Exploitational indicators, Diesel fuel consumption and work quality during disc tiller skimming

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ABSTRACT: During the shallow soil tillage after winter wheat harvest the tractor JOHN DEERE 8200 with disc tiller DOWLANDS 4500 operation was monitored. For dependence of the set field speed within plots acreage the function of type $y = 0.43 \text{ Ln } x + 10.76$ was chosen. Average Diesel fuel consumption at first skimming on plots of total acreage 611.4 ha was 7.98 l/ha, for evaluation of Diesel fuel consumption dependence on particular plots acreage was chosen a logarithmic model of function $y = -0.81 \text{ Ln } x + 10.35$. For the engine Diesel fuel consumption dependence on average length of working drives through the plots the logarithmic model of function $y = -1.83 \text{ Ln } x + 18.95$ was chosen. After first skimming by disc tiller on the soil surface has remained 31.1 wt % of winter wheat post-harvest remainders, in depth of 0–50 mm was found-out of 31.0% of post-harvest remainders, 37.9 wt % of crop remainders was found-out in depth of 50–100 mm. After the second skimming by the blade tiller most of the post-harvest remainders was worked-in to the depth of 50–100 mm (54.3 wt %). After the following pre-seeding soil preparation by combinatory was recorded dislocation of most of crop remainders to depth of 0–50 mm (58.4 wt %).

Keywords: skimming; disc tiller; machines operations monitoring

The high-quality skimming is a part of soil-protection technologies of soil tillage and crop covers establishing. These technologies are considered perspective from view of soil fertility protection within systems of sustainable farming on agricultural land (CANNELL, HAWES 1994; ARSHAD 1999). The post-harvest remainders on soil surface have reduced significantly the harmful soil erosion in period before application of crops cover protective function of the following plant (HANNA et al. 1995). At the aimed utilization of the post-harvest remainders for soil protection against erosion is necessary the skilled utilization of herbicides and other agents for reduction of weeds, diseases and crop pests (JANEČEK et al. 2002).

The technologies based on ploughing substitution by shallow soil skimming bring considerable savings of Diesel fuel and time (TEBRÜGGE, BÖHRENSEN 1995). From point of view of spent costs this savings are compensated by costs spent for agrochemicals purchase.

The objective of the work is to evaluate dependence of selected exploitation indicators and Diesel fuel consumption on plots acreage at disc tiller skimming and to assess layout of grain crop post-harvest remainders after operations of soil tillage for winter rape.

MATERIAL AND METHODS

The method of machines operation monitoring, worked-up at the Research Institute of Agricultural Engineering (KOVAŘÍČEK 2001), was used for data recording of machines utilization assessment during their operations in agricultural enterprise and investigation of Diesel fuel consumption. For data recording was used the appropriate device with microcomputer. This device enables recording of geographical coordinates, to set working speed and time from the GPS receiver and was built-in the GSM module for data sending and function adjustment of the recorder. Besides the GPS data also Diesel fuel consumption is recorded. The source of coordinates, time data and instantaneous working speed is receiver GPS 35-PC Garmin. Diesel fuel consumption was measured by the flow-meter with circular piston EDM 1404.02 with output of 322 pulses per 1 litre of Diesel fuel. The recorded data were processed by the programme products GIS TopoL and Excel.

The measuring was carried-out in 2002 at shallow soil tillage after grain crops and oil crops harvest (skimming) by disc tiller and at pre-seeding preparation of skimmed soil for winter rape. The agricultural enterprise where the measuring was performed is located in the sugar-beet production region. The dominant soil type is typical black earth, degradable black earth and brown earth. From point of view of granularity dominates the loamy earth, on smaller part of acreage the sandy-loam earth.

For skimming was used the disc tiller DOWLANDS 4500 of working width 4.5 m in set with tractor JOHN DEERE 8200 with 155 kW engine.

For working-up of the measured data these indicators and relations were used:

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effective field capacity:

$$W_{02} = 0.1 \,.\, B_p \,.\, v_{op} = 0.1 \,.\, B_k \,.\, k_b \,.\, v_{op}$$

where: W_{02} – effective field capacity (ha/h),
B_p – machine operating width (m), average machine width reached under operational conditions, when $B_p = B_k \,.\, k_b$,
B_k – theoretical operating width (m),
k_b – coefficient of operating width utilization,
v_{op} – field speed (km/h), mean speed reached on plot during main and side activity of machine.

During the soil tillage for winter rape the effect of machines on pre-crop remainders – stubble and crushed straw of winter wheat was assessed. The crop remainders were withdrawn from the soil surface and from depths 0–50 mm and 50–100 mm after appropriate working operation. The crop remainders withdrawal was performed on area of 0.25 m^2 in the five repeated steps after each impact. After drying in laboratory the crop remainders were weighted.

RESULTS AND DUSCUSSION

Exploitation indicators and engine Diesel fuel consumption

In Fig. 1 are recorded the set trajectories during disc tiller skimming – tractor JOHN DEERE 8200 and disc tiller DOWLANDS 4500 of operational width 4.5 m. The skimming was performed within the period from 16. 8. to 12. 9. 2002, total skimming area was 611.4 ha. In all cases was performed first skimming after wheat, sunflower and mustard. The average skimming depth was 100 mm, average real operational width of disc tiller was 4.58 m. Average coefficient of operational width utilization is 1.02.

In Table 1 are recorded indexes for particular plots and Diesel fuel consumption for skimming. By utilization of regressive and correlation analysis the effect of plots parameters for selected exploitation data and Diesel fuel consumption was evaluated.

In Fig. 2 is the structure of productive time at skimming by disc tiller DOWLANDS 4500 in set with tractor JOHN DEERE 8200. Total number of analysed data in time-interval 20 second is 34,202. Real skimming on the plots is analysed consequently.

In Fig. 3 is presented the course of field set speed increase during the skimming by the disc tiller with increasing plots acreage. The coefficient of determination shows a high stage of relationship tightness. For skimming the average set field speed is an important indication with respect to demand for set high area performance, i.e. the basic condition of operations provision in proper time mainly during soil tillage for winter crops. Lower field speed on smaller plots is

Table 1. Skimming by disc tiller DOWLANDS 4500 in set with tractor JOHN DEERE 8200. Average skimming depth 100 mm, from 16. 8. to 12. 9. 2002

Field	Plot acreage (ha)	Field time T_{02} (h)	Field speed v_{op} (km/h)	Average machine operating width B_p (m)	Effective field capacity W_{02} (ha/h)	Average Diesel fuel consumption (l/ha)
1	27.70	5.57	12.27	4.1	4.98	7.43
2	27.29	5.02	12.60	4.3	5.44	7.06
3	42.78	8.53	12.47	4.8	5.02	7.17
4	6.38	1.43	11.54	5.2	4.47	7.43
5	31.98	5.42	12.58	4.6	5.90	6.89
6	63.68	11.66	12.31	4.9	5.46	7.15
7	122.55	22.53	12.69	4.3	5.44	7.20
8	82.44	15.27	12.24	4.6	5.40	6.78
9	22.38	3.69	12.13	4.7	6.06	6.93
11	18.72	3.72	12.16	4.4	5.04	7.54
12	8.88	1.44	11.96	4.6	6.15	6.60
13	12.53	2.67	11.93	4.6	4.70	8.25
14	23.78	4.93	11.65	4.9	4.82	8.24
15	12.74	2.67	12.24	4.3	4.78	8.34
16	7.52	1.78	11.53	4.9	4.22	8.75
17	4.32	1.08	11.02	4.8	4.01	9.81
18	1.66	0.54	10.83	4.8	3.05	11.15
19	12.99	3.37	11.56	4.7	3.85	9.45
20	21.71	5.47	12.38	4.7	3.97	9.83
21	38.12	7.88	12.34	3.4	4.84	7.96
22	21.23	3.82	11.94	4.5	5.55	7.57
Weighted average			**12.02**	**4.58**	**4.91**	**7.98**

Fig. 1. Trajectory of set at disc tiller skimming – tractor JOHN DEERE 8200 and disc tiller DOWLANDS 4500

caused by the time share increasing for set turning on these plots margins.

In Fig. 4 is expressed the dependence of Diesel fuel consumption (l/ha) on the plots acreage during disc tiller skimming. For expression of this dependence the logarithmic model of function was chosen. From the graph is evident that during skimming performed by the mentioned set was found-out decrease of Diesel fuel consumption with increased plots acreage. This decrease is expressed by the regressive function $y = -0.81 \, \mathrm{Ln} \, x + 10.35$.

Further evaluation was focused to effect of average length of operational drives through the plots on Diesel fuel consumption. In Fig. 5 is recorded dependence of Diesel fuel consumption (l/ha) on average length of set operational drives through the plots during disc tiller skimming. The trend of Diesel fuel consumption decrease (l/ha) with increasing average length of operational drives was recorded. For expression of dependence the logarithmic model of function was chosen, coefficient of determination shows the medium stage of relationship tightness between x and y.

Crop remainders distribution during skimming

The pre-crop remainders distribution during skimming is an important indicator of this operation benefit for soil protection against erosion. The aimed utilization of crop remainders for soil protection against water and wind soil erosion is an important sign of systems for soil protective tillage.

In Fig. 6 are presented results of investigation of tillers effect on pre-crop remainders (stubble and crushed winter wheat straw) during first skimming by disc tiller DOWLANDS 4500, during second, repeated skimming by blade skimmer ROSS FARMER and during following pre-seeding soil preparation by combinatory. From Fig. 6 is evident that after the first skimming by disc tiller almost one third of remainders stayed on the soil surface (31.1 wt %), other almost one third of crop remainders was treated to the soil upper layer 0–50 mm (31.0 wt %). Other crop remainders (37.9 wt %) were treated to the soil layer in depth of 50–100 mm. HAYES and YOUNG (1983) presented that the disc til-

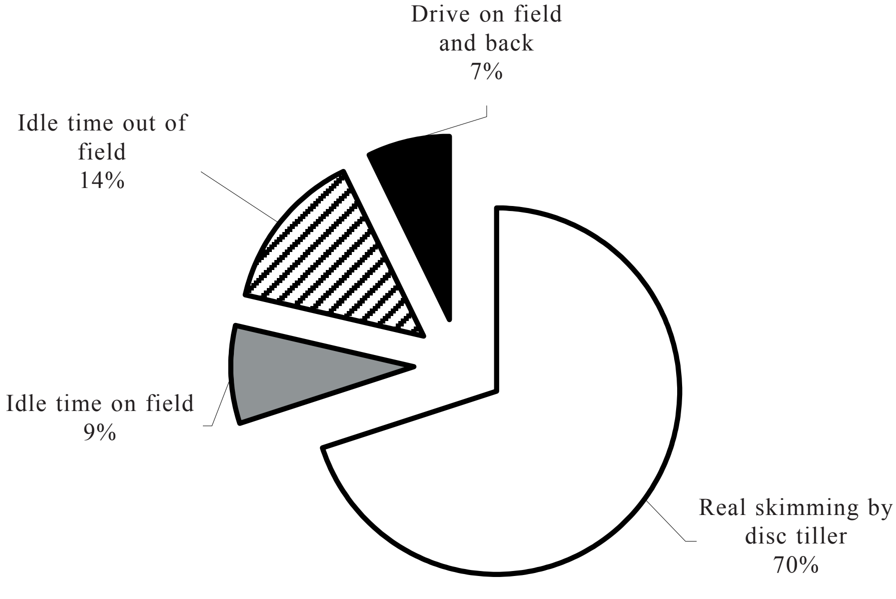

Fig. 2. Structure of productive time – skimming by disc tiller DOWLANDS 4500 in set with tractor JOHN DEERE 8200

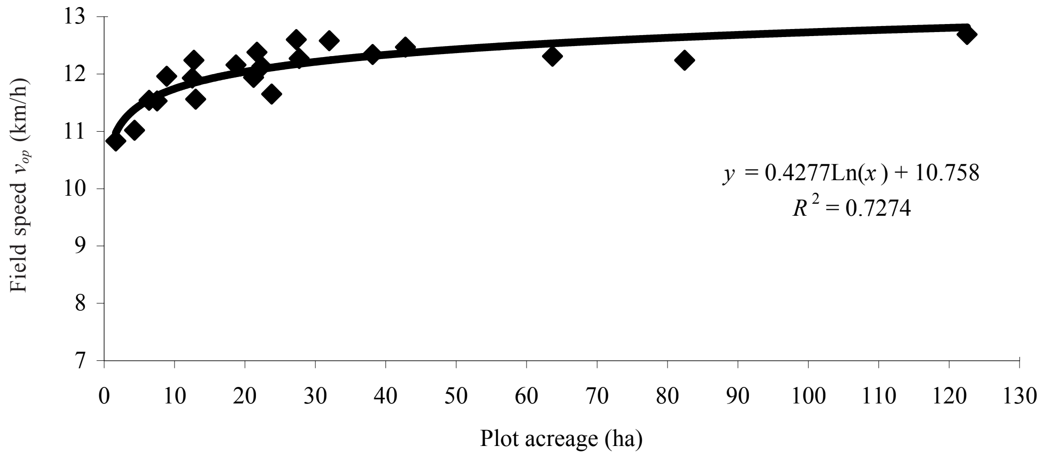

Fig. 3. Dependence of field speed of the set on plots acreage – skimming by disc tiller DOWLANDS 4500 in set with tractor JOHN DEERE 8200

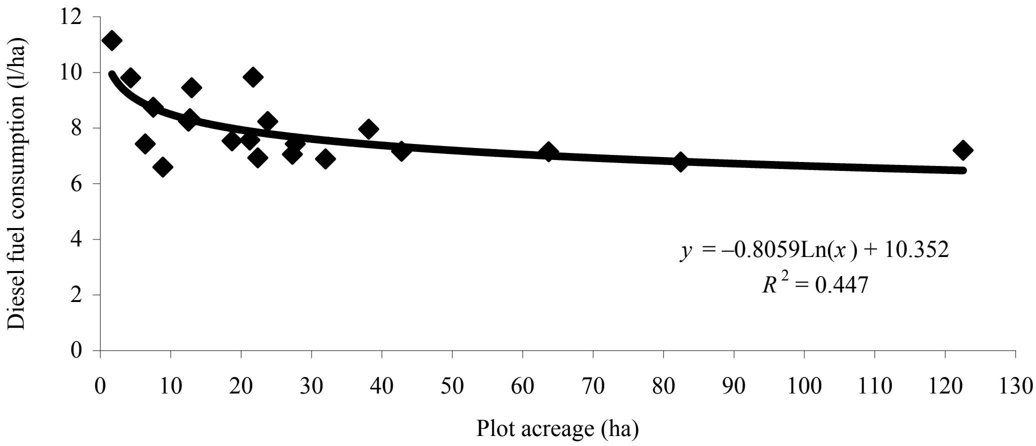

Fig. 4. Dependence of Diesel fuel consumption on plots acreage – skimming by disc tiller DOWLANDS 4500 in set with tractor JOHN DEERE 8200

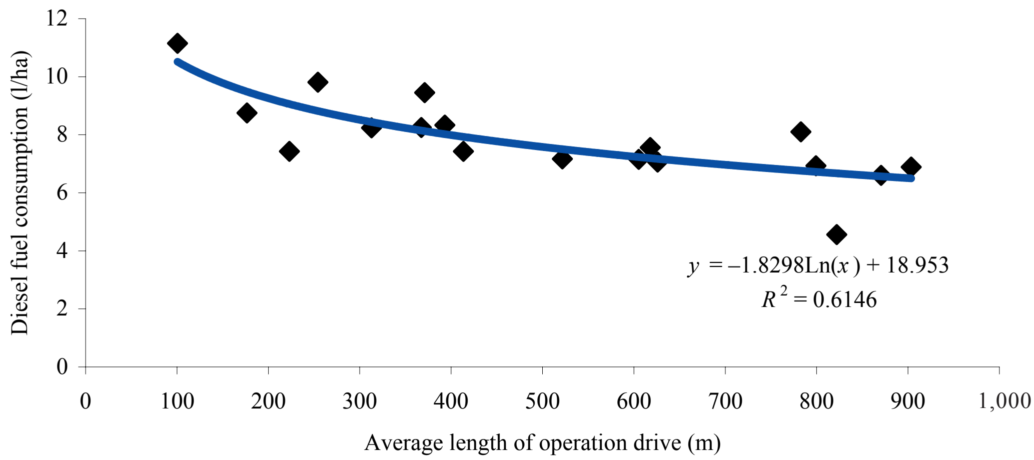

Fig. 5. Dependence of Diesel fuel consumption on average length of operation drive through the plots – skimming by disc tiller DOWLANDS 4500 in set with tractor JOHN DEERE 8200

lers left 60% of crop remainders on the soil surface. This was not confirmed by our measuring-almost one third of the post-harvest remainders (31.1 wt %) staying after the first skimming on the soil surface indicates a higher stage of post-harvest remainders treatment to soil during skimming by the mentioned disc tiller. After the second skimming performed with the time difference of 13 days by the blade tiller was found-out, that most of crop remainders of winter wheat was treated to depth of 50–100 mm (54.3 wt %), on soil surface has stayed

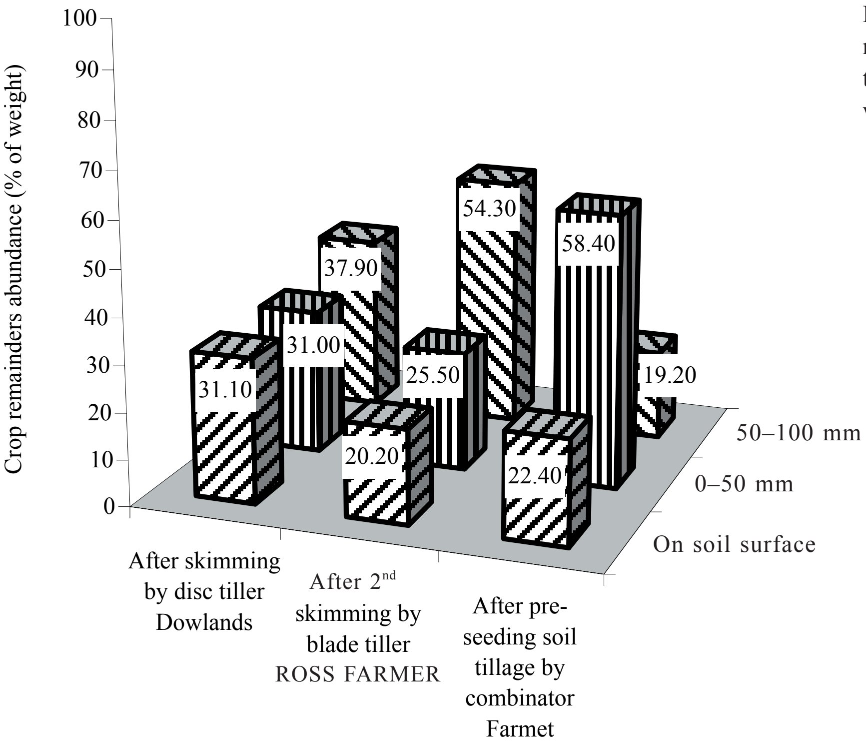

Fig. 6. Distribution of post-harvest remainders of winter wheat after particular operations of soil tillage for winter rape

20.2% of crop remainders (weight) and the rest (25.5%) was found-out in depth of 0–50 mm.

After the following pre-seeding soil preparation by combinatory the highest share of crop remainders in depth of 0–50 mm was recorded. This may be connected with risk of seeds deposition during seeding to the soil layer with increased occurrence of crop remainders. Seeds direct contact with straw is unfavourable not only from point of view of lower water supply to the seeds but also undesirable inhibition effect of inter-products generated during straw decomposition in soil (BRUNOTTE, SOMMER 1997). It was proved that increased amount of crop remainders in seed-bed depth requires to pay attention to evaluation of machines work quality.

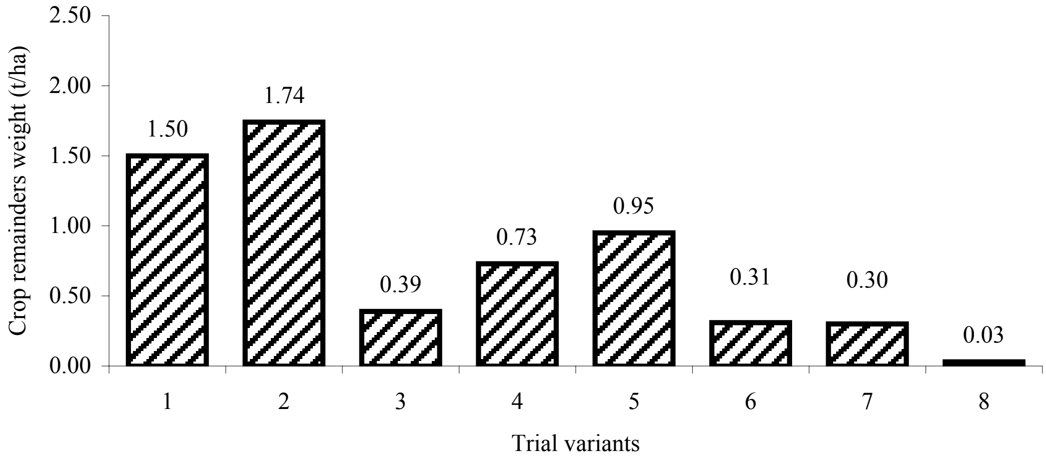

Fig. 7. Weight of post-harvest remainders of wheat on soil surface after winter rape seeding (half-operative field trial with eight variants of soil tillage and seeding)

Trial variants:

1. Direct seeding (JOHN DEERE 750 A)
2. Direct seeding (Horsch CO 6.25)
3. Direct seeding (Howard Semavator 3)
4. Disc tiller skimming. Seeding (JOHN DEERE 750 A)
5. Disc tiller skimming. Seeding (Horsch CO 6.25)
6. Disc tiller skimming. Seeding (Howard Semavator 3)
7. Disc tiller skimming. Soil preparation and seeding (Maschio + Pneusej 4.5 m)
8. Ploughing (plough MF 720 + clods crusher). Soil preparation and seeding (Maschio + Pneusej 4.5 m)

The effect of machines on pre-crop remainders can be completed by data in Fig. 7. In this case is considered the weight of winter wheat post-harvest remainders which have stayed on soil surface after winter rape seeding-results from the half-operational field trial where 8 variants of soil tillage and winter rape seeding were evaluated (1999/2000). In the trial were included 3 variants of winter rape direct seeding into uncultivated soil (variant 1, 2 and 3), 4 variants of seeding after skimming (variants 4, 5, 6, 7) and control variant with conventional soil tillage by ploughing and following soil pre-seeding preparation (variant 8).

In variant 8 was found-out an almost complete treatment of wheat remainders into the soil by ploughing. It means, that in technologies for soil tillage by ploughing the soil surface after winter rape seeding is not protected by the pre-crop post-harvest remainders against possible unfavourable effects of intensive rainfalls on soil structure. The non-protected soil after winter rape seeding can be damaged by water erosion because the end of August and beginning of September are characterised by frequent thunderstorms with intensive rainfall. Since a half of September the soil is partially protected by emerged rape cover.

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Exploatační ukazatele, spotřeba nafty a kvalita práce při podmítce talířovým kypřičem

ABSTRAKT: Při mělkém zpracování půdy po sklizni ozimé pšenice byl monitorován provoz traktoru JOHN DEERE 8200 s talířovým kypřičem DOWLANDS 4500. Pro závislost operativní rychlosti soupravy na výměře pozemků byla zvolena funkce $y = 0{,}43 \text{ Ln } x + 10{,}76$. Průměrná spotřeba nafty při první podmítce na pozemcích o celkové výměře 611,4 ha byla 7,98 l/ha, pro vyhodnocení závislosti spotřeby nafty na výměře jednotlivých pozemků byl zvolen model funkce $y = -0.81 \text{ Ln } x + 10.35$. Pro závislost spotřeby motorové nafty na průměrné délce pracovních jízd na pozemcích byl zvolen model funkce $y = -1{,}83 \text{ Ln } x + 18{,}95$. Po první podmítce talířovým kypřičem zůstalo na povrchu půdy 31,1 % hmotnosti posklizňových zbytků ozimé pšenice, v hloubce 0–50 mm bylo zjištěno 31,0 % posklizňových zbytků, 37,9 % hmotnosti rostlinných zbytků bylo zjištěno v hloubce 50 až 100 mm. Po druhé podmítce radličkovým kypřičem byla většina posklizňových zbytků zapravena do hloubky 50–100 mm (54,3 % hmotnosti). Po následné předseťové přípravě půdy kombinátorem bylo zaznamenáno přemístění většiny rostlinných zbytků do hloubky 0–50 mm (58,4 % hmotnosti).

Klíčová slova: podmítka; talířový kypřič; monitoring provozu strojů

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