ABSTRACT

A theoretical approach was developed for draft prediction of passive-passive combination tillage implements using the concept of reference tillage tool and reference soil condition with scale factors for implement geometry and soil parameters. Laboratory experiments were conducted with reference tillage tools (moldboard plow, cultivator tine, harrow disk) and scale-model individual tillage implements (moldboard plow, cultivator, disk gang) in sandy clay loam soil. The tools were operated at different depths (5 to10 cm) and forward speeds (1.2 to 4.2 km/h) in reference soil condition. The implements were operated at different soil compaction levels (average soil cone index of 445 to 1450 kPa with average soil bulk density of 1.27 to 1.85 g/cm^3) for a given speed and depth of operation. The draft prediction equations developed for individual and combination tillage implements indicated that the draft requirements of both tillage implements were significantly affected by speed, depth, width of cut and soil cone index while the characteristic lengths of implement (curvature and length for moldboard and tine; and concavity for disk) and soil bulk density were found to be non-significant. The small difference between observed and predicted values of draft of tillage implements validated the developed draft prediction equations.

A graphical user interface based decision support system (DSS) was developed for deciding suitable tractor-tillage implement combination on the basis of maximum power utilization, slip and stability of tractor. The DSS could also predict the field performance of tractor-implement system by linking databases (tractor, tire and implement specifications; soil and operating parameters; field size) and models (draft; tractive parameters; fuel consumption; turning time). Based on the simulation results of the DSS, two prototype combination tillage implements (moldboard plow with disk gang, MBP-DG and cultivator with single-acting disk harrow, C-DH) were developed for 31 kW, 2WD tractor.

The field tests of individual (moldboard plow, cultivator and offset disk harrow) and combination tillage implements were conducted to validate the developed draft equations and DSS; to evaluate the performance of tractor-implement combination; to compare the performance of different possible tillage practices in sandy clay loam soil. The predicted values for draft, wheel slip and actual field capacity were in close agreement with the observed values of both individual and combination tillage implements, thus validating the draft equations and DSS. The highest draft and slip values were obtained for the MBP-DG combination tillage implement, while the lowest values were found for the cultivator in the test range of soil condition, speed and depth of operation. The overall performance of different tillage implements and tillage practices considered was expressed in terms of tillage performance index (TPI) taking into account the mean weight diameter of soil aggregates, soil inversion, volume of soil handled per unit time and fuel consumption. The highest TPI was found for C-DH implement and the tillage practice involving two passes of C-DH implement. The moldboard plow and tillage practice involving two passes of moldboard plow and offset disk harrow gave the lowest TPI. The tillage practices involving combination implements outperformed the tillage practices involving respective individual implements in fuel consumption and time by 14.3 to 47.4 and 30.2 to 59.6% respectively.

Keywords: combination tillage implement; reference tillage tool; reference soil condition; draft prediction equations; decision support system; tillage performance index