.

The soil hardness is lower in the surface layer from 31 to 80.5 $N.cm^2$. The average values of the soil hardness during the period of the experiments differs maximum by around 38%.

The experiments have been set up according to the accepted values of the factors on the different levels (Table 1).

The average values of the sputtering P_{0-1} and disintegration P_{1-10} are given in Table 2.

Soil sputtering. The mathematical model for the soil sputtering

Y_{P0-1} is represented by the following regressive equation:

$$Y_{P0-1} = 18.70-1.82X_1-2.93X_3+2.43X_4+1.43X_2X_3+2.26X_3X_4-3.05H_4^2 \quad (1)$$

$$F = 19.88>2.66 = FT$$

The mathematical model for the soil sputtering Y_{P0-1} , according to (Mitkov and Minkov, 1993), is adequate, because the estimated Fisher's criterion $F > F_T$.

The change of the soil sputtering at the different levels of the remaining factors is graphically shown on Figure 1.

Table 1

Values of the levels of the investigated factors in maroon - forest soil

Vakues	Factors							
	Natural				Encoded			
	V_m, m/s	a ,o	a , cm	n , min^{-1}	X_1	X_2	X_3	X_4
Average level	1.097	0	0	220.87	0	0	0	0
Interval of variation	0.403	45	3	93.55	1	1	1	1
Upper level	1.5	45	12	314.42	1	1	1	1
Lower level	0.694	-45	6	127.32	-1	-1	-1	-1

Table 2

Average values of the sputtering and disintegration of maroon - forest oil

Experiment	Factors							
	V	*a*	*a*	*n*	P_{0-1}, %		P_{1-10}, %	
	X_1	X_2	X_3	X_4	Experiment	Theory	Experiment	Theory
					Y_{P0-1}	Y_{P0-1}	Y_{P1-10}	Y_{P1-10}
1	1	1	1	1	24.07	24.09	40.11	39.38
2	-1	1	1	1	19.96	20.46	32.55	32.8
3	1	-1	1	1	21.28	21.24	55.39	53.9
4	-1	-1	1	1	19.08	17.06	47.48	47.32
5	1	1	-1	1	21.47	22.58	42.76	41.48
6	-1	1	-1	1	17.18	18.94	42.42	43.94
7	1	-1	-1	1	27.63	25.44	53.08	56
8	-1	-1	-1	1	21.63	21.8	57.33	58.64
9	1	1	1	-1	14.79	14.72	49.77	48.62
10	-1	1	1	-1	9.87	11.08	41.24	42.04
11	1	-1	1	-1	11.44	10.86	42.91	44.6
12	-1	-1	1	-1	9.66	8.22	39.9	38.08
13	1	1	-1	-1	23.29	22.24	51.47	50.72
14	-1	1	-1	-1	16.86	18.61	56.25	53.18
15	1	-1	-1	-1	25.32	23.1	48.38	46.76
16	-1	-1	-1	-1	20.74	21.46	48.96	49.12
17	1	0	0	0	16.38	20.52	49.83	52.19
18	-1	0	0	0	18.62	16.88	49.07	50.13
19	0	1	0	0	21.15	22.14	40.55	42.79
20	0	-1	0	0	24.98	22.14	51.37	50.16
21	0	0	1	0	14.96	15.71	35.01	37.62
22	0	0	-1	0	22.99	21.63	43.39	44.24
23	0	0	0	1	18.7	18.08	47.99	45.43
24	0	0	0	-1	14.43	13.22	45.26	45.43

The lid angle X_2 (*a*) causes a parabolic change of the sputtering by the availability of a minimum in the factor field. The growing of the levels of the other factors causes a shift of the minimum point to the left. In other words, a bigger sputtering is established both in small and big angle of the lid. The sputtering changes in the following borders: from Y_{P0-1} = 16.25% to Y_{P0-1} = 24.09%, i.e. by 7.84%.

It is probable that in small lid angle the soil aggregates break into it, and in the case

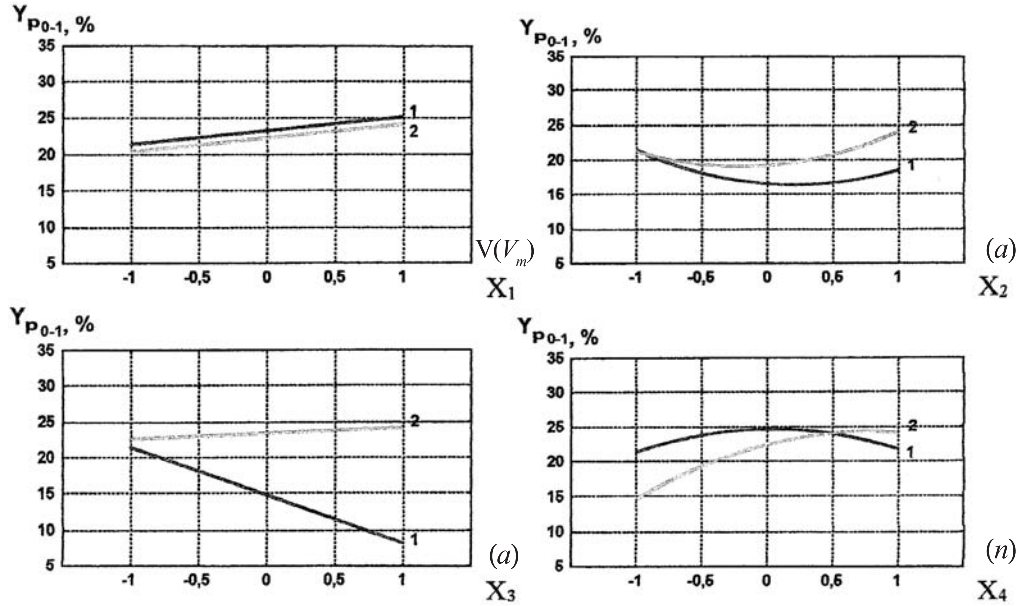

Fig. 1. Influence of the factors: advancing speed V_m, angle of the tiller lid α, working depth *a* and frequency of the tiller drum rotation n over the tiller sputtering Y_{P0-1} of maroon-forest soil at levels of the remaining factors: 1 - lower; 2 - upper

of bigger angle - they return to the tiller drum zone and additionally sputter.

It is evident from Figure 1 that the frequency of the tiller drum causes an analogical linear change of the soil sputtering.

Regardless of the working modes, the soil sputtering ranges within the limits from 8.22% to 25.44%. The minimum sputtering is at the lower level of the advancing speed V_m, angle of the tiller lid , frequency of the tiller drum rotation *n* and at the upper level - of the working depth *a* (Experiment No 12). The maximum sputtering is at the lower level of X_2 and X_3 and the upper level of X_1 and X_4 (Experiment No 7). Therefore, the working mode selection of the soil-cultivating tiller can lessen the sputtering by up to 3.05 times.

If we accept the fact that the tillers work at a constant and preliminary set depths, then the average sputtering at *a* = 6 cm is 21.77%, and at depth *a* = 1 cm - 16.03%.

The strength of influence of the advancing speed over the sputtering is 70.29%, of the lid angle - 15.70%, of the working depth - 11.71% and of the rotation frequency - 2.80%.

Following the advancing speed, the lid angle has the strongest impact over the sputtering.

Soil disintegration. The mathematical model for the soil disintegration Y_{P1-10} is:

$$Y_{P1-10} = 45.43+1.03X_1-2.64X_2-3.31X_3+2.26X_1X_3-4.62X_2X_4+5.73H_1^2-4.50X_3^2 \quad (2)$$

$$F = 26.93>2.66 = F_T$$

The mathematical model for the soil disintegration Y_{P1-10} is adequate, because

$F > F_T$ (Mitkov and Minkov, 1993).

The change of the soil sputtering at the different levels of the remaining factors is graphically shown on Figure 2.

The lid angle X_2 (α) has a bilateral linear effect over the disintegration. At the lower level of the remaining three factors (curve 1) it increases, while at the upper level (straight line 2) it decreases. Moreover, a working mode has been established, in which regardless of the levels of the remaining factors, the disintegration is the same $Y_{P1-10} = 50.0\%$.

It is logical the disintegration to decrease with the lifting of the tiller lid, as is the case with straight line 2, which is explained by the decrease of the soil hitting into it. At the lower level of the other three factors (straight line 1) - the soil grit is comparatively small. It is further disintegrated in the soil cresset. Lifting the lid, a greater and greater soil quantity keeps hitting into it, thus additionally disintegrating.

It is obvious from Figure 2 that the frequency of rotation of the tiller drum also causes a linear change of the soil disintegration.

The change of disintegration by the advancing speed is 43.47%, by the lid angle - 28.92%, by the depth - 20.50% and by the frequency of rotation - 7.11%.

It is clear that the change of the soil disintegration caused by the lid angle is equal to the change, caused by the advancing speed and the drum rotation frequency.

In conclusion, the degree of soil sputtering and disintegration, caused by the lid angle of the tiller drum is commensurable

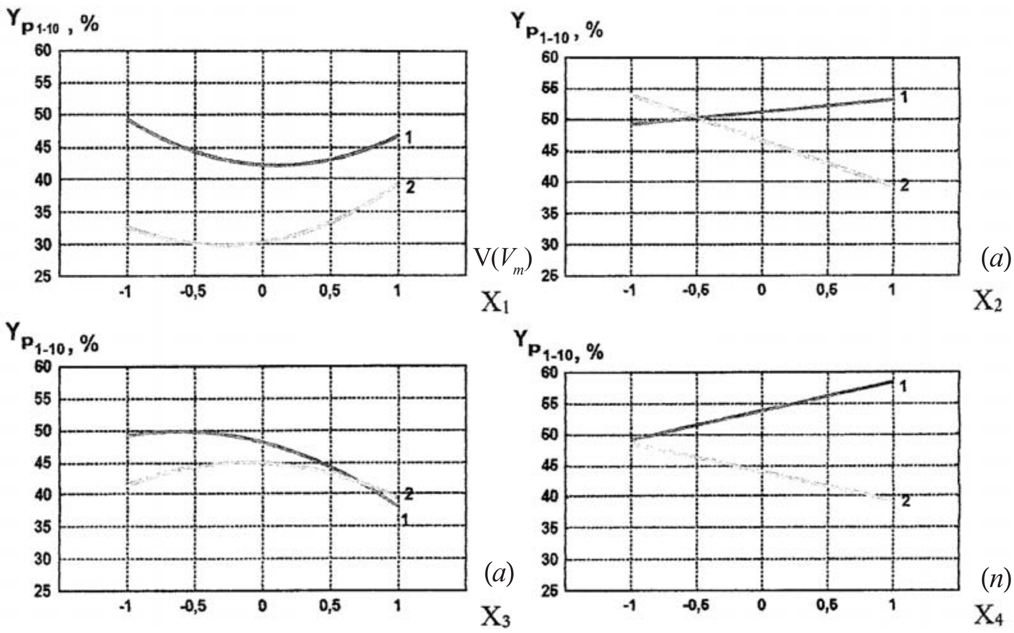

Fig. 2. Influence of the factors: advancing speed V_m, angle of the tiller lid α, working depth *a* and frequency of the tiller drum rotation n over the tiller disintegration Y_{P1-10} of maroon-forest soil at levels of the remaining factors: 1 - lower; 2 - upper

with the degree of soil sputtering and disintegration caused by the advancing speed and is bigger than the influence of the working depth and the drum rotation frequency. Therefore, the lid angle can be included as a technological characteristic feature, through which the quality of soil disintegration can be improved.

This fact can be used for the creation of soil-cultivating tillers with automatic adjustment of the soil sputtering and disintegration, based on a simpler principal - change of the sloping angle of the lid.

Conclusion

The lid of the soil-cultivating tiller has a significant impact over the sputtering and disintegration of the soil. Its degree of influence is equal to the degree of influence of the advancing speed, which for the soil sputtering is from 15.70 to 30.22%, and for the soil disintegration - from 27.90 to 28.92%. This influence is bigger than the impact of the working depth and the drum rotation frequency. The form of this influence is close to the one represented by the drum rotation frequency. For this reason, it is an important characteristic feature for the improvement of the technological result.

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