

Short Communication

Effect of Mole Drain and Tracked Agricultural Prime Movers on Soft Soil Paddy Areas

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Abstract: Soft soil condition has become a major problem faced by Malaysian paddy farmers. MARDI has developed mole drain subsoiler and tracked agricultural prime movers to overcome this problem. The objective of this paper was to evaluate the effect of mole drain integration and tracked prime movers on soft soil area. The mole drain was installed on an identified soft soil area at an experimental plot at the Department of Agriculture (DOA) Station, Kg Bukit Merah, Seberang Perai Tengah, Penang. Tracked prime movers were used for land preparation, transplanting and harvesting. Soil strength data and rainfall were monitored and collected on a monthly basis, using penetrometer and weather station, respectively. Results showed that the soft soil condition of the plot was reduced to from 79% to 17%, corresponding to a reduction of 62%. This shows that mole drain system and tracked agricultural prime movers have the potential to reduce soft soil problem in paddy fields.

Keywords: mole drain; half-tracked prime movers; soft soil; paddy fields

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1. Introduction

Soft soil condition has become a major issue faced by paddy farmers (Taufik *et al.*, 2015). Soft soil is defined as an area with low and inadequate bearing capacity, having less than 0.3 MPa at 30 cm depth, to support the agricultural machineries on it (Ahmad *et al.*, 2020; Fauzi *et al.*, 2018; Rendana *et al.*, 2017; Nordin *et al.*, 2014). In 2013, 8000 hectares of soft soil areas were identified in MADA, 4800 hectares in KETARA and 5200 hectares in IADA Kemasin Semerak (Abdullah, 2014).

Soft soil condition is caused by imperfect drainage system, stagnant water and uneven surfaces that prevent paddy fields from drying continuously in 9 days after paddy harvesting. Soil hardpan layer usually will try to recover or reform during this stage (Sharu *et al.*, 2016). Since good drainage is key to ensuring paddy field can be dried properly, two methods are available, which is surface drainage and sub-surface drainage.

Another issue that also causes soft soil condition is heavy machinery. Soil hardpan layer is required in paddy fields to support the weight of field machineries for mobility (Ahmad *et al.*, 2020; Hemmat & Taki, 2003). The use of pneumatic rubber tires, which produces high ground contact pressure, is claimed to cause damage to the soil hardpan layer. The usage of tractors and combine harvesters weighing more than 5 tons have also created heavy pressure to the soil surface (Ahmad *et al.*, 2020; Vial *et al.*, 2020)

MARDI has developed a few technologies to overcome this problem, namely mole drain subsoiler and low ground pressure, tracked prime movers. These technologies were developed as solutions for soft soil problem specifically in paddy fields.

Mole drain subsoiler was developed by Sharu *et al.* (2016) and further improved by Omar *et al.* (2020). The mole drain is a tractor-mounted implement which comprises of a steel frame, cutting blade, mole channel, and rope application. Its main function is to channel standing water from inside of the plot to the outlet drainage using an absorption method using rope. The furrow or mole opener would create a hole of up to 45 cm deep, big enough for jute or rice-straw based rope to be installed together in one operation. In addition, Omar *et al.* (2020) reported on the positive effect of using this technique to reduce the soft soil problem.

Tracked agricultural prime movers were developed by Taufik *et al.* (2014). This group of technology included 4 half-tracked tractors, rear half-tracked paddy transplanter and a 4 half-tracked high clearance lightweight tractor (Sayuti *et al.*, 2017). A combine harvester equipped with 4 half-tracks was also developed to overcome soft soil problem (Taufik *et al.*, 2015). This technology provides a solution by increasing the ground contact area to reduce the contact pressure onto the soil.

There is a need to integrate these two technologies to observe the effect on soil hardpan layer and to observe the mechanized paddy production using tracked prime movers. The objective of this paper is to evaluate the effect of integrating mole drain and tracked prime movers on soft soil area.

2. Materials and Methods

The experiment was conducted at a specific location at Department of Agriculture (DOA) Station, Kg Bukit Merah, Seberang Perai Tengah, Penang. The experimental plot was 145 m long, 50 m wide, and identified as a problematic area with soft soil problem (DOA, personal communication, March 2018). Initial soil strength data was measured and collected in March 2018 up to 80cm depth using a soil cone penetrometer (Penetrologger, Eijelkamp,

The Netherlands) with a base area of 323 mm². After secondary tillage, mole drain system was installed using a jute rope, which came in 150 cm roll with 35 mm diameter, at 45 cm depth using a mole plough subsoiler (Figure 1). This depth was chosen based on the method used by Sharu *et. al.* (2016) where the depth was lower than the soil hardpan layer (which is located at 30 cm depth) and prevents damage of the mole drain system during ploughing, which occurs in the 20 to 30 cm depth zone. The rope was installed at a distance of 12 m apart. Grid based soil strength data of 10 m by 10 m, which accumulates to 75 points, with 3 replications for each point, were collected every month. (Figure 2)



Figure 1. Mole plough subsoiler used to install mole drain system using jute rope.

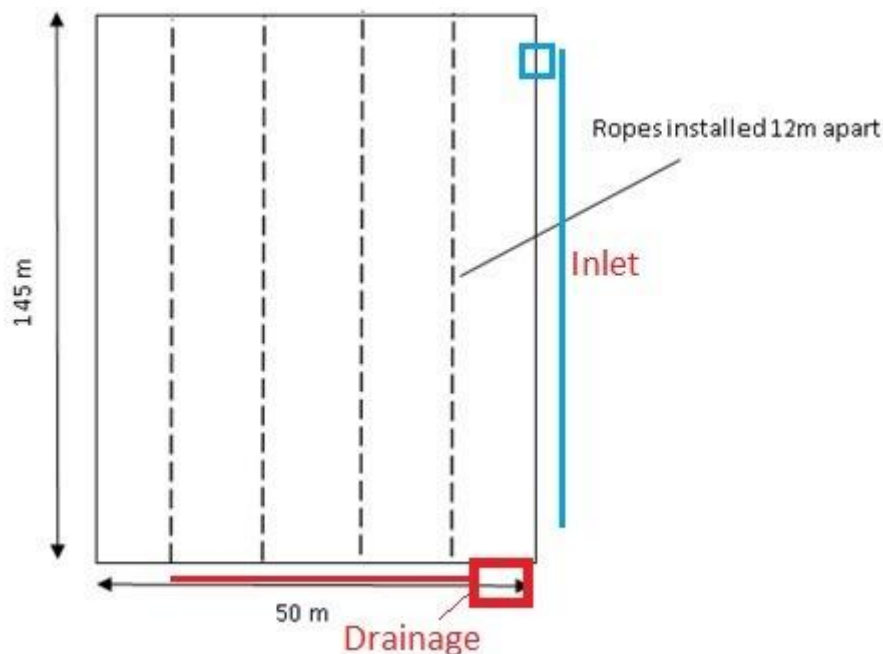


Figure 2. Layout of mole drain system used in the experiment.

2.1. Paddy Cultivation

After applying the subsoiler, a rotor tiller was attached to a 4 half-tracked tractor via PTO (power take-off) to till the soil before transplanting can be done. A transplanter with

rear half-tracks was used for paddy transplanting. After around 100 days, paddy was harvested using a mini combine harvester (DC-60G, Kubota) (Figure 3).

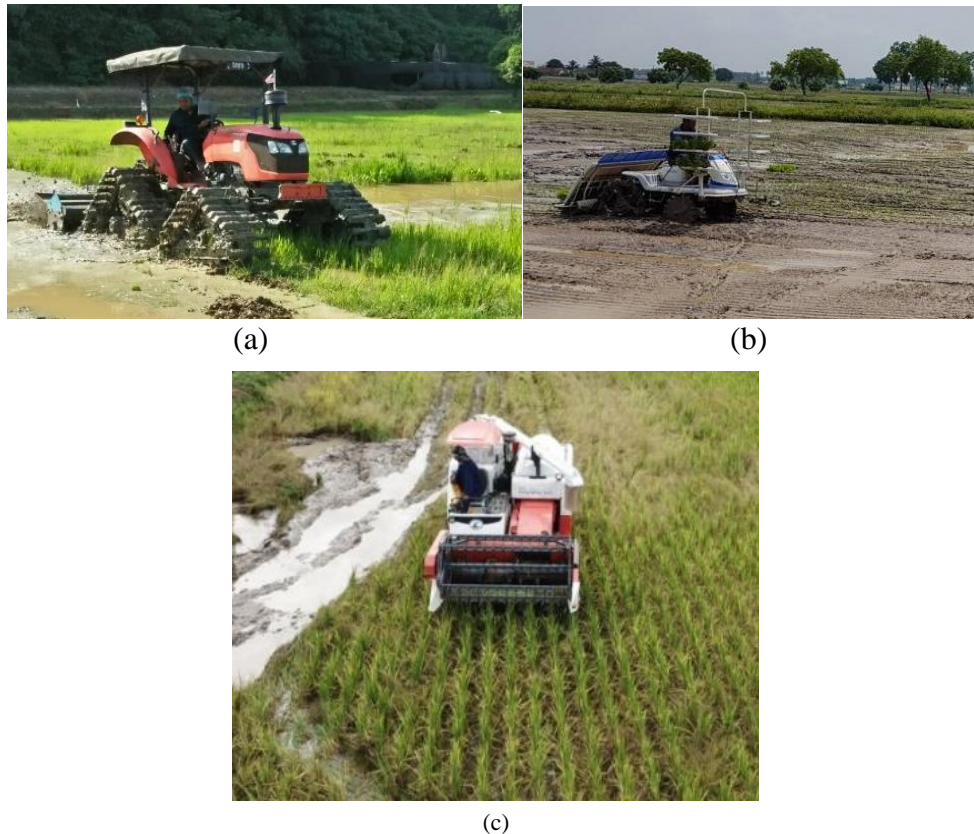


Figure 3. (a) Quad-Track tractor with rotor tiller; (b) Half-Track transplanter, and (c) mini combine harvester that was used throughout the experiment.

2.2. Weather Data

During the duration of the experiment, rainfall data was taken from the MARDI Seberang Perai weather station (Vantage Pro 2, Davis Instruments, USA), which is located 15 km radius from the experiment location. Daily rainfall data was monitored and collected.

2.3. Contour Mapping

Contour mapping software (Surfer, USA) was used to create a soil strength map at 30 cm depth. Since the penetrometer data was taken in a monthly interval, the contour map was also generated and monitored monthly.

2.4. Statistical Analysis

Statistical analyses were done with SAS statistical software (SAS, USA) using means comparison t-test comparing soil strength data before and after integration of mole drain system and tracked prime movers. T-test results and standard deviation (SD) were reported.

3. Results and Discussions

The initial soil strength condition of the experimental plot showed that 79% of the plot showed values of less than 0.3 MPa. This was the reason why DOA considered this plot to be a soft soil area, in addition to the bogging down of heavy machinery during paddy cultivation.

3.1 Contour Map

After applying the mole drain subsurface drainage, soil strength was monitored after tillage, transplanting, and finally during crop harvesting. The results after two harvesting seasons showed significance increase of soil strength data, which in turn reduced the soft soil problem from 79% to 17%. This indicates a significant reduction of 62% ($t = -11.23$, $p = 0.0001$) (Figure 4).

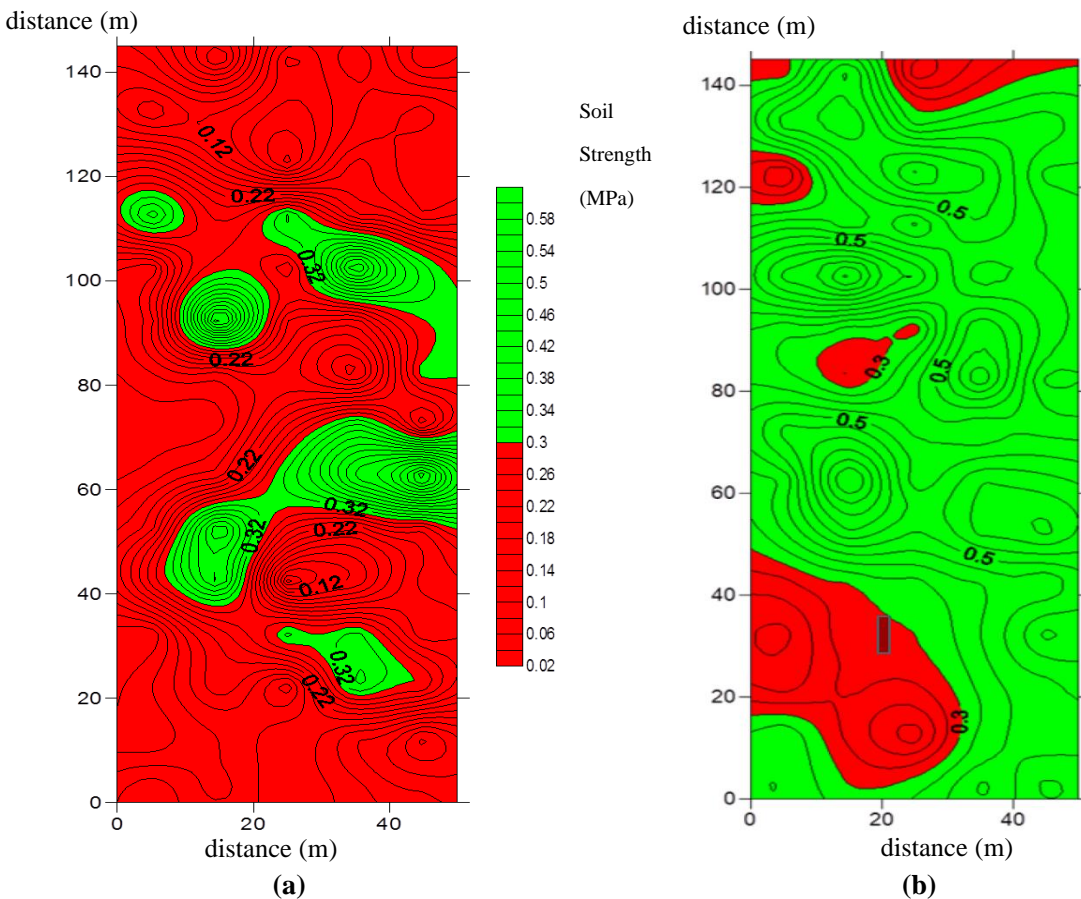


Figure 4. Contour map of the plot at 30 cm depth, (a) before and (b) after integration of mole drain system and tracked prime movers ($n=75$, $SD=0.1864$). Red coloured regions indicate soft soil (soil strength less than 0.3MPa), while green coloured regions indicate no soft soil.

3.2 Weather Data

Average rainfall throughout the duration of the experiment was 173.6 mm ($SD=116.19$) with the highest rainfall of 358.2 mm in May 2018 and the lowest rainfall of

12.8 mm in February 2019. When combined with the rainfall distribution data, reduction of soft soil was related. (Figure 5) The soft soil occurrence was shown to gradually decrease when the monthly rainfall was below 300 mm. Usually during the main season, which is from March to August, the average rainfall is higher than the off season. This period is usually the period where the soft soil occurrence is very high; hence, it is really important to manage the soil hardpan layer during this period. The off season (October to January) is usually the recovery period for the soil hardpan layer and with the help of the mole drain system, the soft soil occurrence inside the plot was drastically decreased.

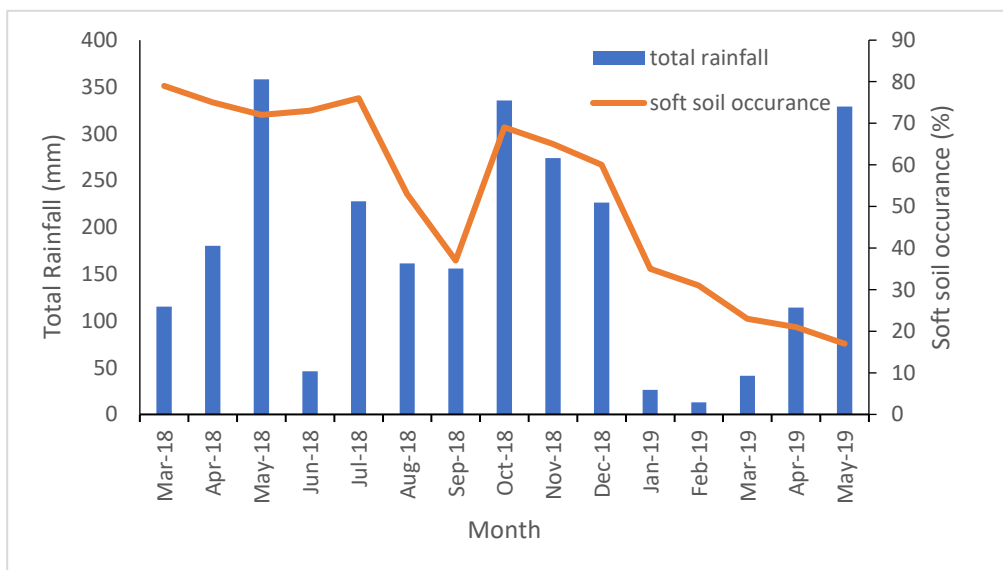


Figure 5. Soft soil occurrence based on monthly rainfall distribution. Main season was from May 2018 to August 2018. The off season was from October 2018 to January 2019.

3.3 Soil Strength Data

The effects on soil strength after the use of both technologies in two harvesting seasons was significant ($t=10.71$, $p=0.0001$). This showed that the mole drain system has successfully drained the standing water from inside the paddy field to the exit drainage. The use of low ground contact pressure prime movers has also helped in maintaining and preserving the soil hardpan layer to ensure machinery mobility in the field. Soil strength increased to 50% was observed at 30cm depth after the use of both technologies. A case study conducted by Fauzi *et al.* (2015) in comparing the usage of mole drain system with a corrugated piping system and sub-surface drainage system, showed that the mole drain system was the best and fastest method to remove excess water from inside the plot to the outlet drainage.

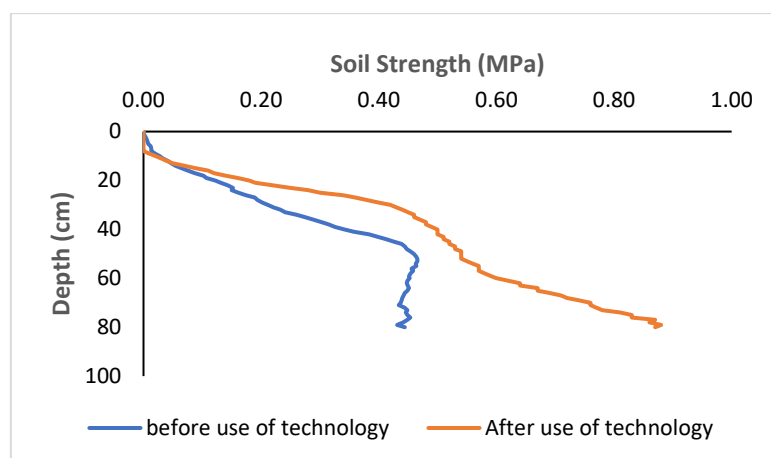


Figure 6. Average soil strength of up to 80cm depth, before and after integration of mole drain system and tracked prime movers. (n=81, SD=0.122).

4. Conclusions

The results showed that by integrating the mole drain subsoiler and agricultural tracked prime movers resulted in the decrease in soft soil problem. The soft soil condition was found to have been reduced from 79% to 17%. Hence, the plot could be cultivated during the whole period. It is essential to manage the soil hardpan layer in paddy fields to ensure mechanization become sustainably possible. The application of these two technologies together will help to improve paddy cultivation. Future study that can be done is to test these two technologies in other granary areas that have soft soil conditions such as MADA (Muda Agricultural Development Authority), KADA (Kemubu Agricultural Development Authority) and IADAs (Integrated Agricultural Development Authority).

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

References

- Abdullah, N. (2014). Approaches to Overcome Soft Soil Problem in Muda Area. In *Proceedings of National Conference on Agricultural and Food Mechanization* (p. 162).
- Ahmad, M., Khadzir, M., Omar, M. (2020). Performance of a Triangular Rubber Tracked Tractor in Paddy Fields. *Advances in Agricultural and Food Research Journal*, 1(2), 1–7. <https://doi.org/10.36877/aafmj.a0000132>
- Hemmat, A., Taki, O. (2003). Comparison of compaction and puddling as pre-planting soil preparation for

mechanized rice transplanting in very gravelly Calcisols in central Iran, 70, 65–72.

- Fauzi, M. I. M., Padzil, A. R. M. N., Chan, C. S., *et al.* (2018). Effects of Five Seasons in Two Years Paddy Planting Programme on Soil Bearing Capacity. *Journal of Built Environment, Technology and Engineering*, 4(May 2018), 252–257. Retrieved from http://www.jbete.com/wp-content/uploads/2018/05/JBETE4_90-92.pdf
- Fauzi, M. I. M., Chan, C. S., Herman, S. E., *et al.* (2015). Soft Soil Study in Bukit Jambul Pendang MADA. Proceedings of National Plantation Industry Conference and Exhibition (NAPICEX 2015).
- Nordin, M. N., Hamid, A. A., Sharu, E. H., *et al.* (2014). Kaedah penggantian tanah untuk meningkatkan kekuatan struktur tanah di kawasan tanah jerlus. *Jurnal Teknologi*, 70(6), 45–47. <https://doi.org/10.11113/jt.v70.3536>
- Omar, M. F. Z., Sharu, E. H., Ahmad, M. T., *et al.* (2020). The application of mole plough with rope applicator to reduce soft soil problem in rice field. *International Journal of Agriculture, Forestry and Plantation*, 10, 345–348.
- Rendana, M., Idris, W. M. R., Rahman, Z. A., *et al.* (2017). Effect of Hasil Tani Organic Compound product (HTOC) on the recovery of soft soil in rice field, 1(September 2016), 13–20.
- Sayuti, A. F. A., Ahmad, M. T., Rani, R. A., *et al.* (2017). Mesin Penanam Padi dan Traktor Berkelegaan Tinggi Menggunakan Sistem Trek Separa Rantai Untuk Mengatasi Permasalahan Tanah Jerlus di Sawah Padi Malaysia. In *Persidangan Padi Kebangsaan 2017* (pp. 1–4). MARDI.
- Sharu, E. H., Nordin, M. N., Fauzi, M. I. M., *et al.* (2016). Effect of Subsurface Drainage on Soil Hardpan Layer in Soft Soil Area. In *Soil Science Conference of Malaysia 2016*. MSSS.
- Taufik, A. M., Khusairy, K. M., Fauzi, M. I. M., *et al.* (2015). Performance of a Quad-Steel Tracked Tractor on Paddy Field. In *Malaysian Soil Science Conference*. Malaysian Soil Science Society (MSSS).
- Taufik, A. M., Khusairy, K. M., Fauzi, M. I. M., *et al.* (2014). Preliminary Trial of A Quad-steel Tracked Tractor on Paddy Field. In *Proceedings of National Conference on Agricultural and Food Mechanization* (pp. 130–133).
- Vial, L. K., Molesworth, A., Lefroy, R. D. B. (2020). Balancing rice and non-rice crops: Managing the risks from soil constraints in Mainland Southeast Asian rice systems. *Field Crops Research*, 246(November 2019), 107677. <https://doi.org/10.1016/j.fcr.2019.107677>

