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Predictive modelling of sweep's specific draft using machine learning regression approaches

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Abstract

Modelling and optimizing soil-tool interaction parameters for tillage operations is crucial for developing efficient and precise tools. This study focused on a specific draft of sweep tools in the soil bin filled with vertisol, considering factors such as tool geometry, cone index, working depth and operational speed. Data analysis showed that the range of specific draft values, from 9.51 to 38.95 kN/m^2. Machine learning models, including artificial neural network (ANN), support vector machine (SVM), bagged trees (BT) and boosted trees (BoT), were developed using experimental data to predict the specific draft of sweep tools with hyperparameter configuration. The developed machine learning models have also been compared with the predictive multiple linear regression (MLR) model, and it was found that the predictive performance of the machine learning models was better than the MLR model during training and testing. The fine-tuned ANN model achieved impressive statistical performance with the lowest mean absolute error (MAE) of 0.489 kN/m^2, root mean square error (RMSE) of 0.619 kN/m^2, standard error of prediction (SEP) of 3.462% and highest coefficient of determination (R^2) of .99 during testing. R^2 values for BT, BoT, SVM and MLR models were .97, .96, .94 and .83, respectively, for specific draft predictions. The findings from this study have practical implications for optimizing sweep tool design and improving tillage operation. Manufacturers and farmers can benefit from predictive modelling using machine learning to design and select appropriate tillage tools for specific soil conditions. This approach can lead to improved soil health, increased yields and reduced costs.

KEYWORDS

ANN, boosted trees, machine learning, soil-tool interaction, specific draft, tillage tools

1 | INTRODUCTION

Soil tillage is a highly energy-intensive and time-consuming farm operation. Predicting and optimizing the soil-tillage tool interaction parameters is a vital strategy to improve the quality of fieldwork and increase their efficiency, as well as to meet the need for soil productivity and fulfil the food demand. The sweep is one of the most popular soil-engaging tools among farmers for primary and secondary field operations because of its large wing width, which causes better coverage of soil manipulation between two furrows. These soil-engaging components