



**UNIVERSITI PUTRA MALAYSIA**

**EFFICACY, COST-EFFECTIVENESS, AND RISK-BENEFIT ANALYSIS  
OF THREE HERBICIDES IN IMMATURE OIL PALM PLANTATION**

**WAHYU WIBAWA**

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**DOCTOR OF PHILOSOPHY  
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THREE HERBICIDES IN IMMATURE OIL PALM PLANTATION**

**By**

**WAHYU WIBAWA**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,  
in Fulfilment of the Requirements for the Degree of Doctor of Philosophy**

**December 2007**



*Dedicated to*  
*Allah S.W.T,*  
*my late father Suroyo Sarwo Darsono,*  
*my late mother Hj. Tumirah,*  
*my wife Sari Susanty,*  
*my son Muhammad Aldrich Akhtar Wibawa*



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment  
of the requirement for the degree of Doctor of Philosophy

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THREE HERBICIDES IN IMMATURE OIL PALM PLANTATION**

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**WAHYU WIBAWA**

**December, 2007**

**Chairman: Professor Rosli Mohamad, PhD**

**Faculty: Agriculture**

Field experiment and survey were conducted at Malaysian Airport Berhad (MAB) Agriculture-Horticulture Sdn. Bhd., Sepang, Selangor. Laboratory and glass-house experiments were done at the Faculty of Agriculture, Universiti Putra Malaysia, Serdang. Two-year old oil palm planted in the plantation was used in the experiment. Paraquat, glufosinate-ammonium and glyphosate were used as treatments. The experimental design was a randomized complete block design (RCBD) with four replications. The general objective of this study was to evaluate the performance and impact of three commonly used broad-spectrum herbicides, namely, paraquat, glufosinate-ammonium and glyphosate on cost, production, environment and safety. Efficacy, short term weed dynamic, oil palm growth, fungi and bacteria population in



soil, residual phytotoxicity effect, residue analysis, and risk-benefit analysis of the three broad-spectrum herbicides were determined and evaluated in the experiment.

Paraquat at 200 and 400 g a.i. ha<sup>-1</sup> were not effective to control weeds, whereas at 600 and 800 g a.i. ha<sup>-1</sup> were effective with the duration of effective weed control of 8.75 and 11.75 weeks, respectively. Glufosinate-ammonium at 200 g a.i. ha<sup>-1</sup> and glyphosate at 400 g a.i. ha<sup>-1</sup> gave excellent weed control, within the duration of effective weed control of 15 and 14.5 weeks, respectively. Thus, efficacy of glufosinate-ammonium and glyphosate was better than paraquat.

Treatments with glufosinate-ammonium and glyphosate increased densities of broadleaf weed, but not on grass and total weed densities. Paraquat treatments did not cause weed shifting, whereas both glufosinate-ammonium and glyphosate treatments caused shifting in the weed species composition.

A round of paraquat sprayed at 200, 400, 600, and 800 g a.i. ha<sup>-1</sup>, glufosinate-ammonium at 200, 400, 600, and 800 g a.i. ha<sup>-1</sup>, and glyphosate at 400, 800, 1200, and 1600 g a.i. ha<sup>-1</sup> did not increase herbicide residues in the soil.

Using paraquat, glufosinate-ammonium, and glyphosate for controlling weeds were safe for vegetative (plant height, the number of fronds/plant) and generative (number

of fruit bunches/plant) growths of oil palm. Severe weed competition affected number of fruit bunch of oil palm significantly, especially at early maturation stages.

Using paraquat, glufosinate-ammonium, and glyphosate for controlling weeds in immature oil palm did not affect bacteria and fungi populations in the soil. The herbicides applied at range of recommended dose were safe not only to oil palm crops but also for bacteria and fungi as expressed by their populations.

Paraquat, glufosinate-ammonium, and glyphosate residues in soil did not cause adverse effects (risk) on seed germination and growth components (plant height, leaf area, root length, and total dry weight) of corn and cucumber seedlings in bioassay study conducted. At the range of recommended application doses, paraquat, glufosinate-ammonium, and glyphosate were safe for seed germination and plant growth.

Paraquat has unacceptable risk to human health, especially to the applicators. Paraquat at 800 g a.i./ha is quite costly (RM 310.80/ha/year) to get the satisfactory weed control. The risk of paraquat clearly outweighed its benefit. Glufosinate-ammonium has acceptable risk level to human health and environment. Glufosinate-ammonium require medium cost (RM 214.19/ha/year) to get to the satisfactory weed control. Glufosinate-ammonium can be used as alternate herbicide to avoid weed resistance. Glyphosate has acceptable risk to human health and environment, and



lower cost (RM 108.95/ha/year) to get to the satisfactory level of weed control. The benefit of glyphosate clearly outweighed its risk. This herbicide should be recommended widely because of its efficacy, cost-effectiveness, and safety. However, alternate herbicide is needed to avoid broadleaf weeds resistance.

Safe and effective use of herbicides in oil palm plantations were depend significantly on herbicide knowledge, experience, and formal education of the applicators. Handling and using herbicides safely were available, but preventive measures are costly. The use of dangerous herbicides should be restricted, when preventive behavior can not be used as a method of controlling the health risks associated with herbicides.





Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**EFIKASI, KEBERKESANAN-KOS, DAN ANALISIS RISIKO-  
KEUNTUNGAN DARIPADA TIGA JENIS RACUN RUMPAI PADA  
LADANG TANAMAM KELAPA SAWIT PRA-MATANG**

Oleh

**WAHYU WIBAWA**

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**Fakulti: Pertanian**

Kajian dan tinjauan di ladang dilakukan di MAB Agriculture-Horticulture Sdn. Bhd., Sepang, Selangor. Kajian-kajian di makmal dan di rumah kaca dilakukan di Fakulti Pertanian, Universiti Putra Malaysia, Serdang. Tanaman kelapa sawit yang berumur dalam lingkungan dua tahun digunakan dalam kajian ini. Parakuat, glufosinat-amonium and glifosat digunakan sebagai rawatan. Rekabentuk eksperimen adalah blok penuh rawak (RCBD) dengan empat replikasi. Tujuan umum kajian ini adalah untuk menilai pencapaian dan kesan daripada tiga jenis racun rumpai berspektrum luas iaitu parakuat, glufosinat-amonium dan glifosat pada kos, pengeluaran, alam sekitar, dan keselamatan. Efikasi, dinamik rumpai jangka pendek, pertumbuhan tanaman kelapa sawit, populasi kulat dan bakteria dalam tanah, kesan sisa baki, analisis sisa baki, dan analisis risiko-keuntungan dari tiga jenis racun rumpai berspektrum luas dinilai dalam kajian ini.



Parakuat pada dos 200 dan 400 g a.i. ha<sup>-1</sup> tidak berkesan mengawal rumpai, sedangkan pada dos 600 dan 800 g a.i. ha<sup>-1</sup> berkesan mengawal rumpai, keberkesanannya masing-masing dalam jangka masa 8.75 dan 11.75 minggu. Glufosinat-amonium pada dos 200 g a.i. ha<sup>-1</sup> dan glifosat pada dos 400 g a.i. ha<sup>-1</sup> sangat berkesan dalam mengawal rumpai, keberkesanannya masing-masing dalam jangka masa 15 dan 14.5 minggu. Efikasi glufosinat-amonium dan glifosat ketara lebih baik daripada parakuat.

Rawatan dengan glufosinat-amonium dan glifosat meningkatkan kepadatan rumpai berdaun lebar, tetapi tidak pada rumpai rumputan dan jumlah rumpai secara keseluruhan. Rawatan dengan parakuat tidak mengubah komposisi rumpai, sedangkan glufosinat-amonium dan glifosat mengubah komposisi spesies rumpai.

Kadar penyemburan sekali parakuat pada dos 200, 400, 600, dan 800 g a.i. ha<sup>-1</sup>, glufosinat-amonium 200, 400, 600, dan 800 g a.i. ha<sup>-1</sup>, dan glifosat 400, 800, 1200, dan 1600 g a.i. ha<sup>-1</sup> tidak meningkatkan sisa baki racun rumpai dalam tanah.

Penggunaan parakuat, glufosinate-amonium, dan glifosat untuk mengawal rumpai adalah selamat untuk pertumbuhan vegetatif (tinggi tanaman, jumlah pelepah daun/pokok) dan generatif (jumlah tandan buah/pokok) daripada tanaman kelapa sawit. Gangguan rumpai yang teruk mempengaruhi jumlah tandan buah/pokok secara ketara, khasnya pada peringkat awal pengeluaran.

Penggunaan parakuat, glufosinat-amonium, dan glifosat untuk mengawal rumput pada tanaman kelapa sawit pra-matang tidak mempengaruhi populasi bakteria dan kulat di dalam tanah. Penggunaan racun rumput pada dos yang disyorkan adalah selamat tidak hanya pada tanaman kelapa sawit tetapi juga pada populasi bakteria dan kulat.

Kajian kesan sisa baki mendapati parakuat, glufosinat-amonium, dan glifosat tidak menyebabkan kesan negatif (risiko) pada percambahan biji benih dan komponen pertumbuhan (tinggi tanaman, lebar daun, panjang akar, dan jumlah berat kering) dari anak pokok jagung dan mentimun. Pada dos yang disyorkan, parakuat, glufosinat-amonium, dan glifosat adalah selamat untuk percambahan biji benih dan pertumbuhan tanaman.

Parakuat mempunyai risiko yang tinggi terhadap kesihatan manusia, khasnya kepada operator pengendali racun rumput . Parakuat pada dos 800 g a.i./ha adalah cukup mahal (RM 310.80/ha setahun) untuk memberikan kawalan rumput yang memuaskan. Glufosinat-amonium sangat kurang mempunyai risiko terhadap kesihatan manusia dan alam sekitar. Glufosinat-amonium memerlukan kos yang agak tinggi (RM 214.19/ha/setahun) untuk memberikan kawalan rumput yang memuaskan. Glufosinat-amonium boleh digunakan secara bergilir dengan glifosat untuk mengawal rumput yang resistan. Glifosat sangat kurang mempunyai risiko terhadap kesihatan manusia dan alam sekitar, malah kosnya adalah rendah (RM

108.95/ha/setahun). Manfaat yang diperolehi daripada penggunaan glifosat adalah lebih banyak berbanding keburukannya. Racun rumpai ini sepatutnya disyorkan secara meluas terutama berkaitan dengan efikasi, keberkesanan-kos, dan keselamatannya. Bagaimanapun, penggunaan racun rumpai secara bergilir diperlukan untuk mencegah resistansi rumpai berdaun lebar.

Penggunaan racun rumpai yang selamat dan berkesan di ladang kelapa sawit adalah ketara bergantung pada pengetahuan tentang racun rumpai, pengalaman bekerja, dan pendidikan formal daripada operator pengendali racun. Pilihan untuk menggunakan racun rumpai secara selamat adalah tersedia, tetapi tindakan keselamatan adalah mahal. Tabiat tidak mengamalkan langkah keselamatan sebagai suatu kaedah dari pengawalan risiko berhubung kesihatan yang berkaitan dengan racun rumpai menyebabkan penggunaan racun rumpai yang merbahaya harus dipertimbangkan.

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Agricultural-Horticultural Sdn. Bhd that have approved the field experiment in the plantation.

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Last but not least, to all my family members, especially my wife (Sri Susanty), my son (Muhammad Aldrich Akhtar Wibawa) thanks for their patience, love, care, sacrifices, endless emotional and physical support, and motivation.



I certify that an Examination Committee has met on 17<sup>th</sup> December 2007 to conduct the final examination of Wahyu Wibawa on his Doctor of Philosophy thesis entitled “Efficacy, cost-effectiveness, and risk-benefit analysis of three herbicides in immature oil palm plantation” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulation 1981. The Committee recommends that the student be awarded the degree of Doctor of Philosophy.

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## **DECLARATION**

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

---

**WAHYU WIBAWA**

Date: 11 January 2008



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