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Research of mechanical traction characteristics of direct sowing equipment

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1. Introduction

Traction forces, which affect agricultural equipment, depend on the technological and construction parameters of the working parts and on the characteristics of the soil [1-5]. The soil compaction has an unavoidable influence on traction forces of sowing coulters and energy consumption of tillage-sowing systems [1, 6]. The assessment of the fuel inputs for tillage-sowing systems, revealed that the greatest amount of diesel fuel (67.2 $l \cdot ha^{-1}$) was used in the traditional deep ploughing and conventional sowing system. The reduced tillage systems required 12-20% less fuel. The lowest amount of diesel fuel was required for the no tillage (direct sowing) system (approximately 28.4 $l \cdot ha^{-1}$) [6].

Bianchini et al. [7] reported that pulling a toothed disc coulter at a depth of 8 cm requires approximately 41% less traction force than pulling a disc coulter with notched blades and approximately 64% less force than pulling a disc coulter with plain blades. Pulling a toothed disc coulter at a depth of 100 mm requires 26% and 55% less traction, respectively. Huijsmans et al. [8] studied a direct sowing double disc coulter (diameter 410 mm, thickness 50 mm) and a thickened single disc sowing coulter (diameter 340 mm, thickness 21 mm). They found that pulling a double disc coulter requires approximately 28% less traction force than a thickened single disc sowing coulter.

Magalhaes et al. [9] investigated the influence of a coulter's diameter on the traction force. Their research showed that a toothed disc coulter with a diameter of 711 mm requires approximately 9% higher traction force than a disc coulter of the same structure with a diameter of 610 mm and approximately 30% higher traction force than a disc coulter with a diameter of 508 mm.

Dedousis [2] compared row cultivator disc coulters with plain and bended blades and demonstrated that an increased coulter inclination angle from 0° to 5° reduces a plain disc coulter's resistance to traction from 81.9 $kN \cdot m^{-2}$ to 22.3 $kN \cdot m^{-2}$ and reduces the resistance of a bended coulter to traction from 46.061 $kN\ m^{-1}$ to 11 $kN\ m^{-1}$.

Germanas [10] states that changing the inclination angle of a disc seeding coulter from 0° to 10° increases the horizontal resistance to traction force from 1.28 to 1.66 times in light loam soil.

Nalavade et al. [11] investigated the traction force of a plain disc coulter with respect to its rotational speed and angle. They showed that, when tilling a soil, the free rotation of a disc coulter requires approximately 67% higher traction than does powered rotation when the rotational speed is between 75 min^{-1} and 125 min^{-1} and the disc coulter angle is 23°. The increase in the angle of the free disc coulter to 33° increases the traction force to approximately 70% compared to the powered disc coulter.

Ranta et al. [12] compared the influence of three different disc coulters (plain, 14-wave, and 26-wave) on the fluctuations of traction forces at various working speeds. They showed that the increase in a disc coulter's working speed from 5 $km \cdot h^{-1}$ to 11 $km \cdot h^{-1}$ increases the fluctuations of traction forces due to the increased vibrations of the coulter's operation. A greater influence of the working speed on the fluctuations of traction forces was noted using plain and 14-wave disc coulters. The most stable operation was noted using a 26-wave disc coulter.

Dedousis [2] states that the increased working speed of a row cultivator with a bended disc coulter at 1.8 $km \cdot h^{-1}$ increases the traction force by approximately 30%, whereas the working speed of a row cultivator with a plain disc coulter increases by approximately 15%.

Canadian researchers performed an investigation on the traction forces of arrow coulters with various constructions in sandy loam soil. They compared two different arrow coulters; one (A) was 330 mm wide and 240 mm long, and the other (B) was 570 mm wide and 490 mm long. The soil was tilled to three different depths (50, 100, and 150 mm) when working speed was 5.04 $km \cdot h^{-1}$. The researchers concluded that the increase in tillage depth significantly increased the traction force, regardless of the construction of the coulter. Tillage using the wider and longer arrow coulter (B) required approximately 80% higher traction force than tillage using the narrower and shorter arrow coulter (A) [13]. Rahman et al. [13] performed traction experiments using double disc and sweep-type coulters. They found that in loam soil, pulling double disc coulters that penetrate to depths of 50, 100, and 150 mm, when working speed was 5.04 $km \cdot h^{-1}$, requires approximately three times less traction force than using a sweep-type coulter under the same conditions.

Mouazen and Ramon [14] investigated the traction of a forged coulter in regards to the soil moisture content and density vs working depth (from 10 to 37 cm) in sandy loam soil. The researchers found that the traction force of a coulter increases with increasing soil moisture, density, and working depth.

Other researcher's [15-18] scientific experiments performed with various tillage and sowing machines in traditional and minimum-till soils were not completely evaluated with respect to the influence of soil compaction and the working speed of the sowing machine on traction forces in no-till and minimum-till soils.

The objective of this study is to identify the influence of a direct sowing machine with complex coulters and various press wheels on traction force under various soil surface compactions.

2. Materials and methods

The research on the mechanical traction characterristics was conducted in 2013 in the Laboratory of the Institute of Agricultural Engineering, University of Hohenheim. The experiment's investigations were performed in a specific soil bin with a length of 46 m, a width of 5 m, a soil layer thickness of 1.2 m, and a soil composition of 72% sand, 16% loam, and 12% clay. The traction force experiments were conducted in soils with three different compactions (Table). These conditions were selected because the surface of no-till or minimum-till soils often is harder than that of traditionally tilled soils.

Table

Compaction of variously prepared soils

Alternatives	Soil preparation
I	The top layer of soil, up to 15 cm, was loosened using a rotary tiller with a vertical axis of 1.5 m width (Fig. 1, a). There was no more tillage. The surface of the soil was loose and wavy.
II	The top layer of soil, up to 15 cm, was loosened using a rotary tiller with a vertical axis of 1.5 m width. Then, the surface of the soil was compacted with a plain cylinder roller of 1.3 m width (Fig. 1, b) and mass of 1000 kg, and the roller was moved in the same direction two times. The surface of the soil was plain and compacted.
III	The top layer of soil, up to 15 cm, was loosened using a rotary tiller with a vertical axis of 1.5 m width. Then, the surface of the soil was compacted with a plain cylinder roller of 1.3 cm width and mass of 1000 kg, and the roller was moved in the same direction six times. The surface of the soil was plain and firmly compacted.

a b

Fig. 1 Soil preparation for the experimental investigations: a – loosening of soil; b – compaction of soil

Prior to the experimental measurements of the traction forces, soil compaction, soil moisture, and soil shear stress were measured. The soil compaction was measured using a manual penetrometer with a time indicator (one step is equal to 6890 Pa). The soil moisture content was measured using a volumetric moisture measurement device (TRIME-FM). And the soil shear stress was measured using a measurement device with an impeller end type (one step is equal to 47.9 Pa). Everyone measurement was carried out at a depth 0-50 mm and involved 10 repetitions.

Experiments were performed using direct sowing equipment that consisted of a frame, complex coulter, seed hopper, press wheel, and other working parts (Fig. 2). Such a machine may be used for seeding sugar beets, corn, or other similar plants in tilled, minimum-till, or no-till soils.

The complex coulter used in the experiment's direct sowing machine consisted of two disc coulters and one shoe coulter. The diameter of both complex coulters was 380 mm; the blades were notched. The disc coulters were fitted at an angle of 15°, and the minimum gap between disc coulters was 6 mm. The disc coulter on the right side had 11 semi-round notches, while the disc coulter on the left had 15 notches of the same shape. The disc coulters penetrated into the soil at a depth of 25 mm. In the centre, between the discs, the machine had a shoe coulter that penetrated into the soil at an angle of 105° and formed a furrow of 30 mm depth.

At the end of the sowing machine, behind the shoe coulter, there was a narrow disc or a finger disc press wheel. Press wheels of such type are often used in sugar beet seeders. The narrow disc press wheel was 220 mm in diameter, 15 mm wide, and 1.4 kg in mass. The finger disc press wheel consisted of two finger discs of 340 mm diameter fitted at a 20° angle. Each disc had 17 fingers in the shape of a cut cone. All fingers were fitted with rubber tips.

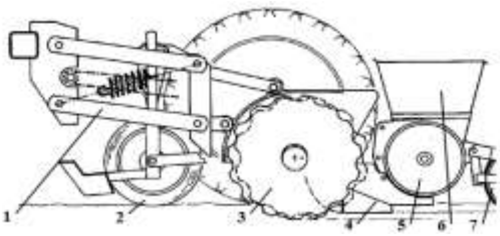

Fig. 2 Experimental direct sowing machine: *1* – frame; *2* – support wheel; *3* – two disc coulters with notched blades; *4* – shoe coulter; *5* – sowing unit; *6* – seed hopper; *7* – press wheel

The traction force of the direct sowing machine was measured using a specific traction force measurement device (Fig. 3) consisting of a two-part frame with six sensors. Three sensors measured the horizontal traction force, two measured the vertical traction force, and one measured the side traction force. Information obtained by the sensors was accumulated in a computer and processed using the computer software MGCPANEN.

The traction force measurement device was fitted between the direct sowing machine and the self-propelled axial carriage GANTRY at a 6 m width. Each second the

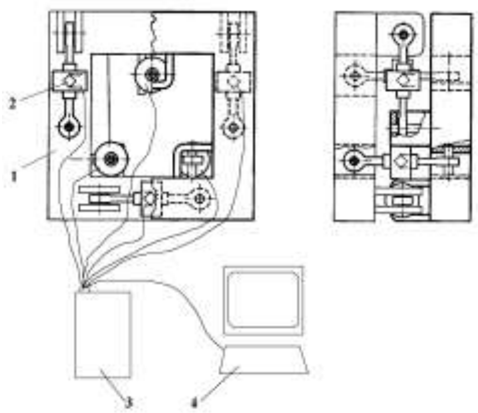

Fig. 3 Traction force measurement device: *1* – frame; *2* – sensors; *3* – amplifier; *4* – computer

device took 10 records of traction forces and speed; the measurement lasted for 10 s. The direct sowing machine was pulled at three different speeds – 5 km·h^{-1}, 7 km·h^{-1}, and 9 km·h^{-1}.

Attempting to compare the traction forces of direct sowing machines of different construction, the experiments were performed using a direct sowing machine without a press wheel, another with a narrow disc press wheel, and another with a finger disc press wheel, each operating at a working speed of 5 km·h^{-1}. Having determined that less traction force is required when a direct sowing machine is equipped with a narrow disc press wheel than a finger disc press wheel, the following experiments were performed with a narrow disc press wheel at the working speeds of 7 km·h^{-1} and 9 km·h^{-1}.

The experiments involved 10 repetitions, and the research data were assessed after calculating the averages under the confidence level of 95% [19].

3. Results analysis

After preparing the soil for the experiments the soil compaction at a depth of 50 mm was found to be 0.044 MPa in Alternative I, where the surface of the soil was loosened by a rotor tiller with a vertical axis. In Alternative II, where the surface of the soil was twice compacted by a cylinder roller, the soil was 11 times harder (0.493 MPa) than the soil in Alternative I. This type of soil compaction is similar to that of minimum-till or light loam no-till soil. In Alternative III, where the surface of the soil was compacted six times by a cylinder roller, the soil was twice as hard (0.827 MPa) as the soil in Alternative II. Such compaction is often common for medium no-till loam soils.

Measurements of the soil shear stress at a depth of 0-50 mm, which corresponds to the depth of seeding sugar beets, showed that the highest soil shear stress was in Alternative III (0.044 MPa). Compared to Alternative III the soil shear stress in Alternative II was 0.027 MPa less (0.017 MPa), whereas it was 0.042 MPa less (0.002 MPa) in Alternative I. The soil moisture content measurements of Alternatives II and III at a depth of 0-50 mm showed that the soil moisture content was 2.5 times higher (11.3% and 10.9%, respectively) after the additional compaction compared to Alternative I (4.5%). This corresponds to approximately the physical soil features in dry climatic conditions.

The traction measurement experiments showed that the highest horizontal traction force (0.68 kN) was from pulling the direct sowing machine without a press wheel at a speed of 5 km·h^{-1} in a soil loosened by a rotary tiller with a vertical axis and compressed six times to the soil compaction of 0.827 MPa. In Alternative I, where the soil compaction reached 0.044 MPa, the horizontal traction force was less (0.08 kN), whereas in Alternative II, where the soil compaction reached 0.493 MPa, the horizontal traction force was higher (0.10 kN) (Fig. 4).

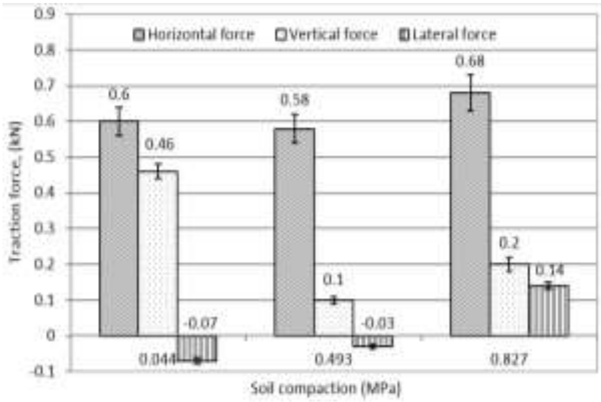

Fig. 4 The influence of soil compaction on the traction forces of a complex coulter at the working speed of 5 km·h^{-1}

The vertical traction force varied more than the horizontal traction force. In Alternative I, the vertical traction force reached 0.46 kN, whereas it decreased to 0.36 kN in Alternative II and 0.26 kN in Alternative III. The highest side traction force (0.14 kN) was observed in Alternative III, where the soil compaction reached 0.827 MPa. Notwithstanding the compaction of the soil, in all cases the horizontal traction force was higher than the vertical and side traction forces. From this perspective the horizontal traction force of the machine or equipment is the most important because it influences the power requirements of the machine [3].

An analogous experiment of traction forces was performed using a direct sowing machine of different constructions. A direct sowing machine was supplemented with a finger disc press wheel. The experiment showed when pulling a complex coulter with a finger disc press wheel at a speed of 5 km·h^{-1} that the highest horizontal traction force (0.65 kN) was in a soil loosened by a rotary tiller with a vertical axis where the soil compaction was 0.044 MPa (Fig. 5). In Alternatives II and III, where the soil surface was further compacted using a 1000 kg plain cylinder roller, the horizontal traction force was 0.02-0.06 kN less than in Alternative I. The highest vertical traction force (0.50 kN) was also in Alternative I, where the soil compaction reached 0.044 MPa. In Alternative II, the vertical traction force was 0.24 kN less, whereas in Alternative III it was 0.03 kN less than in Alternative I. The highest side traction force (0.06 kN) was observed in Alternative III, where the soil hardness reached 0.827 MPa. In the other alternatives the side traction force varied from -0.02 to 0.02 MPa.

For comparison, traction measurement experiments using a direct sowing machine with a complex coulter and narrow disc press wheel were performed. Based on the research results, pulling a complex direct sowing coul-

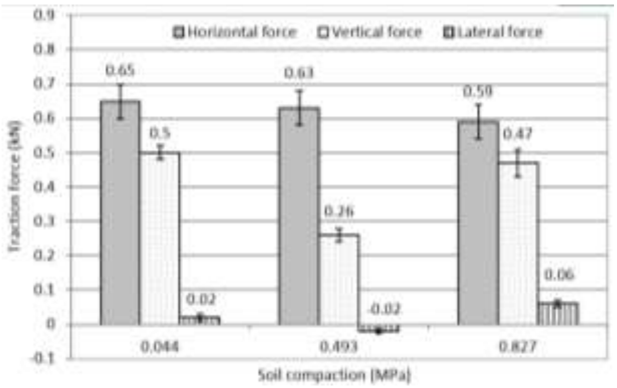

Fig. 5 The influence of soil compaction on the traction forces of a complex coulter with a finger disc press wheel at a working speed of 5 km·h^{-1}

ter with a narrow disc press wheel at a working speed of 5 km·h^{-1}, the highest horizontal traction force (0.64 kN) was in the soil loosened by a rotary tiller with a vertical axis, where the soil compaction was 0.044 MPa (Fig. 6, a). In Alternatives II and III, the horizontal traction force was 0.12 kN less even though the soil was harder than in Alternative I, due to the fact that the surface of the compacted soil was much smoother. The surface of the soil in Alternative I was light and wavy, such that even a support wheel was not able to rotate freely; the support wheel and the press wheel penetrated into the soil that was resistant to traction by the mentioned parts of the direct sowing machine. The highest vertical traction force (0.45 kN) was observed in Alternative II, where the soil compaction reached 0.493 MPa. Compared to Alternative II, the vertical traction force of Alternative I was 0.05 kN less, whereas it was 0.16 kN less in Alternative III. In all Alternatives, the side traction force was insignificant (from -0.01 to -0.03 kN) and was directed to the opposite side.

After increasing the working speed of a complex coulter with a narrow disc press wheel to 7 km·h^{-1}, it was found that the horizontal traction force increased in all the investigated alternatives (Fig. 6, b). In Alternative I, which had the least compacted soil (0.044 MPa) and an uneven surface, the average traction force reached 0.75 kN. In the soils compacted two and six times, the horizontal traction forces were less (0.15-0.20 kN) than in soil loosened by a rotary tiller with a vertical axis. The highest vertical traction force (0.30 kN) was observed in the soil with a compaction of 0.827 MPa. In less compacted soils (0.044 and 0.493 MPa), the vertical traction force was less (approximately 0.02 kN) than in the most compacted soil (0.827 MPa). Traction force of machine depends not only on the working parts of the technological and construction parameters but also on the characteristics of the soil [1] and [2]. Increasing the density of the soil increase the traction force [14]. After increasing the working speed from 5 to 7 km·h^{-1}, the vertical traction force, in contrast to the horizontal traction force, decreased in the soil compaction Alternatives I and II and remained almost unchanged in Alternative III. The side traction force was not significant and varied from -0.03 to 0.05 kN in all Alternatives. After increasing the working speed of the complex coulter with a narrow disc press wheel to 9 km·h^{-1}, the experiments revealed that the highest traction force (0.71 kN) was in soil loosened by a rotary tiller with a vertical axis, where the soil compaction was 0.044 MPa (Fig. 6, c).

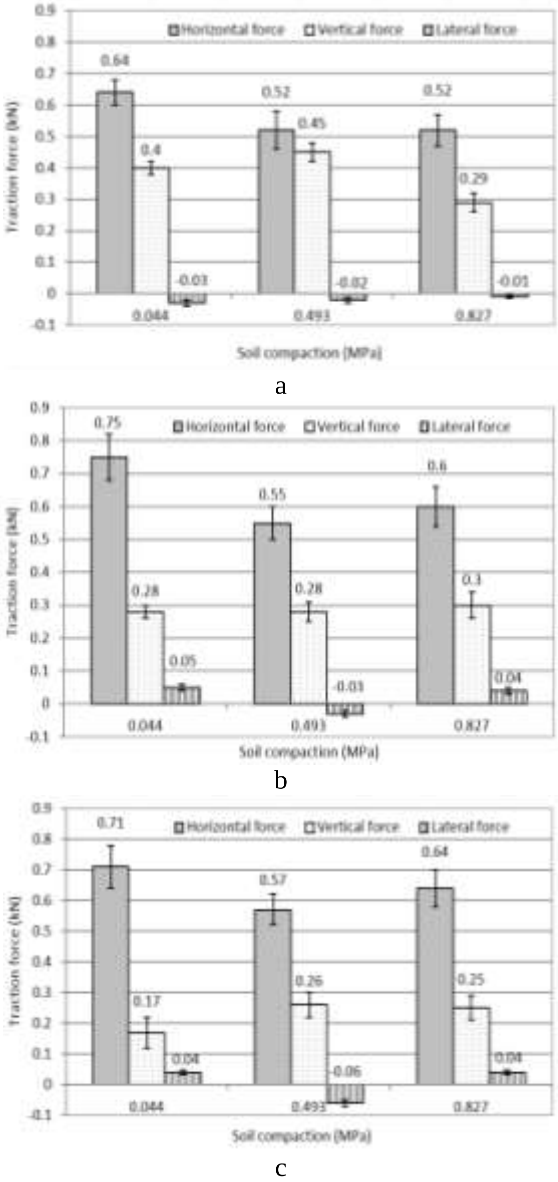

Fig. 6 The influence of soil compaction on the traction forces of a complex coulter with a narrow disc press wheel at a different working speeds: a - 5 km·h^{-1}; b - 7 km·h^{-1}; c - 9 km·h^{-1}

In Alternative II, where the soil compaction was 0.493 MPa, the horizontal traction force was less at 0.14 kN, whereas in Alternative III, the traction force was less, at 0.07 kN, than in the softest soil of Alternative I. The highest vertical traction force (0.26 kN) was found in Alternative II, with a soil compaction of 0.493 MPa. In Alternative I, the vertical traction force was less, at approximately 0.09 kN, whereas in Alternative III, it was less, at 0.01 kN, compared to that in Alternative II. The side traction force varied from -0.06 to 0.04 kN in all soil compaction alternatives.

Comparing the results of the experiments on direct sowing machines with various constructions, at a working speed of 5 km·h^{-1}, it was found that when pulling a complex coulter without a press wheel, the total traction force remains similar to that of pulling a complex coulter with a narrow disc press wheel. Comparing the results of the experiments with different press wheels, when the working speed is 5 km·h^{-1}, it was found that pulling a complex coulter with a narrow disc press wheel requires approximately 0.06 kN less total traction force than pulling a complex coulter with a finger disc press wheel. Thus, only the influence of the speed of a narrow disc press wheel was researched. Increase of traction force depends on the machine working parts construction and technological parametres and working speed [2].

Construction of narrow disc press wheel allows rotating evenly on the soil. Finger disc press wheel touches the soil and fingers penetrates in it. This increases resistance of traction and at the same energy costs.

In summary, pulling a complex coulter with a narrow disc press wheel requires the least traction force at a working speed of 5 $km \cdot h^{-1}$. After increasing the working speed to 7 $km \cdot h^{-1}$, the horizontal traction force increases while the vertical traction decreases. After increasing the working speed to 9 $km \cdot h^{-1}$, all traction forces remain almost unchanged compared to those at a working speed of 7 $km \cdot h^{-1}$.

Analysing influence on soil hardness of the direct sowing equipment traction was obtained interesting results. It was found that increased hardness of the soil from 0.044 MPa to 0.493 MPa decreased horizontal traction force. This result was obtained because in Alternative I the soil was very loose and support wheel of direct sowing machine (Fig. 2) penetrated into the soil and had additionally overcome the resistance of the soil. In Alternative II and III soil hardness was sufficient and support wheel freely rolled on the soil surface.

The experiments were performed with only one direct sowing machine. In actual practise, sugar beets or other plants are seeded several rows at a time, and thus, one frame is fitted with the number of sowing machines corresponding to the number of rows. Most often, one pass covers 6, 8, 12, or 18 rows; thus, the obtained traction forces increase accordingly. Additionally, it should be taken into account that increasing the number of rows requires a heavier frame and support wheels, and thus, actual sowing may result in higher traction forces.

4. Conclusions

1. The experiments were performed in soils with different characteristics. In Alternative I, the soil compaction at a depth of 50 mm was 0.044 MPa, the soil shear pressure was 0.002 MPa, and the soil moisture content was 4.5%. In Alternative II, accordingly, the soil hardness was 0.493 MPa, the soil shear pressure was 0.017 MPa, and the soil moisture content was 11.3%. In Alternative III, the soil hardness was 0.827 MPa, the soil shear pressure was 0.044 MPa, and the soil moisture content was 10.9%.

2. Comparing the influence of various press wheel constructions on traction forces, it was found that pulling a complex coulter without a press wheel at a working speed of 5 $km \cdot h^{-1}$ requires almost the same traction force as pulling a complex coulter with a narrow disc press wheel (0.69 kN and 0.68 kN, respectively), whereas pulling a complex coulter with a finger press wheel requires a higher traction force (0.74 kN). Fingers of rotating finger disc press wheel penetrated into the soil and this increased resistance of the traction compared with narrow disc press wheel.

3. In soil loosened by a rotary tiller, where the surface compaction was 0.044 MPa, the horizontal traction force required for pulling a complex coulter of a direct sowing machine at a working speed of 5 $km \cdot h^{-1}$ was approximately 0.11 kN less than at a working speed of 7 $km \cdot h^{-1}$ and approximately 0.07 kN less than at the working speed of 9 $km \cdot h^{-1}$. A similar effect of a lower horizontal traction force at a lower working speed was also obtained in harder soils artificially compacted using a plain cylinder roller.

4. The vertical and side traction forces of a complex coulter with a narrow press wheel remained less than the horizontal traction force in all cases. At a working speed of 5 and 9 $km \cdot h^{-1}$, the highest vertical traction force was obtained in soil with a compaction of 0.493 MPa, which had been compacted twice with a 1000 kg plain cylinder roller. At a working speed of 7 $km \cdot h^{-1}$, the vertical traction force was higher, at 0.02 kN, in the soil with the compaction of 0.827 MPa, which had been compacted with a plain cylinder roller six times. The side traction force was insignificant compared to the other traction forces and varied from -0.06 to 0.05 kN.

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References

1. **Safa, M.; Tabatabaeefar, A.** 2008. Fuel consumption in wheat production in irrigated and dry land farming, World Journal of Agricultural Sciences 4(1): 86-90.
2. **Dedousis, A.P.** 2007. An investigation into the design of precision weeding mechanisms for inter and intra-row weed control [Ph.D. thesis], Cranfield University.
3. **Mishin, P.; Maksimov, E.; Drandrov, I.** 2005. Ways of efficiency operation soil-cultivating aggregates: Ecological aspects of mechanization of plant production, XI International Symposium, Warszawa.
4. **Gebresenbet, G.; Jonsson, H.** 1992. Performances of seed drill coulters in relation to speed depth and rake angels, Journal of Agricultural Engineering Research 52(2): 121-145. http://dx.doi.org/10.1016/0021-8634(92)80055-W.
5. **Wang, J.; Gee-Clough, D.** 1993. Deformation and failure in wet clay soil: Part 2 soil bin experiments, Journal of Agricultural Engineering Research 54(1): 57-66. http://dx.doi.org/10.1006/jaer.1993.1004.
6. **Šarauskis, E.; Buragiene, S.; Masilionytė, L.; Romaneckas, K.; Avižienytė, D.; Sakalauskas, A.** 2014. Energy balance, costs and CO2 analysis of tillage technologies in maize cultivation, Energy 69: 227-235. http://dx.doi.org/10.1016/j.energy.2014.02.090.
7. **Bianchini, A.; Magalhaes, P.S.G.** 2008. Evaluation of coulters for cutting sugar cane residue in a soil bin. Biosystems Engineering 100(3): 370-375. http://dx.doi.org/10.1016/j.biosystemseng.2008.04.012.
8. **Huijsmans, J.F.M.; Hendriks, J.G.L.; Vermeulen, G.D.** 1998. Draught requirement of trailing-foot and shallow injection equipment for applying slurry to grassland, Journal of Agricultural Engineering research 71(4): 347-356. http://dx.doi.org/10.1006/jaer.1998.0332.
9. **Magalhaes, P.S.G.; Bianchini, A.; Braunbeck, O.A.** 2007. Simulated and eksperimental analyses of a

toothed rolling coulter for cutting crop residues, Biosystems Engineering 96(2): 193-200. http://dx.doi.org/10.1016/j.biosystemseng.2006.10.014.

10. **Germanas, L.** 2006. Straw effect of disc sowing coulter resistance force, Agricultural Engineering, Research Paper 38(1): 29-39 (In Lithuanian).
11. **Nalavade, P.; Salokhe, V.M.; Niyamapa, T.; Soni, P.** 2010. Performance of free rolling and powered tillage discs, Soil & Tillage Research 109(2): 87-93. http://dx.doi.org/10.1016/j.still.2010.05.004.
12. **Ranta, O.; Koller, K.; Ros, V.; Drocas, I.; Marian, O.** 2008. Study regarding the forces that occurs in a no-till technology process in relation with geometrical parameters of the coulter discs, Bulletin UASVM, Agriculture 65(1): 223-228.
13. **Rahman, S.; Chen, Y.** 2001. Laboratory investigation of cutting forces and soil disturbance resulting from different manure incorporation tools in a loamy sand soil, Soil & Tillage Research 58(1-2): 19-29. http://dx.doi.org/10.1016/S0167-1987(00)00181-1.
14. **Mouazen, A.M.; Ramon, H.** 2002. A numerical-statistical hybrid modelling scheme for evaluation of draught requirements of a subsoiler cutting a sandy loam soil, as affected by moisture content, bulk density and depth, Soil & Tillage Research 63(3-4): 155-165. http://dx.doi.org/10.1016/S0167-1987(01)00243-4.
15. **Šarauskis, E.; Masilionytė, L.; Andriušis, A.; Jakštas, A.** 2013. The force needed for breaking and cutting of winter wheat and spring barely straw, Zemdirbyste-Agriculture 100(3): 269-276. http://dx.doi.org/10.13080/z-a.2013.100.034.
16. **Romaneckas, K.; Avižienytė, D.; Šarauskis, E.; Martinkus, M.; Pilipavičius, V.; Adamavičienė, A.; Sakalauskas, A.** 2012. Impact of ploughless tillage on soil physical properties and winter wheat productivity, Journal of Food, Agriculture & Environment 10(1): 501-504.
17. **Avižienytė, D.; Romaneckas, K.; Pališkytė, R.; Bogužas, V.; Pilipavičius, V.; Šarauskis, E.; Adamavičienė, A.; Vaiciukevičius, E.** 2013. The impact of long-term reduced primary soil tillage on maize (Zea mays L.) productivity, Zemdirbyste-Agriculture 100(4):379-384. http://dx.doi.org/10.13080/z-a.2013.100.048.
18. **Šarauskis, E.; Godlinski, F.; Sakalauskas, A.; Schlegel, M.; Kanswohl, N.; Romaneckas, K.; Jasinskas, A.; Pilipavičius, V.** 2010. Effects of soil tillage and sowing systems on sugar beet production under the climatic conditions of Lithuania, Landbauforschung 60(2): 101-110 (in Germany).
19. **Tarakanovas, P.; Raudonius, S.** 2003. The program package "Selekcija" for processing statistical data. Akademija, Kedainiai. 56 p. (in Lithuanian).

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TIESIOGINĖS SĖJOS MAŠINOS DARBINIŲ DALIŲ MECHANINĖS TRAUKOS SAVYBIŲ TYRIMAI

R e z i u m ė

Šiame darbe pateikti eksperimentinės tiesioginės sėjos mašinos įrenginio su kombinuotu noragėliu ir skirtingos konstrukcijos prispaudimo voleliais (diskiniu siauru ir diskiniu pirštiniu) mechaninės traukos savybių tyrimų priklausomybės nuo darbinio greičio ir dirvos kietumo. Įrenginys buvo traukiamas trimis skirtingais greičiais – 5 km·h^{-1}, 7 km·h^{-1} ir 9 km·h^{-1}. Tyrimai vykdyti trijų skirtingų kietumų dirvose. Pirmame variante dirvos kietumas 50 mm gylyje buvo 44 kPa, antrame variante – 493 kPa, trečiame – 827 kPa. Traukos jėga matuota šešiais jutikliais, iš kurių trys matavo horizontalią, du vertikalią ir vienas šoninę jėgą.

Tyrimais nustatyta, kad 5 km h^{-1} darbiniu greičiu traukiant tiesioginės sėjos mašinos įrenginį be prispaudimo volelio reikia panašiai tiek pat suminės traukos jėgos, kaip ir traukiant tiesioginės sėjos mašinos įrenginį su siauru prispaudimo voleliu. Tuo tarpu traukiant tiesioginės sėjos mašinos įrenginį su pirštiniu prispaudimo voleliu reikia vidutiniškai apie 0.06 kN daugiau suminės traukos jėgos. Didinant tiesioginės sėjos mašinos įrenginio su diskiniu prispaudimo voleliu važiavimo greitį iki 7 km·h^{-1}, horizontali traukos jėga didėja, o vertikali – mažėja. Padidinus važiavimo greitį iki 9 km·h^{-1}, visų traukos jėgų pokyčiai lyginant su 7 km·h^{-1} greičiu, buvo nežymūs.

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RESEARCH OF MECHANICAL TRACTION CHARACTERISTICS OF DIRECT SOWING EQUIPMENT

S u m m a r y

The objective of this study is to define the influence of working speed on the traction force of a direct sowing machine with complex coulters and various press wheels (a narrow disc and a finger disc) under various soil compactions. The machine was pulled at three different speeds – 5 km·h^{-1}, 7 km·h^{-1}, and 9 km·h^{-1} – in soils of three different compactions. In the first trial soil compaction was 44 kPa at 50 mm depth, in the second trial – 493 kPa, in the third trial – 827 kPa. The traction force was measured using six sensors – three for horizontal force, two for vertical force, and one for side force. The research indicated that pulling direct sowing machine without a press wheel at working speed of 5 km·h^{-1} requires almost the same total traction force as pulling direct sowing machine with a narrow disc press wheel, while sowing machine with tined disc requires higher traction force at approximately 0.06 kN. Increasing the working speed of direct sowing machine with disc press wheel up to 7 km·h^{-1}, horizontal traction force increases, while vertical traction force decreases. Increasing the working speed up to 9 km·h^{-1}, the traction forces do not expose significant increase compared to the working speed of 7 km·h^{-1}.

Keywords: traction force, speed, soil compaction, complex coulter, press wheels, direct sowing.

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