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Study of Penetration Forces by Drilling on Oil Palm Trees

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ABSTRACT

Ganoderma boninense is a major pathogen causes a devastating oil palm disease called as basal stem rot (BSR). This disease leads oil palm trees rotting on palm bole and eventual death. Applying chemical treatment such as hexaconazol to infected palms is one of current methods in order to control and minimize the losses which is applied through injection by drilling to the trunk. The method of drilling needed to be optimized as it wounds palm trunk that causes other infection. This paper presents the study and analysis of penetration forces by drilling on oil palm trunk. This study can be used in designing a new drilling method and mechanism to increase drilling efficiency.

KEYWORDS

G. boninense, Drilling, Test rig, Drilling.

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INTRODUCTION

Basal Stem Rot (BSR) is a devastating disease that is induced by Ganoderma boninense. The disease kills the infected trees if left untreated. This will lead to economic loses. The G. boninense infections could affect young palm oil trees as old as 5 years old (Ho et al., 1985). Surveys on BSR found out that about 8.05% incidence reported in oil palm plantation of small holder where 2,744.96 ha affected area out of 1,594,286 ha. This disease is a major threat to the oil palm industry as yield losses due to G. boninense disease was up to RM1.5 billion (MPOB, 2016; Ikmal H. et al., 2014). Thus, this disease needs to be controlled and cured significantly.

Trunk injection is one of the methods to cure the affected palm although several methods such as culture practices, good land preparation, soil mounding, biological control and integrated sanitation by deboling for controlling G. boninense do exist (MPOB, 2016). While those methods are useful for control, only injection method is applicable for treatment of life trees. Results in using several fungicides are still inconclusive but some established fungicides are promising (Idris A. S. et al., 2002). Some of the fungicides that have been tested are drazoxolone, cycloheximide, triadimefon, carbonix, benomyl, hexaconazol, penconazol and tetraconazol (Laila N. et al., 2015). Three established methods for applying fungicides include soil drenching, trunk injection, or combination of both methods (Razak J. et al., 2004). Delivering fungicide to G. boninense infected area inside the oil palm trunk is a major issue, but there are cases where the fungus is still intact and infecting the oil palm trees and generating chemical waste which eventually affecting the overall operating cost and also the environment (Idris A. S. et al., 2002; Razak J. et al., 2004).

The Ganoderma basidiomata is originated from infected root and tend to appear at the stem base where usually reflects the position of the infected area within palm trunk (Laila N. et al., 2015; Plantwise, 2016). Ganoderma is located in the stem base to the root system that causes decaying in the palm bole (Cooper R. M. et al., 2011).

This paper describes the study of penetration forces on oil palm trunks in the region where injections are to be administered. A test rig was constructed to enable field experiments. The maximum forces were recorded and analysed.

MATERIALS AND METHODS

Test Rig

Drilling test was performed by a force gauge attached on fabricated test rig (Figure 1). The test rig was designed to measure penetration force in Newton (N) by manipulating penetration variables such as spindle speed, drilling feed rate, drill bit diameter, drilling angle and drill bit type. The drilling mechanism and the feeder system were integrated into the test rig platform. Drilling mechanism consisted of a drill chuck for holding drill bits from 10 mm to 25 mm bit diameter, and it was driven by a 220 V DC motor connected to a speed controller. The motor could drill at maximum speed of 3000 rpm. While the test rig feeder system was using a linear screw drive system to control force gauge platform motion and hence pushing along the drill platform.

Figure 15: A fabricated test rig

Force Gauge

Force gauge (Figure 2) was attached on top-back of the test rig. MARK-10 Force Gauge Series-4 M4-50 was used for this experiment. The device could provide force reading up to 250 N at maximum. The force gauge was interfaced by MESUR™ gauge software.

Figure 2: MARK-10 Force Gauge

Test procedure

Penetration drilling test was carried out at private estate in Hutan Melintang, Perak. The test was conducted on randomly selected 15 years old oil palm trees.

On the test procedure as in Figure 3, test rig was placed horizontally towards the targeted trunk. Then, the drill was moved forward until the drill bit tip was nearly touch on the trunk. Initial position was recorded, and the force gauge reading was in zero. The test was started as feeder motor was switched on and stopped for reaching a desired depth. Drill depth was determined by maximum length for drill bit used for each test. The penetration force was recorded by MESUR™ gauge software.

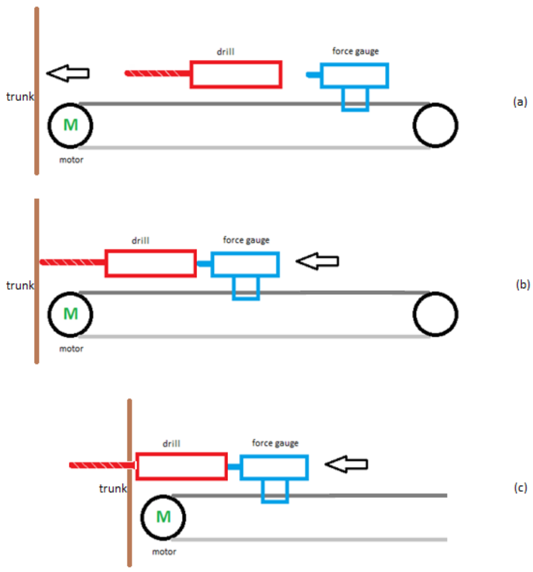

Figure 3: (a) put drill into initial position as drill tip nearly touch on tree surface, (b) starts to drill tree, and (c) stops as it reaches a certain penetration depth.

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Parameter

In the drill test, a few parameters were tested to determine the effect relationship on drilling penetration force. Drilling feed speed was fixed at 15 mm/s. Spindle speed, drill bit diameter and drill bit type were the parameters. Two or three variables for each parameter were compared as spindle speed; 1180 rpm, 2250 rpm and 3000 rpm, drill bit diameter; 8 mm and 11 mm, and drill bit type; wood purpose and general purpose (Figure 4). The load comparison between variables were illustrated in graph form. The test parameters are summarized in Table 1.

Figure 4: Drill bit used in the test; (a) 11 mm drill bit for wood purpose, (b) 8 mm drill bit for wood purpose and (c) 8 mm drill bit for general purpose

Table 1: Parameter of drilling test

Spindle speed	1180 rpm 2250 rpm 3000 rpm
Bit diameter	8 mm 11 mm
Bit type	Wood purpose General purpose

RESULTS AND DISCUSSIONS

Spindle Speed Comparison

In spindle speed comparison test, 8 mm and 11 mm diameter of drill bit for wood drill purpose were used as fixed variable. Figure 5 shows the spindle speed comparison between 1180 rpm, 2250 0rpm and 3000 rpm to penetration force for 8 mm diameter drill bit. Based on the graph, spindle speed at 3000 rpm shows the lowest penetration force (125 N) followed by 2250 rpm (135 N) and 1180rpm (142 N) respectively.

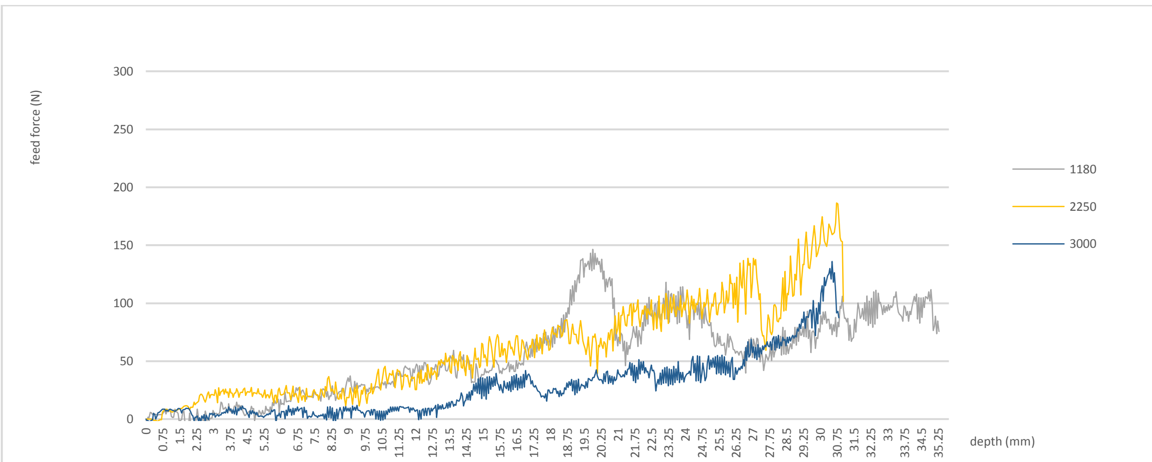

Figure 5: Effect of spindle speed on penetration force for 8 mm diameter of drill bit.

Same test was conducted by using 11 mm drill bit diameter. The result shows as in Figure 6, 3000 rpm give the lowest penetration force (155 N) at certain depth compared to other speed. Thus, spindle speed of drilling did affect the penetration trend for both 8 mm and 11 mm drill bit diameter. The drilling performance increase on higher spindle speed.

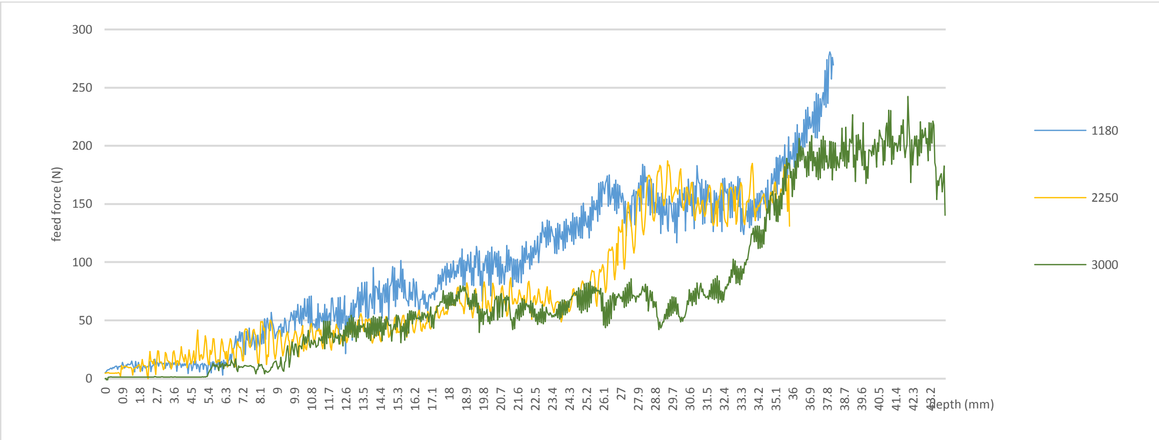

Figure 6: Effect of spindle speed on penetration force for 11 mm diameter of drill bit.

Drill Bit Diameter Comparison

For drill bit diameter comparison test, spindle speed was fixed at 3000 rpm. 8 mm and 11 mm diameter of wood drill purpose were used in this test. Figure 7 shows the penetration force comparison by two drill bit diameter size. 8 mm drill bit causes lower penetration resistance (125 N) compared to 11 mm drill bit (155 N).

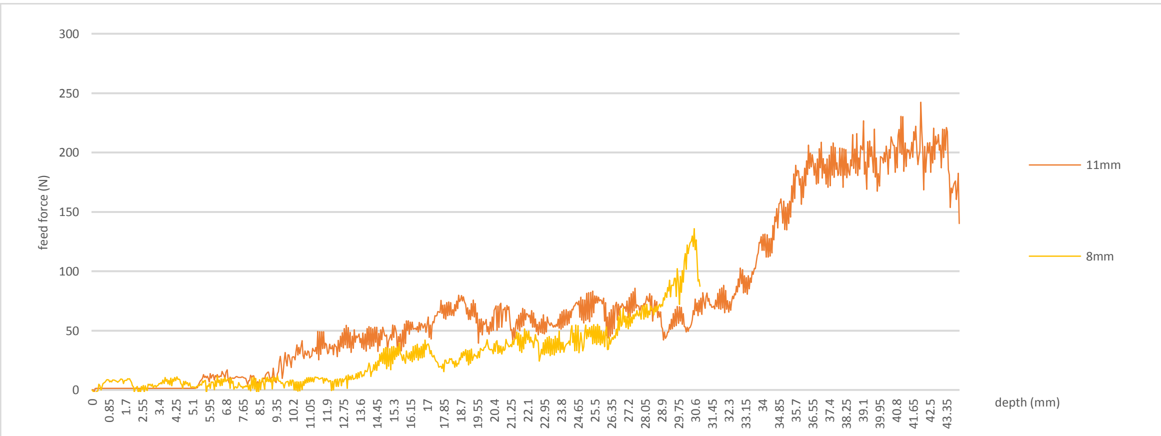

Figure 7: Effect of drill bit diameter of penetration force.

Drill Bit Type Comparison

Drill bit type comparison test was conducted for comparing drill type affected the drill penetration. Two drill types were used as wood drill purpose and general drill purpose. The spindle speed was fixed at 3000 rpm and diameter of the drill bits were 11 mm. Based on the graph in Figure 8, drill bit for general purpose shows much lower penetration force (27 N) through all depth compared to wood purpose drill bit. Thus, design of the drill bit did affect the penetration efficiency.

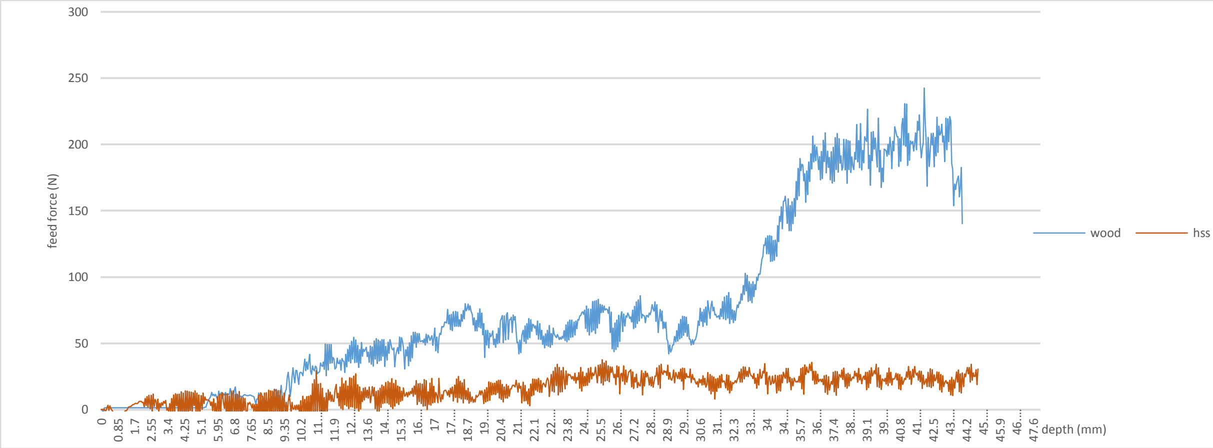

Figure 8: Effect of drill bit type of penetration force.

CONCLUSIONS

In conclusion, the preliminary drill comparison analysis did show significant difference between all variables in the drill parameter. This analysis was important in such to determine the parameter constrain and limit for designing a new drilling method, design, material and technology that could be used in future. Based on the three comparisons, the faster the spindle speed, the lower the penetration force. Besides that, drill bit diameter affected the drill penetration as smaller drill bit let the penetration force decreased. Drill bit type also caused difference on the penetration due to drill bit tip shape design. Drill bit for wood purpose tended to show higher penetration because of three edges on the tip technically gave disadvantage for drilling fibrous material as oil palm trunk. These parameters could help to strengthen and optimize the oil palm injector design in term of drilling.

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