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OPTIMISATION AND MODELLING OF SOIL PULVERISATION INDEX USING RESPONSE SURFACE METHODOLOGY FOR DISK HARROW UNDER DIFFERENT OPERATIONAL CONDITIONS

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The study aimed to determine the optimal pulverisation index of soil for disk harrow by modelling. A mathematical model was developed using a Design-Expert software and response surface methodology. Experiments were carried out in silty loamy soil with three different levels of soil moisture content of 9.25%, 17.56%, and 22.32%, operating depths of 10 cm, 15 cm, and 20 cm, and operating speeds of 3.17, 4.85, and 5.47 km·h^{-1}. The quadratic model proposed by the Design-Expert software was statistically significant (P <0.01), with a strong correlation relationship (R^2 = 0.989) between actual and predicted soil pulverisation index values. The adequacy precision achieved at 41.84 showed the models' ability to navigate the design space. However, statistical analysis, using the t-test and P-value, showed the actual and predicted values have no significant differences in the pulverisation index of soil. The optimal soil pulverisation index (8.61 mm) was achieved with a desirability of 1.00, at a soil moisture content of 14.43%, an operating depth of 11.64 cm, and a forward speed of 5.30 km·h^{-1}. Model validation confirmed acceptability (R^2 = 0.974) and a 99% accuracy in predicting the soil pulverisation index.

Keywords: Design-Expert software; soil moisture; operating depth; forward speed; quadratic model. Model validation

Modern agriculture is witnessing significant transformations aiming to improve the efficiency of resource utilisation. Among these transformations is the issue of energy consumption in tillage operations to preparing the suitable seedbed. This aspect is considered one of the main challenges facing agriculture currently (Natsis et al., 1999). The pulverisation of soil to the extent required for the germination of seed required repeated ploughing operations by conventional ploughs and disk harrows, particularly in hard soils. The improvement of the performance of primary and secondary tillage machines required many tests to determine the suitable tillage machine for the type of soil and the size of the power source (tractor), which in turn increased production costs (Al-Hamed et al., 2014). The selection of tillage machines had to be studied in terms of operating conditions, operating width, and the degree of soil softening. Computer programs facilitated predicting the requirements of machine operation in terms of the field evaluation performance of tillage machines, such as the soil pulverisation index. Computer simulation and modelling could be used to determine the relative importance of factors in field performance without costly field tests. Computer programs for modelling have been broadly developed. Consequently, researchers have utilised these models to predict the performance of soil bed preparation equipment based on operation circumstances and type of tillage machines (Cviklovič et al., 2021; Abrahám et al., 2022; Dahham et al., 2023). The regression model created by Abbaspour-Gilandeh and Sedghi (2015) based on a fuzzy modeling method produced an R^2 of 0.787%, e of 17.6%, and RMSE of 0.706% for soil pulverisation for disk harrows. On the other hand, Al-Janobi et al. (2020) found an R^2 value of 0.68 when employing ANN models and Excel spreadsheets to estimate effective field capacity. To determine what type of agriculture machines would suit a field in terms of performance efficiency and earth pulverisation; some factors such as machine type, treatment width, speed, and operation depth need to be also considered in addition to conditions of soil such as the content of water and texture class of soil (Oduma, 2019). Agriculturalists and agronomists can take advantage of design expert software to select operating factors that optimise the performance of agriculture machines such as disk harrow, without needing to carry out the field testing, thereby decreasing lost time, costs, and the dissipation of tractors and the equipment tillage (Al-Maliki et al., 2021; Udoma et al., 2023). Based on this, the soil crushing index was forecasted using design expert software. The objective of the current investigation was to assess and model the soil pulverisation index of the disk harrow and to determine the best operating conditions for the disk harrow in silty clay soils in southern Iraq.

Material and methods

Field experiment site

The experiments were carried out in the fields of the Agricultural Research Station of the College of Agriculture, University of Basrah, situated at coordinates 47° 44′ 53″ N and 14° 33′ 30″ E in the Basrah province of Iraq. The experimental