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Original Research Article

Evaluation of Lightweight Grousers for Agricultural Tracks: New Solution for Soft Soil Problem

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Abstract: Crop maintenance machinery for herbicide spraying and spreading fertilizer input has been the current practice for paddy production in Malaysia, especially in large granary areas. Soft soil issues in paddy fields have become a significant problem and prevent heavy machinery from conducting field operations. Current paddy prime movers use rubber wheels that produce high ground contact pressure onto the soil for crop maintenance operation. With high ground contact pressure, the probability of machines sinking into the soil, or bogged down, is higher and can cause the machine to get stuck. This also can result in hardpan damage (Mandang *et al.*, 2000). Recently, prime agriculture mover uses steel track that has the issue on-road or soil damaged due to the grousers material use. Engineering Research Centre in Malaysian Agricultural Research and Development Institute (MARDI) have found an alternative solution for this issue by developing and replacing all the wheels on a standard 12.75 kW (17 hp) High Clearance Prime Mover with Polyoxymethylene (POM) grousers equipped on triangular track-based system. This paper aims to find the optimal size of grousers for POM material to be installed on the high clearance machinery for alternative solutions to solve problematic soil and its effect on the soil. Polyoxymethylene or POM was chosen due to its excellent rigidity, impact toughness, abrasion resistance, creep resistance and solvent resistance, hydrolytic stability fatigue endurance, low coefficient of friction lightweight. To develop suitable POM grousers, a triangular track-based system has been tested with three different length sizes of rectangular wooden track grousers 13 x 4 x 4 cm, 15 x 4 x 4 cm, and 18 x 4 x 4 cm that could be quickly mounted on or removed from D4 track chain, permitting rapid sequential testing on the soft soil area. Field tests have been conducted at MARDI Seberang Perai, Pulau Pinang. The measured parameters were slippage, machine sinkage, and soil compaction. The high clearance prime mover obtained slippage of 16.4% using 13cm shoes and 18.2% for 15 cm 22.2% for 18 cm accordingly, and sinkage for all shoe size were less than 30 cm.

Keywords: Quad tracked, Polyoxymethylene (POM), grouser, slippage, sinkage, soil compaction

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1. Introduction

Mechanization using the current practice for machinery has been of paddy production, particularly in large-scale production areas of granaries. Soft soil recently in paddy fields has become a significant area of concern. Local farmers faced an issue that prevented heavy equipment from conducting different field operations (Mohd Taufik *et al*., 2014).

Muda Agricultural Development Authority (MADA) has identified 700 hectares of its paddy fields faced with the soft soil problem in 2013 (Mohd Zubir *et al*., 2013). They also suggested that the extensive use of field machines causes the condition of the soft soil. Heavy-duty machinery has also been said to reduce the soil hardpan layer, which is required in paddy fields to prevent water leakage and support the weight of the machinery on the field (Mohd Khusairy *et al*., 2017).

Rubber wheels used in agricultural prime mover produce high ground contact pressure onto the soil. This is the leading cause of machines sinking into the soil and bogged down in the field. Some farmers use the machine equipped with a track system with steel half-track. It will increase the contact area; however, due to the heavyweight of the steel grousers, this will cause damage to the hardpan layer. Polyoxymethylene (POM), also known as acetal, polyacetal, and polyformaldehyde, has been chosen as a half-track grouser to replace the steel or wooden track. This paper aims to find the optimal size of grousers for POM material to be installed on the high clearance machinery for alternative solutions to solve problematic land.

Using this material as a grouser for the triangular track is still new. However, the reason to choose this material is its lightweight, excellent rigidity, impact toughness, abrasion resistance, creep resistance, and solvent resistance. Good appearance, hydrolytic stability, fatigue endurance, and low coefficient of friction. Better creep resistance, thermal stability, resistance to bases, and processability than homopolymer (Hough & Dolbey, 1995). The lightweight material is one of the initial steps to reduce hardpan damage. Using steel and wooden grousers, the contact pressure, slippage percentage, and hardpan damage can be reduced with the same soil contact area.

2. Materials and Methods

Field tests have been conducted at MARDI Seberang Perai, Pulau Pinang. The plot was planted with a paddy transplanter machine using the MR297 variety. The test was done using three different length sizes of rectangular wooden track grousers 13 x 4 x 4 cm, 15 x 4 x 4 cm, and 18 x 4 x 4 cm, as seen in Figure 1. That could be quickly mounted on or removed from the D4 track chain, permitting rapid sequential testing on the soft soil area. Thirty-six grousers were installed for each half-track, with total of 144 grousers for each session were tested.

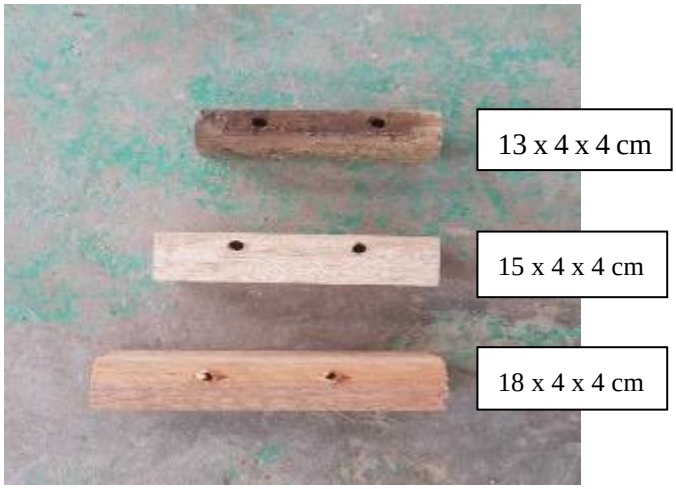

Figure 1. Rectangular wooden track grousers 13 x 4 x 4cm, 15 x 4 x 4 cm, and 18 x 4 x 4 cm

A standard 12.75 kW (17 hp) High Clearance Prime Mover tractor with 4-wheel drive (4WD) was used for this experiment. This high clearance was chosen for its suitability and technical aspects to work in domestic paddy fields.

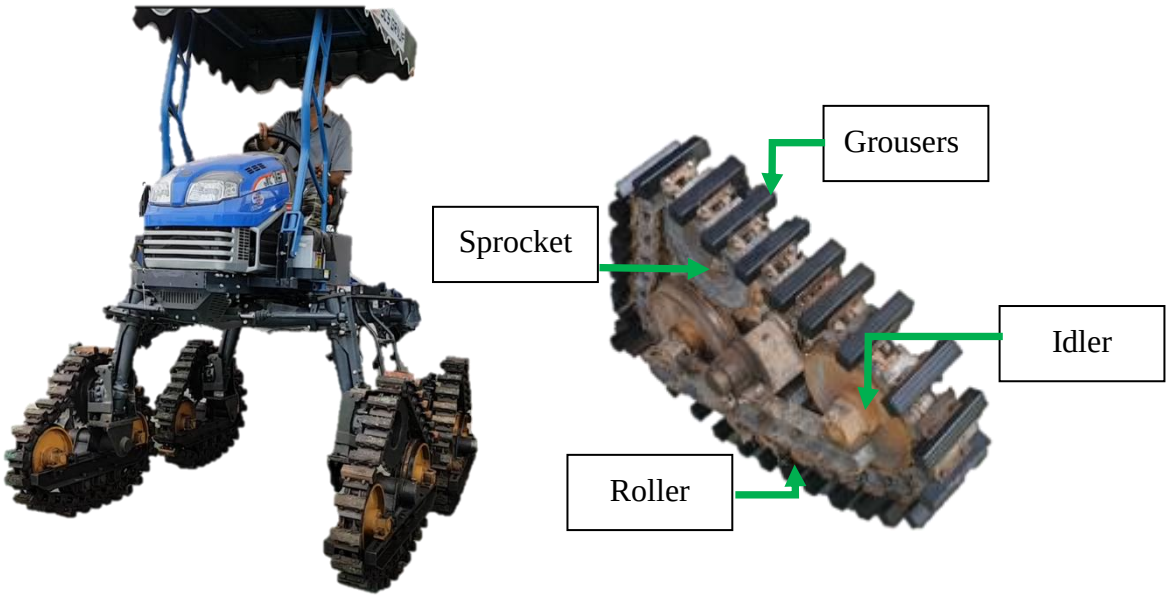

Figure 2. High clearance prime mover tractor with triangular track

Each of the high clearance prime mover wheels had been replaced by a halftrack system and each track is similar in design and weight, estimated at 300 kg each, as seen in Figure 2. The triangular track system consists of a driver sprocket at the top edge, with two idlers located at the two other edges and three rollers located between the two idlers.

Figure 3. Machine performance test on the trial plot at MARDI Seberang Perai

Soil conditions were evaluated by the bulk density on a dry basis and the soil penetration. The parameters were taken before and after the passage for each grouser size with three replicates for each sampling area. The soil strength was measured up to 80 cm depth using a soil cone penetrometer with a base area of 323 mm^2 (ASAE, 1999). The machine performance was evaluated by slippage, crop damage, and soil failure, as seen in Figure 3. The parameters were taken during machine operation on the tarmac and in the field.

3. Results

The results of testing a half-track-based system with three different length sizes of rectangular wooden track grousers 13 x 4 x 4 cm, 15 x 4 x 4 cm, and 18 x 4 x 4 cm in soil compaction are shown in Figure 4. For 13 cm grouser length size, the soil compaction before disturbance was 0.49 MPa; however, after disturbance, it drops 44.8% to 0.27 MPa for 30 cm, which causes a maximum damaged in the hardpan layer and soil pattern change. At the same time, the soil compaction was increased to 50.5% and 60.3% for 15 cm and 18 cm grouser length sizes. Accordingly, the soil compaction was from 0.48 MPa to 0.97 MPa and 0.26 MPa to 0.72 MPa in 30 cm soil depth. This situation shows that the size of 15 cm and 18 cm grouser has low contact pressure that preserves the hardpan layer.

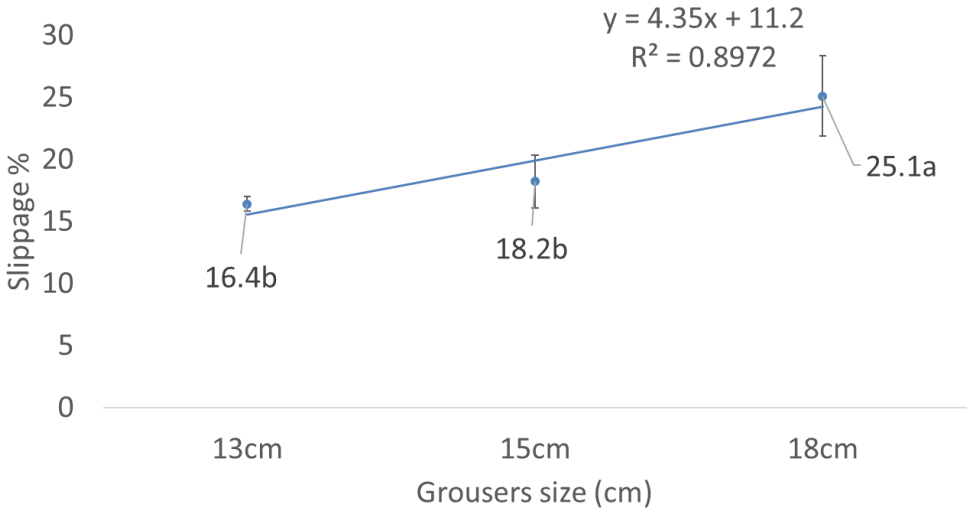

Figure 4. The effect of grousers size on the slippage of machinery movement

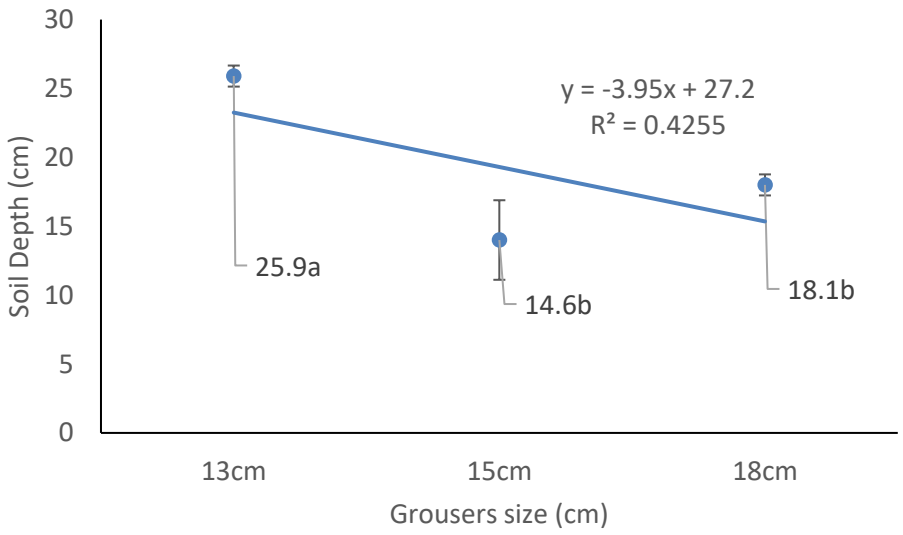

Figure 5. Effect of grousers size on the soil while moving straight

As a result of the tests conducted, the size of 15 x 4 x 4 cm gives good results in terms of slippage% (slippage) (Figure 4) and minor damage to the soil during operation (Figure 5). Therefore, 15 cm grouser length size was chosen as a model to develop a POM (Polyoxymethylene) grouser for the half-track on the high clearance machine due to its low contact pressure, low soil, and crop failure, and acceptable slippage percentage. From the data obtained, the POM grousers did not have a significant effect on the soil before and after entry

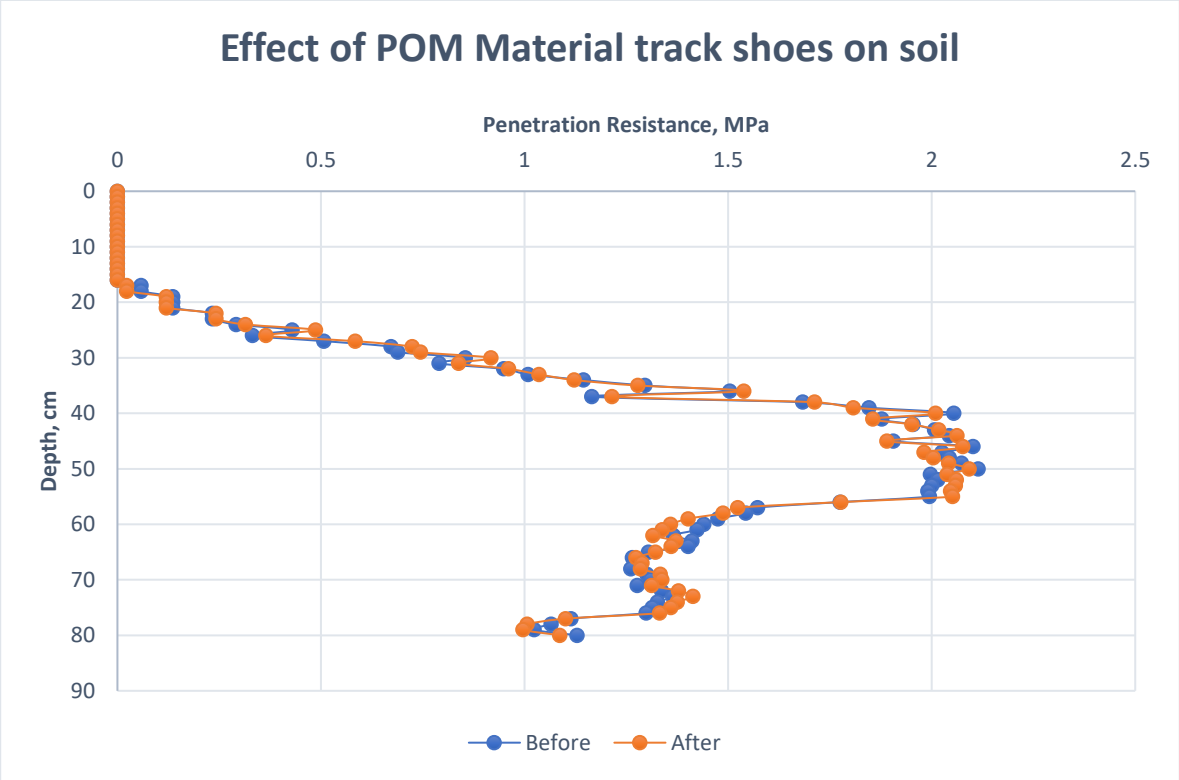

Figure 6. The data show no significant effect before and after the routing machinery uses POM shoes (t = -1.79, p = 0.0812)

5. Conclusions

A four-half-track equipped with three different grouser length sizes was evaluated to observe the effects on soil compaction and the machine performance during field operation. This study finds the best wooden grousers as a model for developing new POM (Polyoxymethylene) grousers. The study concluded that soil compaction was increased 50.5% for 15 cm and 60.3% for 18 cm grouser. The 15 cm grouser was chosen as a model to develop a POM (Polyoxymethylene) grouser for the half-track on the high clearance machine due to its low contact pressure, low soil, and crop failure, and acceptable slippage percentage. Furthermore, from the result, 15cm grouser less damaging the soil hardpan layer than the others.

Conflicts of Interest: The authors declare no conflict of interest.

References

ASAE. (1999). S313.3 Soil Cone Penetrometer. American Society of Agricultural and Biological Engineering (ASABE) standard.

Hough, M. C. & Dolbey, R. (1995). *The Plastics Compedium* (1st ed.). Shawbury, United Kingdom: Rapra Technology Ltd.

Mandang, T., Watanabe, K. &Tojo, S. (2000). Nondestructive evaluation of hardpan characteristics of paddy field using X-ray computed tomography (Ct) scanner. *International Conference on Soil Dynamics*. Adelaide, Australia.

Mohd Taufik, A., Mohd Khusairy, K. & Fauzi, M. I., (2014). Preliminary trial of a quad-steel tracked tractor on paddy field. *Proceedings of National Conference of Agricultural and Food Mechanization*, Kota Kinabalu.

Mohd Khusairy, K., Fauzi, M. I. & Mohd Taufik, A. (2017). Soft soil: Effects of Tractor with rubber tyres and steel half track on soil compaction. *Science and Engineering Technology International Conference 2017*, Langkawi.

Mohd Zubir, M. I., Mohd Taufik, A. & Rohazrin, A. R. (2013). Penggunaan penggerak sistem separangkak bagi jentera di sawah padi Malaysia. *Proceedings of Persidangan Padi Kebangsaan, Penang*.