UNIVERSITI PUTRA MALAYSIA

EFFECT OF ORGANOSILICONE SURFACTANT ON UPTAKE AND TRANSLOCATION OF GLYPHOSATE IN PENNISETUM POLYSTACHION L

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MASTER OF AGRICULTURAL SCIENCE
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By

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EFFECT OF ORGANOSILICONE SURFACTANT ON UPTAKE AND TRANSLOCATION OF GLYPHOSATE IN *PENNISETUM POLYSTACHION*

By

TEO KEE CHIONG

JULY 1997

Chairman : Associate Prof. Dr. Dzolkhifli Omar

Faculty : Agriculture

The effect of adding organosilicone surfactant, Pulse® on efficacy, uptake and translocation of glyphosate (Roundup®) for the control of *Pennisetum polystachion* was evaluated in the glasshouse. The dose-response study with glyphosate on 9-week old *P. polystachion* showed that at the rate of 1.08 kg a.e./ha, glyphosate caused complete mortality of the plants. It was estimated that dosage between 360 to 540 g a.e./ha gave 50% mortality.

When Pulse® was added to the glyphosate spray solutions, the bioefficacy of glyphosate on *P. polystachion* increased as the concentration of Pulse® increased. The optimum concentration of Pulse® was 0.2 % w/w above which no significant increase in the bioefficacy was observed. Spray deposition studies using flourescent tracer technique revealed that the mixture of glyphosate and Pulse® gave 42% higher spray deposition compared to glyphosate alone, thus contributing to the increase in bioefficacy of glyphosate observed in the mixture.

Further studies with ^{14}C-labelled glyphosate showed that the uptake of glyphosate was significantly higher ($p \leq 0.05$) with addition of Pulse® compared to glyphosate alone for the same amount of spray deposition. However, addition of Pulse® to glyphosate spray solution did not significantly increase translocatory activity of glyphosate to different parts of the plant. The distribution of ^{14}C-labelled glyphosate was observed to be highest in the stem (21.8%) and lowest in the root (3.0%). The results indicate that the higher spray deposition enhanced stomatal infiltration and faster initial rate of cuticular penetration.

Abstrak tesis ini diserahkan kepada Senat Universiti Putra Malaysia sebagai memenuhi sebahagian daripada syarat untuk mendapatkan Ijazah Master Sains Pertanian.

KESAN ORGANOSILIKON SURFAKTAN KE ATAS PENGAMBILAN DAN TRANSLOKASI GLIFOSAT DI DALAM *PENNISETUM POLYSTACHION*

Oleh

TEO KEE CHIONG

JULAI 1997

Pengerusi : Prof. Madya Dr. Dzolkhifli Omar

Fakulti : Pertanian

Kesan penambahan surfaktan organosilikon, Pulse® ke atas pengambilan dan translokasi glifosat untuk mengawal *Pennisetum polystachion* telah dikaji di rumah kaca. Kajian dos-respon glifosat terhadap *P. polystachion* yang berumur 9 minggu menunjukkan glifosat pada kadar 1.08 kg a.e./ha menyebabkan 100% kematian. Adalah dianggarkan dos glifosat di antara 360 hingga 540 g a.e./ha memberi 50% kematian.

Apabila Pulse® dicampur pada larutan semburan glifosat, efikasi glifosat meningkat dengan peningkatan kepekatan Pulse®. Kadar kepekatan Pulse® yang optima adalah 0.2% w/w, dan kadar yang melebihi 0.2% w/w tidak memberi kesan yang bererti kepada peningkatan bioefikasi glifosat. Kaedah pengesan pendaflor menunjukkan campuran glifosat dengan Pulse® memberi peningkatan perletakan semburan 42% lebih tinggi perletakan semburan berbanding dengan glifosat sahaja. Ini menyumbang kepada peningkatan efikasi glifosat yang di perolehi daripada campuran tersebut. Peningkatan perletakan semburan menggalakkan infiltrasi glifosat menerusi stomata dan kemasukan glifosat melalui kutikel ke dalam tisu tumbuhan.

Kajian selanjutnya menunjukkan pengambilan ^{14}C-glifosat untuk rawatan campuran glifosat dan Pulse® adalah lebih tinggi ($p \leq 0.05$) berbanding dengan glifosat sahaja. Sebaliknya, penambahan Pulse® kepada larutan semburan glifosat tidak meningkatkan aktiviti translokasi glifosat ke bahagian lain rumpai berkenaan. Taburan ^{14}C-glifosat di dapati tertinggi pada bahagian stem (21.8%) dan terendah pada bahagian akar (3.0%).

CHAPTER I

INTRODUCTION

Mission grass (*Pennisetum polystachion* L.) commonly known as cat's tail or 'ekor kucing' is an important grass weed in Malaysia and many other countries in South East Asia. The word 'mission' for *P. polystachion* is appropriate since its seeds, being mainly wind-dispersed, can colonize new areas and set up new mission points, where they start to germinate and multiply rapidly (Lee, 1988).

Its distribution covers mostly tropical regions. In Indonesia, it is found at altitudes up to more than 900 m above sea level (Soerjani *et al*., 1987). In the South East Asia region, *P. polystachion* becomes a troublesome weed when it takes over waste- and cultivated lands (Soerjani *et al*., 1987). It is a noxious weed in rubber plantations in Java, Indonesia and Thailand as it occupies the open space between young rubber trees. Reasons for its recognition as a noxious weed may be due to its perennial characteristics and its tendency to replace *Imperata cylindrica* in rubber plantations (Tjitrosoedirdjo, 1990). It is a perennial weed which interferes with agronomic operations because of its height and dense coverage (Chee *et al*., 1993). The replacement of *I. cylindrica* by *P. polystachion* in rubber plantations in West Java was noted in 1975 (Soedarsan & Amri, 1975).

In Malaysia, *P. polystachion* grows profusely along roadsides and highways and can also be found in most estates such as rubber, oil palm, cocoa, coconut and sugarcane, orchards, vegetable and upland rice farms (Lee, 1988; Ipor & Tawan, 1994). *P. polystachion* is a relatively new weed, but it is already widespread throughout the country, infesting at least 10 km^2 of roadsides in 1988 (Bakar *et al.*, 1990).

Glyphosate or N-(phosphonomethyl)glycine is a systemic, broad spectrum post-emergence herbicide which has been shown to give cost-effective control of mission grass (Chee *et al.*, 1993). Its translocative ability enables it to kill the weed and gives longer period of control. However, the foliar absorption of glyphosate was only 25% to 50% of the amount applied (Sprankle *et al.*, 1975). This was due to its inability to readily penetrate the leaf cuticle, and it requires the addition of surfactant for adequate penetration (Ross & Lembi, 1985).

Adjuvants such as surfactants have been widely used in both herbicides and pesticides application. The need for adjuvants with glyphosate sprays has been recognized for some time, especially for the control of grasses (Sprankle *et al.*, 1975; Bishop & Field, 1983). The addition of surfactant to herbicide solutions can increase the herbicidal efficacy and further enhance the herbicide penetration (McWhorther, 1963).

Increased efficacy allows application rates of a potentially toxic and expensive active ingredient (a.i.) to be lowered, while maintaining biological effectiveness (Holloway & Stock, 1990; Zabkiewicz *et al*., 1990). Thus, the operation cost can be cut down and the amounts of a.i. can be reduced to levels that are economically and environmentally acceptable.

Pulse (an organosilicone surfactant) is utilized as an adjuvant with Roundup® as it can provide high and continuous uptake almost instantaneously *via* stomatal infiltration (Stevens *et al*., 1992). Although other organosilicone surfactants also have this ability, none of those studied provided such high levels of uptake *via* stomatal infiltration and all were attenuated to a greater extent by partial stomatal closure compared to Pulse (Stevens *et al*., 1992).

This research project was undertaken to study uptake and translocation of glyphosate and effect of adding Pulse on the effectiveness of glyphosate for control of Mission grass (*P. polystachion*). The research consisted of two parts. Part one was a preliminary screening on dose response effect of glyphosate and effect of Pulse on the effectiveness of glyphosate for the control of mission grass (*P. polystachion*). The second part was to study the uptake and translocation of glyphosate by *P. polystachion* with and without Pulse using radiolabelled ^{14}C-glyphosate.

CHAPTER II

REVIEW OF LITERATURE

Mission Grass (*Pennisetum polystachion*)

Distribution of Mission Grass

Mission grass (*P. polystachion* L.) is a perennial weed, native of Tropical Africa (Chee *et al.*, 1993). It is commonly known as cat's tail, feather pennisetum (English), rumput ekor kucing (Malaysia) and yaa khachyon chop (Thai). The native tropical grass species belongs to the family Gramineae (Soerjani *et al.*, 1987).

P. polystachion is believed to have been introduced into Malaysia from Thailand in late 1980s. It was first observed by scientists from the Bogor Research Institute for Plantations Crops at Subang, Purwakarta and Pondok Gede, Bogor in 1972 (Soedarsan & Amri, 1975).

Morphology and Growth of Mission Grass

P. polystachion is a tuft grass, erect, simple or branched (50 cm to 190 cm), nodes hairless with linear leaves up to 60 cm long and 5 mm to 18 mm wide, sheath half the node length, base rounded and margin rough. The inflorescence terminal is yellowish brown and spike like panicle up to 5 cm to 25 cm long and 1.3 cm to 2.6 cm wide. The inflorescence terminal composes of sessile unit of 1 to 4 spikelets. The plant produces tillers and grows in clumps to about 2 m or more in height. It flowers almost throughout the year (Chee *et al.*, 1993). It has high reproductive capacity and spreads rapidly through highly viable seeds (Noda *et al.*, 1985). The seeds are dispersed by wind. They have a resilient ability to survive drought and certain cultural and chemical control methods (Lee, 1988). Once established, it can grow and spread rapidly, especially during the wet seasons. It favours growing in unshaded and lightly shaded conditions. It grows well in the moist, fertile soils of agricultural fields, roadsides and wastelands.

The high survival of this species is due to profuse tillering and heavy seed production (Ipor & Tawan, 1994). Studies showed that shoots could regenerate from cut stem fragments. Shoot regeneration is influenced by age of the nodes, depth of burial and duration of exposure of the stems to the environment.

Older stem fragments closer to the base of the plant are more viable than the younger fragments close to the apical shoots. It was also observed that the deeper the fragments were buried in the soil, the lesser the number of shoots regenerating (Chee *et al*., 1993). The regrowth can also occur from dormant buds located at the 'basal bulb' area (Lee, 1988).

The tall *P. polystachion* also shaded young rubber plants (Chee, 1994). This competitive weed species had massive root systems which were suppressive and resulted in poor growth of rubber roots as reported by Chee (1994). Table 1 shows that *P. polystachion* reduced the growth of rubber much more than other weeds.

Therefore, *P. polystachion* needs to be controlled in order to prevent competition for nutrients and water as well as to promote easy accessibility along the planting strips in rubber estates (Chee *et al.*, 1993).

Table 1

Effect of Weed Species on the Height of Young Rubber after One Year

No.	Weed species	Height of rubber (cm)	% of height compared to control	% reduction
1.	Control (no weed)	292.7	100.0	-
2.	*Pueraria phaseoloides*	261.9	89.5	10.5
3.	*Borreria latifolia*	244.0	83.4	16.6
4.	*Ottochloa nodosa*	238.0	81.3	18.7
5.	*Paspalum conjugatum*	228.2	77.9	22.1
6.	*Asystasia gangetica*	225.0	76.9	23.1
7.	*Imperata cylindrica*	208.6	71.3	28.7
8.	*Vetiver zizanoides*	196.7	67.2	32.8
9.	*Ischaemum muticum*	190.8	65.2	34.8
10.	*P. polystachion*	173.0	59.1	41.9

Source : Chee, 1994

Control of Mission Grass

Manual Control

Manual control of *P. polystachion* is by cutting using a 'parang', sickle or motorized slasher. However, regrowth of the weed is rapid owing to regeneration of shoots from the living stems at the base of the plant. Most effective control can be achieved by hoeing the basal stems and rhizomes out of the soil (Chee *et al*., 1993). Exposing the stems to environment or hot sun also reduced regeneration and viability of the shoots due to desiccation, and longer exposure produced more effective kill. Burning the dried fragments is also effective in controlling shoot regeneration.

Chemical Control

Another effective method of control of *P. polystachion* is using herbicides. However, the lack of translocation of herbicides within *P. polystachion* is cited as an obstacle to good control (Hauser, 1963). Contact herbicides, such as paraquat (Gramoxone) and glufosinate ammonium (Basta 15) did not give persistent control due to limited translocation of the herbicides (Chee *et al*., 1993). Only parts of the weed which are in contact with the herbicide were scorched or killed, while the remaining living stems gave rise to new shoots. The duration of control was short and several spraying rounds were necessary.

Systemic or translocatory herbicides, which are able to move to the unsprayed parts of the weed, give longer duration of control compared to contact herbicides. Some effective systemic herbicides are glyphosate (Roundup), imazapyr (Assault 100A) and monosodium methylarsonate (MSMA) (Chee *et al*., 1993).

In Sri Lanka, *P. polystachion* is a problem in tea plantations. It can be controlled by spraying diuron at 2 g a.i./litre to plants less than 45 cm high or before the emergence of influorescence (Watson, 1986). The spray did not kill mature flowering plants.

Apart from the type and rate of herbicide, the weed density also determines the efficiency of control. A dense weed could result in less effective control. Pevious studies by Chee *et al*. (1993) showed that the most cost-effective treatment among the herbicides tested was glyphosate (Table 2).

Table 2

Effect of Herbicides on Control of *P. polystachion*

Herbicide	Rate (L/ha)	Cost (RM/Ha/Round)	Remarks
Paraquat (Gramoxone)	3	27.60	Contact activity 1-2 months control
Glufosinate ammonium (Basta 15)	3.3	56.51	Contact activity 1-2 months control
Paraquat + Diuron (Para-col)	3	43.20	Contact activity 1-2 months control
Glyphosate (Roundup)	3	33.75	Systemic activity > 4 months control
Imazapyr (Assault 100A)	5	160.63	Systemic activity > 4 months control
Monosodium methylarsonate (MSMA)	6	42.60	Systemic activity > 2 months control

Source : Chee *et al.*, 1993

Glyphosate

Introduction

Glyphosate or N-(phosphonomethyl)glycine has been considered as one of the most important organophosphorus herbicides (Hance & Holly, 1990). It is a systemic, non-selective and post-emergence herbicide. However, selectivity may be achieved by directional application. It is very effective on perennial, annual, biennial species of sedges, grasses and broadleaves (Martin & Worthing, 1974).

Glyphosate is a highly effective foliar herbicide (Hance & Holly, 1990). It could provide complete control of weeds both above and below ground with a single foliar application. This is because it penetrates into the weed and is readily translocated throughout the weed including underground root or rhizome systems. Once inside the weed, it is extremely toxic. Thus, not only are aerial parts of plant killed, but also roots, rhizomes, stolons and other reproductive tissues (Chase & Appleby, 1979). The systemic property results in total destruction of hard to kill perennial weeds such as *Sorghum halepense*, *Agropyron repens*, *Circium arvense*, *Cyperus spp*, *Cynodon dactylon* and *Imperata cylindrica* (Franz, 1985). However, its activity on some tropical grasses and sedges may be limited by restricted penetration (Hance & Holly, 1990).

Glyphosate is a non-residual herbicide. Any amount which comes in contact with the soil is immediately inactivated as it is tightly bound to the soil making it unavailable for root uptake. Therefore, it has low phytotoxicity *via* soil (Aston & Monaco, 1991). It is also practically non-toxic to mammals, birds, fish, insects and bacteria (Hance & Holly, 1990).

Glyphosate has low solubility in water (*ca* 1.2% at 25 °C), and is therefore applied as the isopropylamine salt (IPA) (the highly water-soluble a.i. in the commercial formulations) at 1.0 to 1.5 kg of a.e. (acid equivalent) per hectare (Caseley *et al.*, 1976; Caseley & Coupland, 1985; Bryson, 1987, 1988).