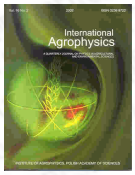

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Finite element aided brittle fracture force estimation during two-dimensional soil cutting

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abstract Short crack behaviour during the two-dimensional cutting of brittle agricultural soils is a non-symmetrical mixed mode crack loading problem. The inability to resolve this problem limited the brittle fracture soil cutting theory developed earlier by Aluko and Chandler (2004). In this paper, finite element modelling was used to simulate the loading of a brittle soil, in which a horizontally propagating crack had been initiated, by a two- dimensional plane cutting blade. Using a finite element subroutine, solutions were obtained for the separate values of the modulus ( ), mode I (KI) and mode II (KII) stress intensity factors for both short and long crack regimes. Further analysis of the stress intensity factor curves led to two possible interpretations for estimating peak soil cutting forces: the energy criterion and the direct mode I criterion. Using both criteria, brittle fracture force predictions were carried out for polished plane cutting blades in a sandy loam and a clay loam soil. The energy criterion was found to under-predict soil cutting forces when compared with published experimentally measured forces on these soils. However, the direct mode I criterion gave reasonable force estimates compared to measured values over a limited range of low rake angles. In conjunction with the passive pressure theory, the brittle fracture model can be used to predict the expected soil failure mechanism in a given situation by applying the minimal energy criterion in the comparison of forces predicted by both theories.

keywords soil fracture, crack growth, finite element method, blade configuration, soil cutting forces