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Effect of coating materials on draft requirement of tractor drawn mould board plough

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Abstract

The article presents the draft requirements of tractor drawn single bottom mould board plough by using teflon and chromium coating on the soil engaged components such as the mould board, share and landside in comparison with uncoated plough. Trials were conducted in Tamil Nadu Agricultural University, Coimbatore, at three levels of moisture content *viz*., 20-25(M_1), 25-30 (M_2) and 30-35 (M_3) per cent moisture content on a clay loam soil. The selected levels of coating materials for mould board plough bottom were uncoated i.e bare (C_1), chromium (C_2) and teflon (C_3). The forward speeds of operation selected for investigation were 2 (F_1), 3 (F_2) and 4 kmh^{-1}(F_3). The teflon coating (C_3) material had a profound effect in decreasing the draft compared to chromium coated (C_2) and uncoated plough bottom (C_1) for all selected levels of forward speed and moisture content. The linear increase in draft was observed with increase in moisture content from 20-25 per cent (M_1) to 30-35 per cent (M_3) for the selected levels of coating material and forward speed. The minimum draft was registered as 0.235 kN for the mould board coated with teflon (C_3) at the forward speed of 2 kmh^{-1} (F_1) and in the moisture range of 20-25 (M_1) per cent. The maximum draft of 0.336 kN was registered for the uncoated plough bottom (C_1) operating at the speed of 4 kmh^{-1}(F_3) in the moisture range of 30-35 per cent (M_3).

Keywords: draft, teflon coating, chromium coating, forward speed and moisture content

1. Introduction

The tractor drawn mould board plough is widely used for primary tillage in India. Generally the mould board plough works well as a low speed soil inverting implement and improvements in the design can be obtained mainly by reducing draft and wear. The tillage operation requires the most energy and power spent on farms. Therefore, draft and power requirements are important in order to determine the size of the tractor that could be used for a specific implement. The draft required for a given implement will also be affected by the soil conditions and the geometry of the tillage implement (Taniguchi *et al*., 1999; Naderloo *et al*., 2009; Olatunji *et al*., 2009) [4, 2, 3]. The draft force of soil tillage machines is affected by conditional parameters such as tool type, working width, working depth, and working speed. The second area of factors influencing draft force are the factors dependent on the site, such as soil type, soil bulk density and soil moisture (Arvidsson *et al*., 2004) [1].

Various attempts have been made to reduce friction and adhesion of soil on tillage implements by using coatings, such as glass, teflon, special paints and other low friction materials. According to Wismer *et al*. (1968) [5], friction on mould board plough may represent as much as 30 per cent of the total draft. They found that covering the plough bottom with teflon reduced the draft by 23 per cent. Considering that teflon and chromium coating technique is cheap and readily available in the industry and with the promising results obtained so far, it was decided to evaluate the draft requirement of teflon and chromium coated single bottom tractor drawn mould board plough and compare its performance with similar uncoated plough under similar working conditions.

2. Materials and Method

2.1 Experimental site

The traditional rice fields of Tamil Nadu Agricultural University located approximately 11° 00’ 11’’ N and 76° 55’ 28’’ E was selected for the field experiment.

2.2 Soil sampling and analysis

The soil samples were collected from the experimental rice fields at a depth of 20 cm and particle size distribution (sand, silt and clay) was analyzed under the laboratory. The soil in the experimental site was identified as clay loam. The clay loam soil consisted of 36.5 per cent clay, 20.9 per cent silt and 46.6 per cent sand. The soil cohesion and angle of internal friction were 67.5 kN m^{-2} and 26.8°.

2.3 Draft measuring experimental test rig

To investigate the influence of the selected levels of variables *viz.*, forward speed, mould board plough bottom and moisture content an experimental draft measuring unit was constructed. The draft measuring unit consists of a frame, a shank, load cell assembly and an indicator. The main frame consists of a rectangular section of 1500 x 550 mm made of 75 x 40 x 6 mm mild steel channel section. To hitch the unit with the tractor the three point hitch assembly was provided in the front part of the main frame. Two support frames of 75 x 40 x 6 mm mild steel channel for 900 mm length were mounted at the bottom portion of the main frame with a spacing of 7 mm to fit the shank of the mould board plough bottom. At the rear end of 900 mm length sub frame a 50 x 50 x 6 mm 'L' angle section of length 700 mm was welded vertically. The shank of length 1100 mm made of 50 x 12.7 mm mild steel was inserted between the two support frames. The middle part of the sub frame shank was made to rest on the bolt, connecting the shank with the sub frame. The oscillating movement of the shank was arrested by minimizing the clearance between the sub frames by providing suitable washers. The shank's rearward lateral movement was arrested by providing a lock plate. For the provision of load cell attachment, top part of the shank was provided with holes at an interval of 20 mm. The load cell assembly consists of a 100 kg capacity 'S' type tension load cell connected to the indicator with suitable cable, an adjustable and fixed sleeve. Load cell was placed in line with shank and vertical 'L' section, one end of the load cell was attached to the vertical 'L' section with adjustable sleeve and other end was fixed to the shank with fixed sleeve. The plough bottom was attached to the experimental unit and operated; the force exerted on the plough bottom was noted from the load cell indicator and recorded for every ten meters of length.

2.4 Field experiment

The experimental field of 70 m x 50 m was flooded to saturation level and were allowed to dry to attain desired moisture level of 30-35 per cent (wet basis). The soil samples were collected at ten different locations in the field and their average soil moisture contents was found by oven method. Similar method was adopted for other moisture levels 25-30 per cent and 20-25 per cent. The forward speed of 2, 3 and 4 km h^{-1} was achieved with appropriate gear selection. The plough bottom was attached to the experimental unit and operated; the force exerted on the plough bottom was noted from the load cell indicator and recorded for every ten meters of length. For the experiments teflon and chromium coated and uncoated ploughs were set to operate at a nominal depth of 150 mm and width of 120 mm. The trials for each test were replicated three times maintaining approximately the same working conditions. The draft measuring test rig in action is shown in Fig.1.

Fig 1: Draft measuring test rig in action

3. Results and Discussion

The effect of forward speeds on draft at selected levels of moisture contents (M) and coating materials (C) is shown in Fig. 2. It is noticed that the increase in forward speed is directly propositional to draft for all the plough bottoms. Increase in forward speed from 2 km h^{-1} (F_1) to 4 km h^{-1}(F_3) in the moisture range of 20-25 per cent (M_1) resulted in 13.86, 15.10 and 15.74 per cent increase in draft for uncoated (C_1), chromium (C_2) and teflon (C_3) coated ploughs respectively. The teflon coated (C_3) plough registered minimum draft values than chromium (C_2) and uncoated (C_1) plough for all the levels of forward speed (F)). The minimum and maximum draft of 0.235 and 0.304 kN was observed for teflon coated (C_3) and uncoated plough (C_1) at 2 km h^{-1}(F_1) and 4 km h^{-1}(F_3) respectively in the moisture range 20-25 per cent (M_1). Increase in moisture content from 20-25 per cent (M_1) to 25-30 per cent (M_2) showed a marginal increase in draft for all the selected levels of forward speeds (F) and plough bottom coating materials (C). When the moisture content was increased from 20-25 (M_1) to 25-30 per cent (M_2) there was increase in draft by 6.25, 3.54 and 2.94 per cent respectively for bare, chromium and teflon plough bottoms, when operated at the forward speed of 4 km h^{-1}. The same trend as that of 20-25 and 25-30 per cent was reflected with draft variation 0.268 to 0.336 kN for all the selected levels of plough bottom coating materials and forward speeds in the moisture range of 30-35 per cent (M_3).

In general, teflon coated (C_3) plough exhibited lower draft values than chromium (C_2) and uncoated (C_1) ploughs for all selected levels of forward speed (F) and moisture content (M). The anti-adhesive property of teflon against the soil reduced the draft force for all the selected levels of variables for investigation. It was noticed that there was linear increase in draft values when moisture content was increased from 20-25 per cent (M_1) to 30-35 per cent (M_3). Increase in forward speed of operation showed there was linear increase in draft for all the selected levels of moisture contents and plough bottom coating materials. The minimum draft was registered as 0.235 kN for the mould board coated with teflon (C_3) at the forward speed of 2 kmh^{-1} (F_1) and in the moisture range of 20-25 (M_1) per cent. The maximum draft of 0.336 kN was registered for the uncoated plough bottom (C_1) operating at the speed of 4 kmh^{-1}(F_3) in the moisture range of 30-35 per cent (M_3).

The teflon coated plough is cheap and affordable innovation in the tillage practice. Observations were also made for any scratches or damage on the coated surface of the plough, but none were found. Since these were preliminary observations based on short term applications we could not conclude about strength and durability of the teflon coating. Further investigations are needed to find out its wear resistance, reliability and applicability in practice. Apart from the improved draft characteristics the teflon coated plough showed improved scouring abilities as compared to uncoated plough and chromium. These were observed particularly at 20-25 per cent moisture content, where the soil engaged surfaces were always free of stuck soil clods. Therefore, the application of teflon coating contributed not only to improved plough draft requirements but also to better soil scouring properties.

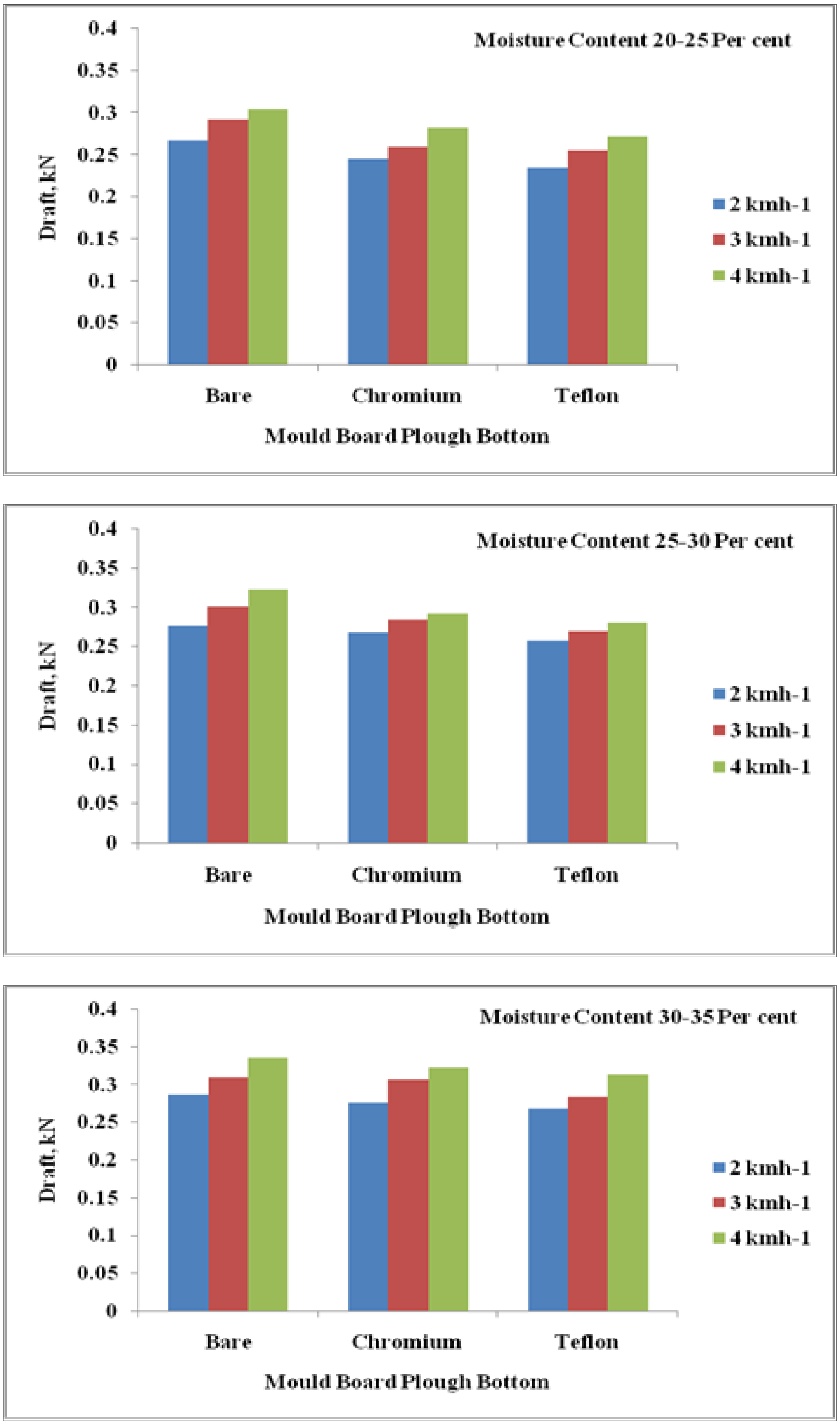

Fig 2: Effect of teflon and chromium coated and uncoated ploughs on draft at selected levels of forward speed and moisture content

4. Conclusion

Results confirm that teflon coating has a considerable influence on the working performance of tractor drawn mould board plough. It was found that teflon coated plough reduced the draft by as much as 15.74, 8.53 and 17.16 per cent at 20-25, 25-30 and 30-35 per cent soil moisture contents respectively. Based on the considerable draft reduction and as well as better soil scouring performance it may be concluded that the draft requirement of the teflon coated plough are compatible with the tractor drawn mould board plough when compared to uncoated and chromium coated plough bottoms.

5. References

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