EFFECTS OF ALACHLOR AND GLYPHOSATE ON DEVELOPMENT OF *Glomus mosseae* AND ITS SYMBIOTIC ASSOCIATION WITH PEANUT

ASKIF PASARIBU

DOCTOR OF PHILOSOPHY
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By

ASKIF PASARIBU

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Chairman : Professor Rosli Mohamad, Ph.D.

Faculty : Agriculture

Data on the effect of herbicides on vesicular-arbuscular mycorrhiza (VAM) symbiosis is still lacking as compared to fungicides. This study aims to evaluate the effect of alachlor (soil acting herbicide) and glyphosate (foliage acting herbicides) on *Glomus mosseae* (VAM fungus) growth phases directly and indirectly on its symbiotic association with peanut plant. Laboratory experiment was carried out to determine the effects of herbicides on spore germination and hyphal growth of *G. mosseae*. The recommended rates of alachlor for soil and water agar media are 3.6 µg ai g⁻¹ soil and 24 µg ai mL⁻¹ agar, and for glyphosate are 2.16 µg ae g⁻¹ soil and 14 µg ae mL⁻¹ agar, respectively. Alachlor at ten fold of the recommended rate significantly (P ≤ 0.01) reduced spore germination of *G. mosseae* by 36 and 43%, and hyphal length was reduced by 61 and 83% in soil and water agar media, respectively. The application of alachlor at ten folds of the recommended rate (36 µg ai g⁻¹) reduced the length of active external hyphae of *G. mosseae* by 40% (23.99 cm g⁻¹). Alachlor at one and half of the recommended rate (5.4 µg ai g⁻¹) decreased the development and succinate dehydrogenase (SDH) activity
of internal hyphae of *G. mosseae*, and amount of mycorrhizal tissue. In contrast, glyphosate at all rates had no negative effects on spore germination and hyphal length of *G. mosseae* in both soil and water agar media, and also did not affect the external and internal hyphae.

The effect of herbicides on *G. mosseae* symbiosis with peanut was also studied in the greenhouse. The adverse effects of alachlor on the mycorrhizal plants was greater than in non-mycorrhizal plants. The phosphorus concentration in the shoot was unaffected by alachlor in the non-mycorrhizal plant or by glyphosate in the mycorrhizal plant and vice versa. Alachlor and glyphosate did not affect P inflow into non-mycorrhizal plants. However, P inflow into mycorrhizal plant was increased by glyphosate application at 2.16 µg ae g⁻¹ which gave 65.31 x 10⁻¹³ mol P m⁻¹ s⁻¹. It increased hyphal inflow of 41.48 x 10⁻¹³ mol P m⁻¹ s⁻¹, and consequently increased hyphal uptake from soil to be 479.72 from 48.04 x 10⁻¹³ mol P m⁻¹ s⁻¹ in control. The effect of *G. mosseae* on the persistence and degradation of herbicides in the soil showed that the rate of degradation of alachlor was higher in *G. mosseae* inoculated soil than in the uninoculated soil. Therefore, the persistence of alachlor in the soil was shortened by 6 days with the presence of *G. mosseae*. However, the persistence of glyphosate in the soil was unaffected by the presence of the fungi.

The result of study showed that the type of herbicides and their rates are important factors mediating the effects of herbicides on *G. mosseae* and its symbiosis with peanut plant. The distinct growth phases of *G. mosseae* may differ in their tolerance to alachlor
herbicide. There was an interaction between alachlor and *G. mosseae* which was indicated by the adverse effect on mycorrhizal plants, and evidence that the persistence of alachlor in the soil was shortened by the fungi. In contrast, glyphosate did not affect the growth phases of *G. mosseae*. 
Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PENGARUH ALAKLOR DAN GLIFOSAT KE ATAS PERKEMBANGAN \textit{G. mosseae} DAN HUBUNGAN SIMBIOTIKNYA DENGAN KACANG TANAH

Oleh

ASKIF PASARIBU

Ogos 2004

Pengurusi : Profesor Rosli Mohamad, Ph.D.

Fakulti : Pertanian

Data mengenai pengaruh racun herba ke atas simbiosis “vesicular-arbuscular mycorrhiza (VAM)” ini masih jarang dibandingkan pada racun kulat. Kajian ini bertujuan untuk menilai pengaruh alaklor (racun herba yang bertindak melalui tanah) dan glifosat (racun herba yang bertindak melalui daun) ke atas fasa-fasa pertumbuhan \textit{Glomus mosseae} (kulat “VAM”) secara langsung, dan secara tidak langsung ke atas hubungan simbiotiknya dengan kacang tanah. Percubaan di makmal dijalankan untuk menentukan kesan racun herba ke atas percambahan spora and pertumbuhan hifa \textit{G. mosseae}.

Kadar-kadar alaklor yang disyorkan untuk media tanah dan “water agar” adalah 3.6 µg ai g⁻¹ tanah and 24 µg ai mL⁻¹ agar, dan untuk glifosat adalah 2.16 µg ae g⁻¹ tanah and 14 µg ae mL⁻¹ agar, berturut-turut. Alaklor pada sepuluh kali ganda kadar yang disyorkan nyata sekali (P≤ 0.01) mengurangkan percambahan spora \textit{G. mosseae} 36 dan 43% dan pemanjangan hifa diurangkan 61 dan 83% dalam masing-masing media tanah dan “water agar”. Aplikasi alaklor pada sepuluh kali ganda kadar yang disyorkan (36 µg ai g⁻¹) mengurangkan panjang hifa aktif 40% (23.99 cm g⁻¹). Alaklor pada kadar satu
setengah kali dari kadar yang disyorkan (5.4 µg ai g⁻¹) mengurangkan perkembangan dan aktiviti “succinate dehydrogenase” (SDH) hifa internal *G. mosseae*, dan jumlah tisu mikorizal. Sebaliknya glifosat pada seluruh kadar tidak memberi kesan negatif ke atas percambahan spora dan pemanjangan hifa *G. mosseae* dalam kedua-dua media tanah dan “water agar”, dan tidak mempengaruhi hifa eksternal dan internal.

Pengaruh racun herba ke atas simbiosis *G. mosseae* dengan kacang tanah juga telah dikaji di rumah kaca. Kesan negatif alaklor ke atas tanaman yang diinokulasi dengan mikoriza adalah lebih besar berbanding tanaman yang tidak diinokulasi dengan mikoriza. Konsentrasi fosforus pada pucuk tidak dipengaruhi oleh alaklor pada tanaman tanpa mikoriza, atau oleh glifosat pada tanaman yang mengandungi mikoriza dan sebaliknya. Alaklor dan glifosat tidak mempengaruhi aliran fosforus pada tanaman tanpa mikoriza. Tetapi aliran fosforus kepada tanaman yang mempunyai mikoriza ditingkatkan oleh penggunaan glifosat pada kadar 2.16 µg ae g⁻¹ yang memberikan 65.31 x 10⁻¹³ mol P m⁻¹ s⁻¹. Ini meningkatkan aliran hifa 41.48 x 10⁻¹³ mol P m⁻¹ s⁻¹, dan selanjutnya meningkatkan pengambilan fosforus melalui hifa dari tanah kepada 479.72 dibandingkan 48.04 x 10⁻¹³ mol P m⁻¹ s⁻¹ pada kontrol. Pengaruh *G. mosseae* ke atas persistensi dan degradasi racun herba dalam tanah menunjukkan kadar degradasi alaklor adalah lebih tinggi pada tanah yang diinokulasi dengan *G. mosseae* berbanding dengan tanah yang tidak diinokulasi. Oleh itu, persistensi alaklor dipendekkan 6 hari dengan kehadiran *G. mosseae*. Akan tetapi, persistensi glifosat tidak dipengaruhi dengan kehadiran kulat ini.
Hasil kajian menunjukkan bahawa jenis racun herba dan kadarnya adalah faktor penting pengantara kesan racun herba ke atas *G. mosseae* dan simbiosisnya dengan kacang tanah. Fasa-fasa pertumbuhan *G. mosseae* yang berbeza juga boleh membezakan toleransi mereka ke atas racun herba alaklor. Terdapat interaksi antara alaklor dan *G. mosseae* yang ditunjukkan melalui kesan negatif ke atas tanaman yang mempunyai mikoriza, dan bukti bahawa persistensi alaklor dipendekkan dengan kehadiran kulat tersebut dalam tanah. Sebaliknya, glifosat tidak mempengaruhi seluruh fasa pertumbuhan *G. mosseae*. 
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I certify that an Examination Committee met on 16th August 2004 to conduct the final examination of Askif Pasaribu on his Doctor of Philosophy thesis entitled “Effects of Alachlor and Glyphosate on Development of *Glomus mosseae* and its Symbiotic Association with Peanut” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulation 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

**Kamaruzzaman Sijam, Ph.D.**  
Associate Professor  
Faculty of Agriculture  
Universiti Putra Malaysia  
(Chairman)

**Radziah Othman, Ph.D.**  
Associate Professor  
Faculty of Agriculture  
Universiti Putra Malaysia  
(Member)

**Mohd. Hanafi Musa, Ph.D.**  
Associate Professor  
Faculty of Agriculture  
Universiti Putra Malaysia  
(Member)

**Baharuddin Salleh, Ph.D.**  
Professor  
School of Biological Sciences  
Universiti Sains Malaysia  
(Independent Examiner)

---

**GULAM RUSUL RAHMAT ALI, Ph.D.**  
Professor/Deputy Dean  
School of Graduate Studies  
Universiti Putra Malaysia  
Date:
This thesis submitted to the senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for degree of Doctor of Philosophy. The members of the Supervisory Committee are as follows:

**Rosl Mohamad, Ph.D.**  
Professor  
Faculty of Agriculture  
Universiti Putra Malaysia  
(Chairman)

**Azizah Hashim, Ph.D.**  
Professor  
Faculty of Agriculture  
Universiti Putra Malaysia  
(Member)

**Zaharah Abd. Rahman, Ph.D.**  
Professor  
Faculty of Agriculture  
Universiti Putra Malaysia  
(Member)

**Dzolkhifli Omar, Ph.D.**  
Professor  
Faculty of Agriculture  
Universiti Putra Malaysia  
(Member)

---

**AINI IDERIS, Ph.D.**  
Professor/Dean  
School of Graduate Studies  
Universiti Putra Malaysia

Date:
DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

ASKIF PASARIBU

Date:
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