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WORKING RESISTANCE OF SELECTED MACHINES FOR PREPARATION OF SEEDBED

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Abstract. Cultivation machines meet resistance during their operation. Mostly the magnitude of resistance depends on resistance caused by tilled material. This study presents the results of the measurements of working resistance for a disc harrow U-239 manufactured by Akpil and a seedbed former and a cultivator with a string roller manufactured by Egedal. The tests were conducted on open tree nursery in Kłaj, being part of the Forest District of Niepołomice. Sandy-loam and loam-sandy soils prevail in the nursery. The measurements of resistance were conducted in three quarters with black fallow. The compactness and humidity of soil were determined (16-24%). Working resistance was determined by the hauling method with the usage of force strain gauge. The average value of working resistance for the disc harrow fit in the range between 2.25 kN and 2.82 kN, for the seedbed former between 2.35 kN and 2.53 kN, for the cultivator with string roller between 1.50 kN and 2.37 kN.

Key words: tree nurseries, working resistance, nursery machines

INTRODUCTION

Technical development covers every part and field of our life. Automation and mechanization occupy the first position in the production process, also in forestry and agriculture. This tendency relates also to nurseries, yet on a smaller scale. Currently tree nurseries are equipped with modern tractors and expensive foreign machines whose runtime can be monitored through, for example, the GPS system. With the purpose of optimizing the technological process in mind, it is extremely important to know the operating parameters of those machines. The parameter that directly influences the work of a unit is its working resistance. The proper selection of a tractor to machines when it comes to drawbar pull is very important to the run of the production process in a nursery [Słowiński and Walczyk 2001]. The usage of the proper set of machines decreases the scope and amount of manual work, improves the safety, health and quality of seedlings. During the work, cultivation machines meet resistance defined as working resistance

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[Lejman 1996, 1998]. It is generated during the movement of a machine and is caused by the work of active working sets.

MATERIAL AND METHODS

The purpose of this study was to determine the change in the resistance of the whole unit consisting of selected machines for the preparation of seedbed in the nursery and a tractor. The following machines were selected for conducting tests: a disc harrow type U-239 manufactured by Akpil (operating depth about 0.15 m, operating width 1.8 m, the harrow was not additionally preloaded), a seedbed former manufactured by Egedal (height of formed seedbed 0.18 m, operating width 1.2 m) and a cultivator with a string roller (17 blades, operating depth 0.07 m, operating width 1.2 m) manufactured by Egedal. The tests were conducted on an open tree nursery in Kłaj, being a part of the Forest District of Niepołomice. The measurements of resistance were conducted in three quarters with black fallow. The compactness and humidity of soil were determined.

Soil compactness was determined with an electrically-driven cone penetrometer (Fig. 1). The penetrometer has two motors powered by acid battery (12V 60 Ah). The measuring probe with the opening angle of 30º and the base diameter of 12.83 mm (according to ASEA Standards 313.2) was used for tests, therefore the measuring range of penetrometer was between 0 and 7.5 MPa. The depth of measurements by penetrometer was between 0 and 52.5 cm. The force was measured by one strain gauge with the measuring range between 0 and 1.5 kN [Słowiński 2006, 2007].

Soil humidity was specified by Radwag moisture balance WPS S series. Soil for measurements was taken from one level from 0 to 15 cm. The mechanical structure of the soil was determined by Casagrande's aerometric method modified by Prószyński. The type of soil was specified according to Polish norm PN-R-04033.

The working resistance of machines was determined using the hauling method [Potocki 1988]. For this purpose, polypropylene line and force gauge were used to connect two tractors: Ursus 4512 and MF 235, which was connected with the tested machine (Fig. 2). The strain gauge EMS 150 produced by Wobit with the measuring range between 0.5 and 20 kN, was used. The measured data concerning working resistance was stored on the measuring interface APEK AL. 154 with 10 ms sampling time. The obtained data was later copied to PC.

Three rides, measurement of movement resistance and two measurements of working resistance were performed on each field.

Then the following were determined:

– working resistance of the machine (F_a) according to the equation:

$$F_a = F_c - F_f$$

where:

F_c – measured total resistance of the unit, kN,
F_f – measured rolling resistance, kN,

– unit resistance of the machine:

$$k = \frac{F_a}{b}, \text{ kN/m}$$

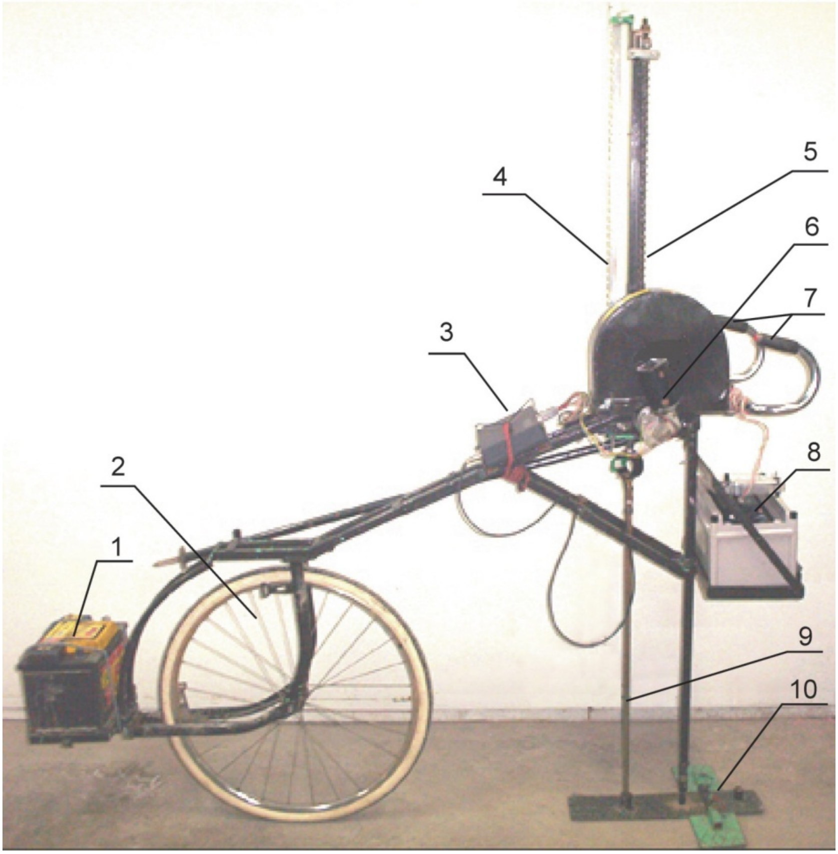

Fig. 1. Cone penetrometer: 1 – battery, 2 – wheel, 3 – bucket for electric controlling – amplifying system, 4 – strip with holes, 5 – gear rack, 6 – motor, 7 – control handle, 8 – bucket for register interface, 9 – bar terminated with removable measuring cone, 10 – feet

Rys. 1. Penetrometr stożkowy: 1 – akumulator, 2 – koło jezdne, 3 – kosz na elektryczny układ sterująco-wzmacniający, 4 – listwa z otworami, 5 – listwa zębata napędu, 6 – silnik elektryczny, 7 – uchwyty sterujące, 8 – kosz na interfejs rejestrujący, 9 – pręt zakończony wymiennym stożkiem pomiarowym, 10 – stopa

where:

b – operating width of the machine, m,

– rolling resistance ratio of the unit (f) according to the equation:

$$f = \frac{F_f}{G_a}$$

where:

F_f – measured rolling resistance, kN,
G_a – weight of the unit (tractor and machine), kN.

Fig. 2. Tractor MF 235 with attached force gauge EMS 150 and polypropylene line connecting both tractors
Rys. 2. Ciągnik MF 235 z przyłączonym czujnikiem siły EMS 150 i liną polipropylenową łączącą ze sobą dwa ciągniki

RESULTS

Soil humidity on 3 fields that were examined: fallow no. 1 – 24.3%, fallow no. 2 – 16.5%, fallow no. 3 – 17.2%. The Table 1 presents the mechanical composition of the soil. Figure 3 shows the chart of soil compactness of every fallow.

The curves depicting soil compactness of fallows 1 and 2 are characterized by small values and a very similar course. Soil compactness goes up till the depth at the level of 12.25 cm and reaches the value of 0.11 and 0.12 MPa, respectively. It means that

Table 1. Mechanical composition of soil
Tabela 1. Skład mechaniczny gleby

Soil texture, % Skład mechaniczny, %						Total Razem			Soil textural group Gatunek gleby
1-0.1	0.1-0.05	0.05-0.02	0.02-0.006	0.006-0.002	< 0.002	sand piasek	silt pył	silt and clay części spławialne	
75	4	10	6	3	2	75	14	11	Loamy sand Piasek słabo gliniasty

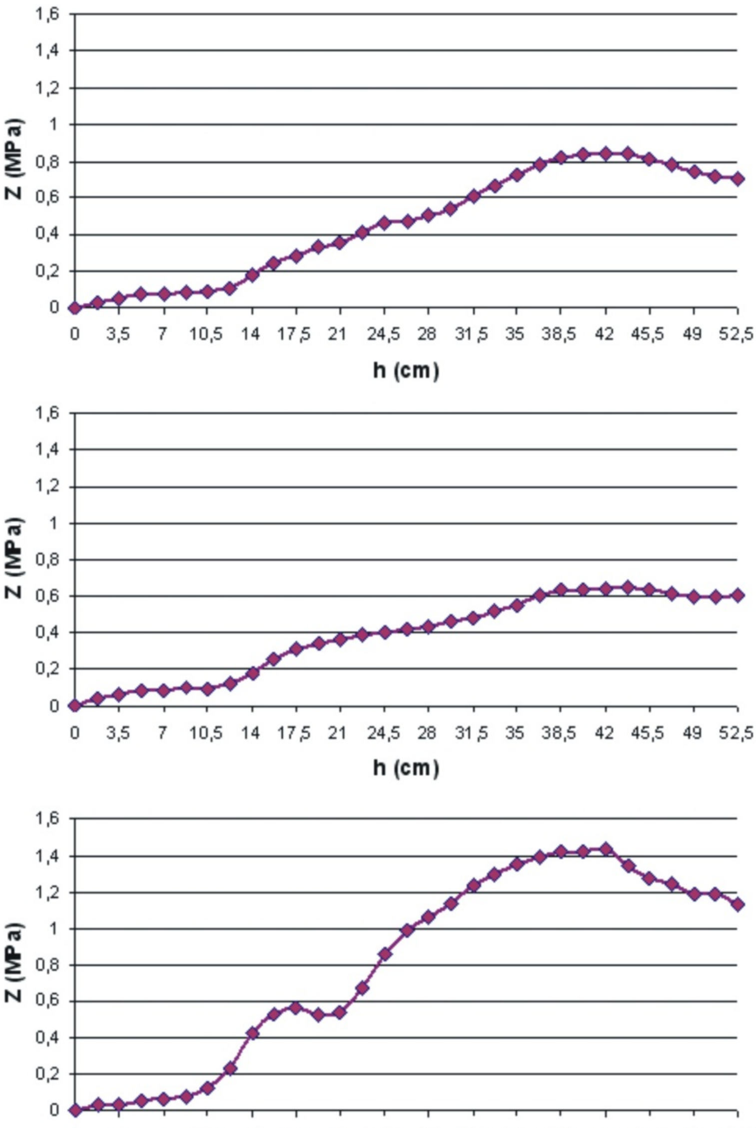

Fig. 3. Distribution of soil compactness on the examined fields: Z – soil compactness, h – depth

Rys. 3. Rozkład zwięzłości gleby na polach badawczych: Z – zwięzłość gleby, h – głębokość

the soil is friable and can create favorable conditions for the growth of seedlings. From the depth of 12.25 cm the compactness increases significantly on both fields up to the depth of 42 cm (field no. 1) and 43.75 cm (field no. 2). At this level, the value equals 0.84 MPa for field no. 1 and 0.65 for field no. 2 and those are maximum values for both surfaces. From those depths, the compactness decreases and at the depth of 52.5 cm amounts to 0.70 and 0.60 MPa respectively.

This distribution of soil compactness on fallows 1 and 2 indicates that they were subjected to agro-technical care using cultivation machines. Relatively small values for soil compactness at bigger depths for the entire measured surfaces can mean that the fields were subsoiled. Friable soil can be found up to the depth of 12.25 cm. The curve depicting soil compactness on the field no. 3 has a slightly different distribution comparing to other two fields. Down to the depth of 10.5 cm, where the soil compactness equals 0.13 MPa, the distribution is similar to the curves analysed earlier in the text. However, down to the depth of 17.5 cm the compactness rises suddenly, reaching 0.7 MPa. Then there is a slight drop in soil compactness to the depth of 21 cm and the value of 0.54 MPa. From this level, the compactness once again rises and as in the case of field no. 1 reaches its maximum value of 1.44 MPa at the depth of 42 cm. And at the level of 52.5 cm the compactness decreases to 1.13 MPa.

The distribution of compactness for the field no. 3 and its values can suggest that the field was not subsoiled. Low values up to the depth of 10.5 cm mean that the soil was processed with the usage of cultivation machines.

The Table 2 shows rolling resistance ratios for individual fallows and the values of rolling resistance. An average value of the resistance ratio 0.032 and average rolling resistance for tractor MF 235 equals 0.82 kN. Figure 4 shows the measured values of rolling resistance and the total resistance on fallows resulting from tests for disc harrow. Table 3 contains values of total resistance for individual fallows for tractor MF 235 connected with tested machines. An average value of total resistance for tractor MF 235 connected with disc harrow is 3.29 kN, for the same tractor with seedbed former it is 3.27 kN and for the unit tractor MF 235 plus cultivator with string roller it is 2.74 kN.

Table 2. Resistance ratios and their values for individual fallows
Tabela 2. Współczynniki oporów oraz jego wartości dla poszczególnych ugorów

Value – Wartość	Field 1 – Ugór nr 1	Field 2 – Ugór nr 2	Field 3 – Ugór nr 3
	Rolling resistance – Opory toczenia		
Average, kN Średnia, kN	0.82	0.82	0.82
Standard deviation, kN Odchylenie standardowe, kN	0.33	0.14	0.08
Coefficient of variation, % Współczynik zmienności, %	40.7	17.2	10.4
	Rolling resistance ratios – Współczynnik oporów toczenia		
Average, kN Średnia, kN	0.033	0.032	0.032
Standard deviation, kN Odchylenie standardowe, kN	0.013	0.005	0.003
Coefficient of variation, % Współczynik zmienności, %	40.7	17.2	10.4

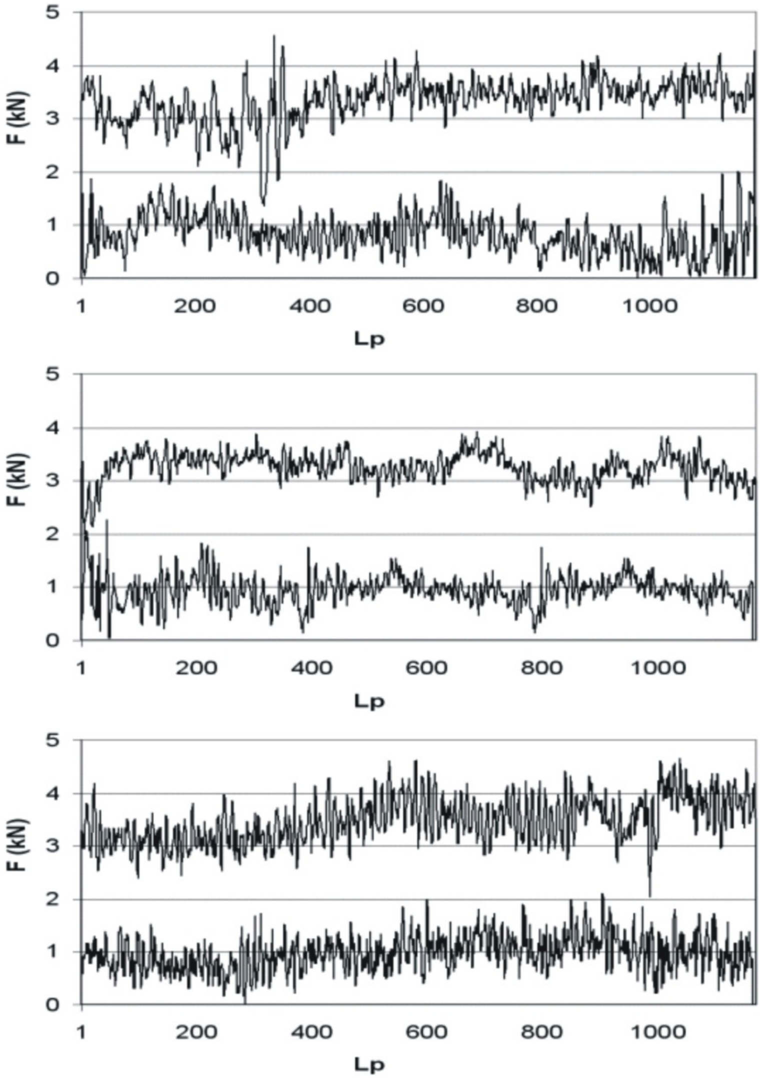

Fig. 4. Distribution of measured values of rolling resistance and total resistance of fallows tested for disc harrow: F – resistance, Lp – number of measurements

Rys. 4. Przebieg wartości pomiarowych oporów toczenia i toczenia całkowitego na ugorach dla badań brony talerzowej: F – opór, Lp – liczba pomiarów

Table 3. Values of total resistance for the unit consisting of tractor MF 235 and disc harrow, seedbed former, seedbed cultivator with string roller
Tabela 3. Wartości oporów całkowitych agregatu ciągnik MF 235 z broną talerzową, naorywaczem grzędy, kultywatorem grzędowym z wałem strunowym

Value – Wartość	Field 1 – Ugór nr 1	Field 2 – Ugór nr 2	Field 3 – Ugór nr 3
	Total resistance disc harrow Opory całkowite brony talerzowej		
Average, kN Średnia, kN	3.18	3.07	3.63
Standard deviation, kN Odchylenie standardowe, kN	0.47	1.07	0.81
Coefficient of variation, % Współczynik zmienności, %	14.7	34.8	22.4
	Total resistance bedformer Opory całkowite naorywacza grzędy		
Average, kN Średnia, kN	3.17	3.29	3.35
Standard deviation, kN Odchylenie standardowe, kN	0.76	0.60	0.63
Coefficient of variation, % Współczynik zmienności, %	18.3	13.9	15.9
	Total resistance cultivator with rolling harrow Opory całkowite kultywatora grzędowego z wałem strunowym		
Average, kN Średnia, kN	2.32	2.71	3.18
Standard deviation, kN Odchylenie standardowe, kN	1.10	0.71	0.27
Coefficient of variation, % Współczynik zmienności, %	47.5	28.8	7.69

DISCUSSION

An average value of working resistance for disc harrow for 3 fields with black fallow, which were previously subsoiled (field no. 1 and 2) and cultivated equaled 2.36; 2.25 and 2.82 kN, respectively.

In the paper "Computer program measuring operating parameters of agriculture units" Kiełbasa et al. [2005] used disc harrow type U351. The measurement was made during soil tillage of green manure and when harrow was operating at a fixed depth of 10 cm. Average soil humidity was 7.68%. The average value of working resistance for disc harrow measured by taximeter framework equaled 3.65 kN. In that study, there is no data concerning soil compactness, but it can be assumed that on the surface on which the plants intended for green manure were grown most of the time, this value will be higher than for black fallow which was subsoiled and cultivated.

The average value of working resistance for seedbed former for 3 fields with black fallow equaled 2.35; 2.47 and 2.53 kN, respectively, average 2.45 kN, whereas for the seedbed cultivator with a string roller: 1.51; 1.89 and 2.37 kN, average 1.92 kN.

Values of unit resistance for the tested machines fit in the range:

– for the disc harrow – between 1.25 and 1.56 kN/m, average value 2.04 kN/m,
– for the seedbed former – between 1.96 and 2.11 kN/m, average value 1.37 kN/m,
– for the cultivator with the string roller – between 1.26 and 1.97 kN/m, average value 1.60 kN/m.

When analyzing the graphs showing the distribution of soil compactness and values of working resistance, it can be seen that there is a co-relation between values of soil compactness on fields and working resistance for those surfaces. On field no. 3, which is characterised by visibly higher values for soil compactness, the increase in values of working resistance can also be noticed comparing to analyzed fields no. 1 and 2.

CONCLUSION

1. By analysing the obtained tests results, we can confirm the relation between increase in working resistance and increase of soil compactness.

2. The tests of soil compactness of the fallows showed that one of them (field no. 3) had plough pan and before the next seedlings production cycle it must be subsoiled.

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OPORY ROBOCZE WYBRANYCH MASZYN DO PRZYGOTOWANIA GRZĘDY SIEWNEJ

Streszczenie. Podczas pracy maszyny uprawowe napotykają na opory. Na wielkość obciążeń wpływają najbardziej opory, których źródłem jest obrabiany materiał. W pracy przedstawiono wyniki pomiaru oporów roboczych: brony talerzowej typ U-239 firmy Akpil, naorywacza grzędy siewnej oraz kultywatora z wałem strunowym firmy Egedal. Badania przeprowadzono w otwartej szkółce leśnej w Kłaju wchodzącej w skład Nadleśnictwa Niepołomice. W szkółce przeważają gleby piaszczysto-gliniaste oraz gliniasto-piaszczyste. Pomiary oporów wykonano na trzech kwaterach, gdzie występował ugór czarny. Dla powierzchni badawczych określono zwięzłość i wilgotności gleby (16-24%). Opory robocze maszyn określono metodą przeciągania, stosując tensometryczny czujnik siły. Średnia wartość oporów roboczych zawierała się w przedziałach: od 2,25 kN do 2,82 kN – brona talerzowa, od 2,35 kN do 2,53 kN – naorywacz grzędy siewnej, od 1,50 kN do 2,37 kN – kultywator z wałem strunowym.

Słowa kluczowe: szkółki leśne, opory robocze, maszyny szkółkarskie

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