



UNIVERSITI PUTRA MALAYSIA

**IMPACT OF GROUND-BASED LOGGING MACHINE
ON SOIL PHYSICAL PROPERTIES AND TREE GROWTH**

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IMPACT OF GROUND-BASED LOGGING MACHINE
ON SOIL PHYSICAL PROPERTIES AND TREE GROWTH

by

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An abstract of the thesis submitted to the Senate of Universiti
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Faculty : Forestry

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Five experiments were conducted to determine the impacts of ground-based logging machines on soil physical properties and on early growth of Acacia mangium Willd. The experiments are: (i) a survey of the areal extent of logging machine disturbance, (ii) effects of logging machines on soil physical properties, (iii) effects of travelling intensity with a rubber-tired and track-type logging machine on some soil physical properties, (iv) recovery rate of compacted soils, and (v) measurement of growth responses of A. mangium on compacted and non-compacted soils and their loosening treatments.



Areal disturbance on 10 logging blocks following logging with crawler tractors averaged 30(18), 28(27), and 42(55) percent in 'undisturbed', 'moderate', and 'serious' class of disturbance on clay loam soils in the dry(wet) season, respectively. For sandy loam soils under dry(wet) season, the areal extent of logging disturbance were 16(27), 44(22), and 40(48) percent, respectively. Average values for to penetration, and soil temperature of prelogging soils, adjacent undisturbed soil, secondary forest roads, secondary landings, primary landings and skid trails were also determined.

Vehicular compaction test of an unloaded rubber-tired and track-type logging machine showed that changes in soil bulk density, total pore space, aeration (macro) porosity, available water-holding capacity, saturated hydraulic conductivity and resistance to penetration of the rubber-tired log loader did not exceed those caused by a track-type crawler tractor despite a two-fold difference in ground contact pressure. The changes in soil bulk density and total porosity caused by these logging machines increased with increasing soil moisture content. However, changes in macroporosity, available water-holding capacity, saturated hydraulic conductivity and resistance to penetration decreased with increasing soil moisture content. Most soil properties studied reached a maximum after the first two trips and remained constant with additional trips.



Based upon regression analysis, the estimated average time required for natural recovery of bulk density, total porosity, saturated hydraulic conductivity and resistance to penetration on skid trail, bush landing and secondary forest road to the undisturbed soil are listed in consecutive order as follows: (i) 22, 17 and 14 years; (ii) 24, 17 and 15 years; (iii) 52, 37 and (iv) 28 years; and 19, 14 and 12 years.

Early growth of A. mangium seedlings in the glasshouse on compacted soils was substantially less than on non-compacted (undisturbed) soils. Loosening compacted soils increased early height and diameter growth almost as high as on non-compacted soils, but loosening compacted soils did not significantly improve biomass growth. However, poor root and shoot growth and poor mycorrhizal infection occurred on compacted soils. A. mangium seedlings grown for 24 weeks in pots with soil at bulk densities of 0.8 (control), 1.0, 1.2, 1.4, 1.6, 1.8, and 2.0 g/cm³ showed that root and shoot oven-dry weights, root system, seedling height, diameter and leaf surface area increased significantly with decreasing soil bulk density. Significant differences in seedling diameter and leaf surface area appeared during the tenth to twelfth week after transplanting and continued to increase until harvest at week 24. Poor root and shoot growth and poor mycorrhizal infection occurred on heavily compacted soils.



Abstrak tesis yang dikemukakan kepada Senat Universiti
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KESAN MESIN PEMBALAKAN BERASASKAN BUMI
KE ATAS CIRI FIZIK TANAH DAN PERTUMBUHAN POKOK

oleh

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Lima eksperimen telahpun dijalankan untuk menentukan kesan mesin pembalakan berasaskan bumi ke atas ciri fizik tanah dan pertumbuhan pokok Acacia mangium Willd. Eksperimen tersebut ialah: (i) satu survei eksten keluasan kerosakan mesin pembalakan, (ii) kesan mesin pembalakan ke atas ciri fizik tanah, (iii) kesan keamatan laluan mesin pembalakan menggunakan tayar getah dan jenis trak ke atas beberapa ciri fizik tanah, (iv) kadar pulih semula tanah padat, dan (v) pengukuran gerak balas pertumbuhan A. mangium di atas tanah padat dan tak padat dan rawatan renggangan mereka.



Luas kerosakan ke atas 10 blok pembalakan selepas pembalakan dengan traktor roda lipan masing-masing berpurata 30(18), 28(27) dan 42(55) peratus di kelas kerosakan 'tidak rosak', 'sederhana' dan 'teruk, ke atas tanah lom liat di musim kering (basah). Untuk tanah lom pasir dimusim kering (basah), eksten luas kerosakan pembalakan masing-masing ialah 16(27), 44(22) dan 40(48) peratus. Nilai purata ketumpatan pukal, keronggaan makro, keronggaan mikro, jumlah keronggaan, muatan pegangan air tersedia ada, kekonduksian hidraulik tepu, tahanan penembusan dan suhu tanah bagi tanah pradibalak, tanah berdekatan yang tak rosak, jalan hutan sekunder, matau sekunder, matau utama dan jalan gelongsor juga ditentukan.

Ujian kepadatan kenderaan mesin pembalakan tanpa muatan jenis trak dan bertayar getah menunjukkan perubahan ketumpatan pukal tanah, jumlah ruang rongga, ruang pengudaraan (makro), muatan pegangan air tersedia ada, kekonduksian hidraulik tepu dan tahanan penembusan pemuat balak bertayar getah tidak melebihi traktor roda lipan jenis trak walaupun ada dua kali perbezaan tekanan kontek bumi. Perubahan pada ketumpatan pukal tanah dan jumlah keronggaan disebabkan oleh mesin pembalakan ini menaik dengan kenaikan kandungan kelembapan tanah. Walau bagaimanapun, perubahan pada keronggaan makro, muatan pegangan air tersedia ada, kekonduksian hidraulik tepu dan tahanan penembusan menurun dengan kenaikan kandungan kelembapan tanah.



Kebanyakan ciri tanah yang dikaji sampai ke maksima selepas dua trip yang pertama dan tidak berubah dengan trip tambahan selanjutnya.

Berdasarkan analisa regresi, purata anggaran masa yang diperlukan bagi pulih semula ketumpatan pukal, jumlah keronggaan, kekonduksian hidraulik tepu dan tahanan penembusan di atas jalan gelongsor, matau belukar dan jalan hutan sekunder kepada tanah tak rosak adalah disenaraikan mengikut susunannya sepertimana berikut: (i) 22, 17 dan 14 tahun; (ii) 24, 17 dan 15 tahun; (iii) 52, 37 dan 28 tahun; dan (iv) 19, 14 dan 12 tahun.

Pertumbuhan awal anak benih A. mangium di dalam rumah kaca di atas tanah padat adalah sangat rendah daripada yang di atas tanah tak padat (tak rosak). Perenggangan tanah padat menaikkan pertumbuhan awal ukur lilit dan ketinggian sehampir tinggi seperti di atas tanah tak padat, tetapi perenggangan tanah padat tidak memberi baikan pertumbuhan biomass yang ketara. Walau bagaimanapun, pertumbuhan yang lemah berlaku kepada akar dan pucuk dan infeksi mikoriza di atas tanah padat. Anak benih A. mangium yang ditanam di dalam pasu selama 24 minggu bersama tanah pada ketumpatan pukal 0.8 (bandingan), 1.0, 1.2, 1.4, 1.6, 1.8 dan 2.0 g/sm³ menunjukkan bahawa berat keringoven akar dan pucuk, sistem akar, ketinggian anak benih, garis' pusat dan luas permukaan daun menaik dengan ketara

