Abstract

Walking tractors are popular among small and marginal category farmers because of their low cost and are mostly used in puddling operations and seed bed preparation. Utilization of walking tractors for other farm operations is usually limited due to low draftability of these machines owing to the small sized pneumatic wheels and low weight. Therefore, a rubber track system suitable for 9.7 kW walking tractor was designed and developed to improve its draftability. Empirical traction prediction equations were used in genetic algorithm-based multi-objective optimization to decide the optimum dimensions of the track system to give maximum drawbar pull and tractive efficiency while minimizing the motion resistance ratio over a range of soil conditions. A prototype 9.7 kW walking tractor with track width and track length of 150 mm and 780 mm, respectively was developed with a total weight of 5395.5 N. To ensure proper steerability, the prototype was provided with a mechanism to reduce the contact length and hence frictional resistance of the track during turning. Tractive performance evaluation of the prototype and comparison with similar walking tractor fitted with wheels at an inflation pressure of 147 kPa, were carried out in test fields having sandy clay loam soil, with average cone index (CI) 250, 500 and 1000 kPa and also on tarmacadam road. Walking tractor with rubber tracks showed motion resistance of 1012, 775 and 620, and 450 N in soil with average CI 250, 500 and 1000 kPa and on tarmacadam surface, respectively as compared to 935, 675, 530 and 370 N with wheels. Tracks developed 115.2%, 75.9%, 62.4% and 29.4% higher drawbar pull than wheels in soils with average CI 250, 500 and 1000 kPa and on tarmacadam surface, respectively. Also, higher tractive efficiency (TE) was obtained in walking tractors fitted with rubber tracks in all terrain conditions. Moreover, tracks reached peak TE (0.51, 0.63, 0.70 and 0.78 at 16.8%, 11.85%, 9.96% and 6.70% slip in soil with average CI 250, 500, 1000 kPa, and on tarmacadam road respectively) at higher net traction ratio (NTR) and maintained higher TE for a wider range of NTR. Wheels reached maximum TE (0.387, 0.55 and 0.64 and 0.75 at 20.6%, 15.25%, 13.24% and 9.20 slip, respectively) at lower values of NTR, which dropped off at higher NTR values. Results indicate a significant improvement in the tractive ability of walking tractor. Drawbar power comparison revealed that higher drawbar power was developed by rubber tracked walking tractor in all terrain conditions followed by wheeled tractor with ballast and wheeled tractor without ballast in that order. The specific fuel consumption of walking tractor fitted with tracks was found to be on an average 1.3% and 5.8% lower than that when fitted with wheels with ballast and without ballast, respectively due to higher drawbar power developed by the tracks. Steering performance analysis revealed that the developed steering aid mechanism for track type walking tractor could reduce the contact length of track on terrain by lifting the front idlers of track system up to 80 mm in 5 s. Thus it helped in reducing both turning radius and turning time on an average by 35% and 33% in different terrains, respectively as compared to when in full contact with the terrain.

Keywords: Rubber tracks; Multi-objective optimization; Genetic algorithm; Drawbar pull; Tractive efficiency; Net traction ratio; Steering aid.