Optimization of mechanical and operating parameters for improving chisel plow performance in heavy clay soils

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Abstract

A chisel plow is considered an effective implement in different agricultural soils, especially in heavy soils requiring improvement of their physical properties. The effectiveness of this plow may differ depending on various parameters as soil type, tillage depth, operating work conditions, power required, and chisel tines shape. So, the main goal of this study is to ameliorate the performance of chisel plow in heavy soils using different mechanical and operating parameters. Three main factors were studied four sweep chisel widths (pointed-15cm, pointed-20cm, severed-15cm, and served-20 cm), three tillage depths (15, 25, and 35cm), and two tillage speeds (1.87, and 2.74km.hr^{-1}). A complete randomized block design in split-split plot was used to analyze data. The findings illustrated that the chisel pointed shape-20 cm using a tillage depth of 15 cm and tillage speed of 2.74 kmh^{-1} significantly influenced in comparison to the other chisel shapes in recording the lowest draft force of 12.91 kN.m^{-2}, the lowest slippage percentage of 31.37%, and the lowest fuel consumption rate (4.78 lha^{-1}). Although the severed chisel with a width of 20 cm was superior in increasing the percentage of pulverized soil and reducing the percentage of resistance to the soil penetration, it recorded the highest percentage of slippage, 44.4%. The interaction between the tillage speed (2.74 km.h^{-1}) and the chisel-pointed shape at 20 cm width recorded the highest value in the efficiency of energy (38.35 Mj.m^{-3}) using the tillage depth 15cm. it is recommended by using a chisel-pointed shape, a maximum tillage speed, and the lowest depth as result to ameliorate the performance of the chisel plow under heavy soil conditions.

Keywords: Tillage depth, forward speed, tines shape, soil characteristics, energy

1. Introduction

Obtaining acceptable soil properties largely depends on the quality of the soil tillage which enhances the effectiveness of all subsequent agricultural processes (Upadhyaya et. al., 2001; Muhsin, 2017). Tillage equipment using agricultural machinery is considered one of the main solutions and key to the improvement of soil quality and minimizing power consumption. So, soil tillage is a major concept in the process of crop production, which consumes nearly 30 to 35% of the total energy requirements of crop production (Osman et al., 2014). Chisel tillage refers to soil conservation technologies, and chisel tools provide low power. In addition, preservation and rational use of soil moisture that is relevant in arid climates. Using a chisel plow in heavy soils compared to conventional tillage systems was investigated in various studies to improve their performance (Aday and Muhsin, 2019). The best benefit of a chisel plow in the field is to leave more crop residue on the ground surface and fuel consumption is significantly lower. As well as, the weeds and large amounts of straw may also cause considerable practical difficulties and require adequately dimensioned chisel plows. Sowing equipment that can cope with surface residue is required (El-Iraqi et al., 2009). The chisel was able to penetrate down to the bottom of a compacted layer at 12–20 cm depth except for the duck-foot type. The plow works in comparison with the other primary tillage equipment except the subsoiler plows provides more depth of soil (0.38 m when 0.15 m real tillage and 0.2 m in the control variant) at comparable energy consumption.