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Performance of New Design Mouldboard Plough Model (Double Sided Plough) in a Soil Bin

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Abstract: Mouldboard plough is common tillage tool tool in the traditional tillage system by farmers in the world. Single-sided moldboard ploughs (SMP) are used widely for conventional tillage. But, SMP forms ridges or open furrows in the field due to its way of entering to the field which causes deformation in the field leveling. Unnecessary empty turns of SMP decreases not only the efficiency of the plough but also increases the fuel consumption. To avoid the disadvantages of SMP, reversible mouldboard plough (RMP) is used by farmers. But RMP requires high power tractors due to its heavy structure (2 ploughs in the same frame). Beside its heavy structure, RMP are quite expensive to buy comparing the prices of SMP. The advantages of SMP are low buying price and not requiring high power tractors, but they have also disadvantages like causing deformation in the field leveling, high fuel consumptions and low efficiency comparing the RMP. New mouldboard plough was designed to avoid disadvantages but at the same time to gain advantages of both SMP and RMP. This new design plough was named **Double Sided Mouldboard Plough (DSMP)** can invert the soil in both directions of the tractor like RMP does. DSMP has similar number of plough body like SMP and does not require a high power tractor. Due to its light structure, DSMP removes the disadvantages of RMP while maintains the advantages of both SMP and RMP.

The objective of this research was to evaluate the performance of DSMP and compare the results with two different models SMP in a soil bin. For this purpose, one half scale of single bottom DSMP model was constructed and tested in the soil bin with 10% moisture content located in the department of farm machinery, Warsaw Agricultural Faculty, Warsaw, Poland. Tillage quality and specific draft of the DSMP at different travel speed were measured for the performances of the model plough in the soil bin. The results were compared with previously made experiment in which similar models of SMP used in the same soil bin with 14% moisture content. According to the results, DSMP can be used effectively as an alternative to the SMP and RMP in the field conditions once its frame properly designed.

Keywords; Conventional tillage, mouldboard plough, reversible plough, double sided plough, plough models, tillage, soil bin.

INTRODUCTION

The conventional mouldboard plough is the main implement for tillage. It is used for soil cutting, crumbling, lifting and turning to create the necessary conditions for plant growth. As a consequence, scientists continue to impart great attention to improving the geometry and investigating the power characteristics of the plough.

The working resistance is the basic parameters for evaluation of tillage implements. As it is evident from numerous investigations, the resistance values of plough bodies are significantly influenced –apart from soil parameters- by characteristic constructional features of the bodies, connected with dimensions and shape of working surface of the body, particularly: the rake angle and cutting angle of the share, setting angle of the mouldboard etc. (Guclu et al., 1995).

Since early this century, mouldboard plough draught has been measured to analyze the effect of several variables which are thought likely to influence its magnitude. Randolph and Reed (1938), Collins et al. (1978), and Bloome et al. (1983), have all related draught to travel speed of tractor-drawn mouldboard ploughs by quadratic functions of speed in a variety of soil types and at speeds ranging from 0.44 to 2.69 m/s. Later, Gebresenbet (1989) reported a similar relationship for the 0-2 m/s speed range. O'Callaghan and McCoy (1965) measured the forces on the share; mouldboard and coulter within a speed range of 0.4 - 1.65 m/s and found that the major portion of increase in draught force was due to increase in the forward speed of ploughing.

Singh et al. (1979) studied the effect of speeds in the range 0.31-1.13 m/s on specific draught of mouldboard and disc ploughs in clay soil and recorded a linear response. Singh et al. (1991) also reported a linear relationship between draught and speed over the 0.45-0.90 m/s range. Depth has a significant effect on draught of tillage implements. The relationship has derived limited investigation (1991) probably due to difficulties encountered in its assessment under field operating conditions.

Randolph and Reed (1938) and Reed (1941), reported on the effect of depth on specific draught of mouldboard ploughs in six soil types. Their data indicated that the depth of operation can be increased by up to 130 mm without an appreciable increase in draught in most soil conditions. Collins et al. (1978) reported a linear function of draught with depth for the mouldboard plough. Garner and Wolf (1981) fitted a linear relationship for draught with depth for different soil zones. Gunderson et al. (1981) working on depth control of implements fitted a quadratic function of depth for field cultivators.

MATERIALS and METHODS

New mouldboard plough was designed to avoid disadvantages but at the same time to gain advantages of both Single-sided moldboard plough (SMP) and reversible mouldboard plough (RMP). This new design plough was named as **Double Sided Mouldboard Plough (DSMP)** which can invert the soil in both directions of the tractor like RMP does (Figure 1). Side views of the DSMP model was given in Figure 2.

Figure 1. Double Sided Moldboard Plough (DSMP)

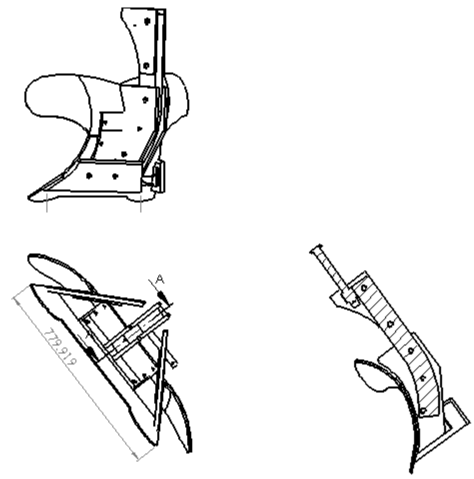

Figure 2. Side views of DSMP

Figure 3. Soil bin

To examine the performance of the new designed plough in a soil bin conditions, 1/2 scale of DSMP was constructed and tested in a soil bin located in the department of Farm Machinery, Warsaw Agricultural University (SGGW) (Figure 3). Dimensions of soil bin were 9 x 1 x 0,5 m filled with clayish sand soil according to the soil science classification. The mechanical composition of the soil is presented in Table 1.

Table 1. Mechanical composition of soil in the soil bin

Share of particular fractions (%)		
1 – 0.1 mm	0.1 – 0.02 mm	< 0.02 mm
81	**12**	**7**

To evaluate the performance of DSMP model in a soil bin, tillage quality and specific draft of the DSMP at different travel speed were measured. The results were compared with previously made experiment (by Yavuzcan and his friends, 1998) in which similar models of SMP (Body A and B) used in the same soil bin with 14% moisture content (Figure 4).

Figure 4. Compared plough models (Body A and B)

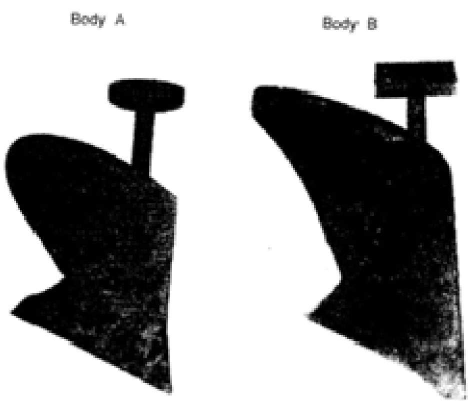

Figure 5. Plough body is mounted on the strain gauge handles

The investigated model plough bodies were equipped with semi-digger (cylindroid) mouldboards. Technical specifications of the ploughs are given in Table 2. The bodies were mounted on strain gauge handles, enabling to measure the working resistances during measuring runs (Figure 5). The results were recorded with the use of computer equipped with an analogue - numerical card.

Table 2. Technical Specifications of the model ploughs

Index	Unit	Bod A	Body B	DSMP
Length of share, L	mm	217	287	440
Rake angle of share, Q_o	(...°)	40	40	31
Cutting angle of share, γ	(...°)	39	25	21
Angle of mouldboard wing setting, Q_s	(...°)	48	44	45
Length of mouldboard wing, L_o	mm	310	430	480
Heigh of body, H	mm	238	260	250

The soil preparation for the measurements involved its deep loosening and then compacting with the use of a flat roller equipped with additional weights. The measurements were made in the soil with 10% moisture content for DSMP and 14% for models A and B and soil compactions 0.51 (MPa) for DSMP and 0.405 MPa for models A and B measured with cone penetrometer (ASAE Standard R 313.3). Tillage was performed with two working speeds of 0,5 and 1.0 m/s. The working width of all plough models was 20 cm, while depth of work amounted to 15 cm.

Figure 6. Soil profile measurements by laser in the soil bin

Soil profiles were measured by laser (Figure 6) to determine the tillage quality of DSMP after tillage.

Statistical analysis was not made due to comparison of two studies but made in different time and with different soil moisture contents. The comparison was made upon average specific draft requirements of the model ploughs.

RESULTS and DISCUSSION

Specific Draft

According to the experiments, it could be said that DSMP showed similar behavior for specific draft measurements with other plough models A and B in an average similar soil conditions (Figure 7). Plough model B had the least specific drafts of 16,2 kN/m^2 and 19 kN/m^2 at 0,5 m/s and 1 m/s forward speeds, respectively. Model A and the double sided model plough required similar specific draft for tilling the soil in the soil bin as 18,8 kN/m^2 and 23 kN/m^2 at 0,5 m/s and 1 m/s forward speeds, respectively. All model ploughs had higher specific drafts for 1 m/s forward speed comparing 0,5 m/s.

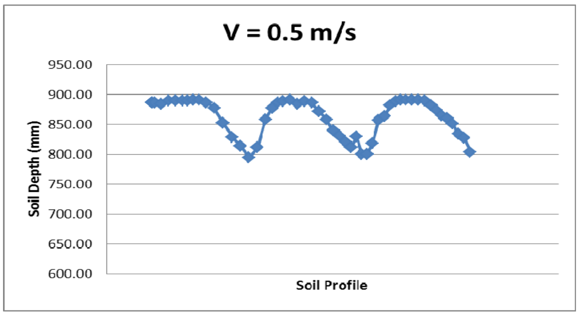

Figure 7. Specific drafts of model ploughs

Soil Profile

Soil profiles of DSMP for 0,5 m/s and 1 m/s forward speeds were given in figure 8 and 9. Model DSMP inverts and lay down the soil to the side as desired from the regular plough model. There was found irregular soil profile for only forward speed 1 m/s due to increasing speed. Increasing speed increased the pulverizing effect which caused the irregular shape on the soil profile.

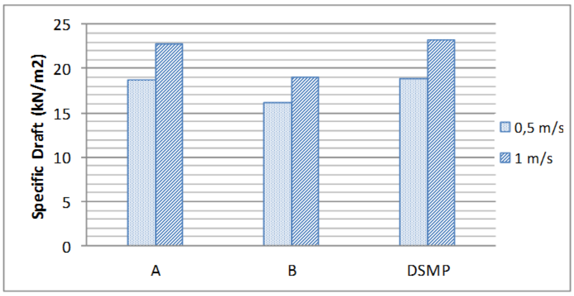

Figure 8. Soil profiles for tillage with a speed of 0,5 m/s

CONCLUSIONS

According to the results, it can be concluded that new design double sided plough can be used effectively as an alternative to the standard plough since it does the tillage as effective as the other model ploughs and creates acceptable soil profile.

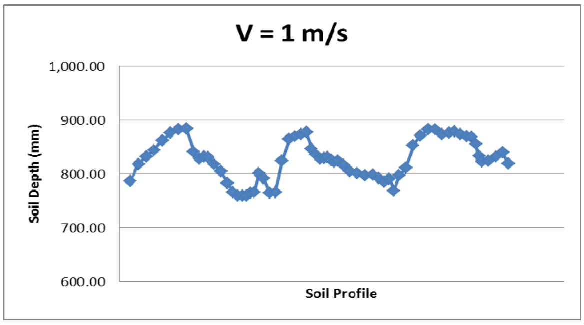

Figure 9. Soil profiles for tillage with a speed of 1 m/s

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