UNIVERSITI PUTRA MALAYSIA

INFLUENCE OF ADDITIVE, AGE OF FOLIAGE AND APPLICATION TECHNIQUE ON THE CONTROL OF *IMPERATA CYLINDRICA* (L.) BEAUV. WITH DALAPON AND GLYPHOSATE

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INFLUENCE OF ADDITIVE, AGE OF FOLIAGE, AND APPLICATION TECHNIQUE ON THE CONTROL OF *IMPERATA CYLINDRICA* (L.) BEAUV. WITH DALAPON AND GLYPHOSATE

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This thesis attached hereto, entitled "Influence of Additive, Age of Foliage, and Application Technique on the Control of Imperata cylindrica (L.) Beauv. with Dalapon and Glyphosate" prepared and submitted by Yeoh Chong Hoe in partial fulfilment of the requirements for the Degree of Master of Agricultural Science, is hereby accepted.

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TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS	i
TABLE OF CONTENTS	ii
LIST OF TABLES	v
LIST OF FIGURES	vii
ABSTRACT (English)	viii
ABSTRACT (Bahasa Malaysia)	x
INTRODUCTION	xii
LITERATURE REVIEW	1
Distribution and Economic Importance of *Imperata cylindrica*	1
Persistence and Spread of Lalang	2
Mechanical Control of Lalang	4
Chemical Control of Lalang	4
Effect of Additives and Surfactants on the Activity of Dalapon	7
Age of Lalang Foliage and Effectiveness of Herbicides	8
Effect of Additives and Surfactants on the Activity of Glyphosate	8
Effect of Site of Application of Herbicides	9
Effect of Environmental and other Factors on the Performance of Herbicides	10
MATERIALS AND METHODS	13
Experiment I	13
Experiment II	19
Experiment III	22
Experiment IV	24

	Page
RESULTS	28
Experiment I	28
Visual Injury Symptoms	28
Effect of Dalapon and Glyphosate on Lalang as Determined by Visual Assessment	28
Effect of Ammonium Sulphate on the Activity of Dalapon as Determined by Visual Assessment	31
Effect of Ammonium Sulphate on the Activity of Glyphosate as Determined by Visual Assessment	33
Dry Weight of Foliage Still Living at 90 Days After Treatment	36
Dry Weight of Rhizomes Still Living at 90 Days After Treatment	36
Experiment II	40
Effect of Ammonium Sulphate on Lalang	40
Effect of Glyphosate and Dalapon on Lalang	40
Glyphosate and Ammonium Sulphate Interaction on Lalang	44
Dalapon and Ammonium Sulphate Interaction on Lalang	48
Assessment for Synergistic or Antagonistic Effect of Ammonium Sulphate on Glyphosate and Dalapon	52
Experiment III	56
Site of Application and Effectiveness of Glyphosate on Lalang	56
Major Anatomical Features of the Lalang Leaf Surfaces	61
Experiment IV	64
Influence of Spray Volume on the Activity of Glyphosate as Assessed by Visual Leaf Injury	64
Influence of Spray Volume on the Activity of Dalapon as Assessed by Visual Leaf Injury	64
Influence of Spray Volume on the Activity of Glyphosate and Dalapon as Assessed by Dry Weights of Leaves, Rhizomes and Roots	64

	Page
DISCUSSION AND CONCLUSION	68
Effect of Dalapon and Glyphosate on Lalang	68
Effect of Ammonium Sulphate on the Activity of Dalapon and Glyphosate	69
Effect of Environmental Factors on Herbicide Response	72
Site of Application and Effectiveness of Herbicides on Lalang	73
Influence of Spray Volume on Performance of Herbicides	74
Cost of Lalang Control	75
SUMMARY	81
LITERATURE CITED	85
INDEX OF APPENDICES	91
APPENDIX	93

LIST OF TABLES

Table		Page
1	Main Plot Treatments (Experiment I)	15
2	Technical Data on Chemicals Used	18
3	Meteorological and Other Data Recorded at the Time of Treatment in Experiment I	19
4	Meteorological and Other Data Recorded at Time of Treatment in Experiment II	21
5	Meteorological and Other Data Recorded at Time of Treatment in Experiment III	24
6	Herbicide Treatments and Spray Volume Used in Experiment IV	25
7	Meteorological and Other Data Recorded at Time of Treatment in Experiment IV	26
8	Mean Dry Weights of Lalang Foliage Still Living at 90 Days after Treatment (Experiment I)	35
9	Mean Dry Weights of Lalang Rhizomes Still Living at 90 Days after Treatment (Experiment I)	37
10a	Visual Assessment of Leaf Injury of One Month Old Lalang Foliage after Treatment with Glyphosate and Ammonium Sulphate (Experiment II)	41
10b	Visual Assessment of Leaf Injury of Three Months Old Lalang Foliage After Treatment with Glyphosate and Ammonium Sulphate (Experiment II)	42
10c	Visual Assessment of Leaf Injury of Six Months Old Lalang Foliage after Treatment with Glyphosate and Ammonium Sulphate (Experiment II)	43
11a	Visual Assessment of Leaf Injury of One Month Old Lalang Foliage after Treatment with Dalapon and Ammonium Sulphate (Experiment II)	45
11b	Visual Assessment of Leaf Injury of Three Months Old Lalang Foliage after Treatment with Dalapon and Ammonium Sulphate (Experiment II)	46
11c	Visual Assessment of Leaf Injury of Six Months Old Lalang Foliage after Treatment with Dalapon and Ammonium Sulphate (Experiment II)	47

Table		Page
12	Mean Dry Weights of Leaves, Rhizomes and Roots Living at 90 Days after Treatment with Combinations of Glyphosate and Ammonium Sulphate (Experiment II)	49
13	Mean Dry Weights of Leaves, Rhizomes and Roots Living at 90 Days after Treatment with Combinations of Dalapon and Ammonium Sulphate (Experiment II)	51
14	Effect of Ammonium Sulphate on the Activity of Dalapon (Experiment II)	53
15	Effect of Ammonium Sulphate on the Activity of Glyphosate (Experiment II)	54
16	Visual Assessment of Lalang Leaf Injury as Influenced by Site of Application of Glyphosate	56
17	Mean Dry Weights of Lalang Leaves, Rhizomes and Roots Surviving at 53 Days after Treatment with Glyphosate (Experiment III)	59
18	Visual Ratings of Leaf Injury Caused by Glyphosate and Dalapon in Various Volumes of Water (Experiment IV)	65
19	Mean Dry Weights of Leaves, Rhizomes and Roots at 70 Days after Treatment with Herbicides in Various Volumes of Water (Experiment IV)	66
20	Cost on Present Recommended Method of Lalang Control	76
21	Cost on Low Volume Method of Lalang Control	77
22	Comparison between Costs of Present Recommended Method and the Low Volume Method of Lalang Control	79

LIST OF FIGURES

Figure		Page
1	General View of the Experimental Area (Experiment I)	12
2	Lay-out Plan of Treatments in Experiment I	14
3	A Schematic Diagram showing a Modified Sprayer Used for Applying the Herbicides in this study	16
4	Leaf Injury Symptoms Induced by Dalapon and Glyphosate Recorded at 20 Days after Treatment	27
5	Leaf Injury Response of 1, 3 and > 6 Months Old Foliage to Dalapon and Glyphosate (Experiment I)	29
6	Regeneration of Lalang at 55 Days After Treatment with Dalapon Mg/Na at 10 kg a.i./ha	30
7	Leaf Injury Response of 1, 3 and > 6 Months Old Lalang Foliage to Dalapon + Additive (Experiment I)	32
8	Leaf Injury Response of 1, 3 and > 6 Months Old Foliage to Glyphosate + Additive (Experiment I)	34
9	Mean Dry Weights of Lalang Foliage and Rhizomes (g /m^2) Still Living 90 Days after Treatments (Experiment I)	38
10	Mean Percentage Leaf Injury of Lalang Plants as Influenced by Site Application of Glyphosate (Experiment III)	57
11	Response of Lalang to Glyphosate Placement at 50 Days after Treatment (Experiment III)	58
12	Lower Surface of Lalang Leaf	60
13	Upper Surface of Lalang Leaf	60
14	Cross-Section of Lalang Leaf	62
15	Outer and Inner Surfaces of a Mature Lalang Leaf Sheath Showing(a)Prominent Leaf Hairs (b) Absence of Leaf Hairs.	62
16	Effect of Spray Volume on the Response of Lalang to Glyphosate and Dalapon (Experiment IV)	63

ABSTRACT

Experiments were conducted to evaluate the influence of ammonium sulphate as an additive to dalapon (2,2-dichloropropionic acid, Mg/Na salt) and glyphosate [N(phosphonomethyl) glycine], and the influence of age of foliage and spray volume on the control of lalang [Imperata cylindrica (L.) Beauv.]. The most effective site of uptake of glyphosate in the control of lalang was also determined.

Higher rates of glyphosate (2.0 kg/ha) and dalapon (15 kg/ha) gave higher leaf injury ratings on the 1-, 3- and 6-month foliage treatments compared to lower rates (1.5 and 10 kg/ha respectively) in both the field and pot experiments. Improved control with higher glyphosate rate was also reflected in the significantly lower dry weight of rhizomes harvested 90 days after treatment in the pot experiment. There were no significant differences in the two levels (10 and 15 kg/ha) of dalapon used in terms of weight of rhizomes irrespective of foliage age in both the experiments. At the usual recommended rates, glyphosate gave better control of lalang than dalapon in both the field and pot trials; glyphosate was also more effective on younger foliage than dalapon. The results also suggest that there was no advantage in cutting the lalang foliage and treating the young foliage regrowth with dalapon.

Significant antagonistic responses due to ammonium sulphate (5 kg/ha) as additive were obtained with 1- and 3-month old foliage treatments at the 10 kg/ha dalapon level. In general,

the additive had either no influence or a negative effect on the activity of dalapon on lalang. The influence of ammonium sulphate on glyphosate were both synergistic and antagonistic and the responses appeared to be specific to the rate of glyphosate used, rate of additive and age of the lalang foliage at treatment. At the 2.0 kg/ha glyphosate level, the responses due to ammonium sulphate (10 kg/ha) were antagonistic on the 3-month old foliage treatments in both the field and pot experiments and on the 6-month old foliage in the pot trial. Glyphosate at 1.5 kg/ha when incorporated with ammonium sulphate at 10 kg/ha exhibited a significant synergistic response in the pot trial, the response being stronger with younger foliage.

More effective control of lalang was obtained when glyphosate was applied on all young leaf sheaths and culms where abundant leaf hair was prominently present and on the lower leaf surfaces where there were most stomatal openings. These sites of application apparently favoured more rapid absorption and resulted in more effective control of the lalang.

Glyphosate in a spray volume of 200 l/ha gave more effective control of lalang than the recommended volume of 1000 l/ha tested. With dalapon, there was no significant influence of spray volume on its performance over the range of 200 to 1000 l/ha. The results indicate that considerable savings could be realised by reducing the spray volume for both herbicides from 21 to 29% on labour cost particularly on hilly and difficult terrain.

RINGKASAN

Kajian dijalankan bagi menilaikan pengaruh amonium sulfat sebagai bahan campuran, umur daun dan isipadu semburan bagi mengawal lalang [*Imperata cylindrica* (L.) Beauv.], dengan dalapon (2,2-dichloropropionic acid Mg/Na salt)dan glyphosate [N (phosphonomethyl) glycine] dan juga menentukan tempat yang paling berkesan penyerapan glyphosate.

Kadar tinggi glyphosate (2.0 kg/ha) dan dalapon (15 kg/ha) memberi kerosakan daun yang tinggi mengikut kadar dalam semua pelakuan daun 1-, 3- dan 6-bulan berbanding dengan kadar racun herba rendah 1.5 kg/ha dan 10 kg/ha dalam kedua percubaan di ladang dan percubaan dalam pasu. Membaiki kawalan dengan kadar glyphosate yang tinggi telah digambarkan dalam berat kering raizom yang rendah dipungut 90 hari selepas perlakuan dalam percubaan dalam pasu. Tiada perbezaan bagi dua paras dalapon (10 dan 15 kg/ha) dalam sebutan berat raizom dengan tidak memandang umur daun dalam kedua percubaan di ladang dan percubaan dalam pasu. Kadar syor biasa, glyphosate memberi kawalan lalang yang baik dari dalapon dalam kedua percubaan di ladang dan percubaan dalam pasu dan glyphosate lebih berkesan bagi daun muda dari dalapon. Keputusan juga menunjukkan tiada faedah diperolehi dari menebas atau memotong lalang sebelum menyembur dalapon atau menyembur dalapon pada daun muda yang baru tumbuh. Pertentangan tindakbalas yang utama kerana bahan campuran telah didapati dengan 1- dan 3-bulan umur daun perlakuan bagi paras 10 kg/ha dalapon. Pada amnya bahan campuran sama ada mempunyai kesan negatif atau tidak mempunyai pengaruhi dalam aktiviti dalapon atas lalang. Pengaruh amonium sulfat

dalam glyphosate ialah dua iaitu sinegistik dan pertentangan dan tindakbalas kelihatan tertentu kepada kadar kegunaan glyphosate, kadar bahan campuran dan pelakuan umur daun lalang. Dengan paras 2.0 kg/ha glyphosate tindakbalas kepada bahan campuran (10 kg/ha) adalah bertentangan dalam umur daun 3 bulan perlakuan dalam kedua percubaan di ladang and percubaan dalam pasu dan juga bagi umur daun 6 bulan dalam percubaan dalam pasu. Glyphosate 1.5 kg/ha bila bercampur dengan amonium sulfat 10 kg/ha menunjukkan pertentangan tindakbalas yang utama bagi percubaan dalam pasu dan tindakbalas adalah lebih kuat dengan daun muda. Keputusan mencadangkan lalang lebih berkesan dikawal dengan kadar rendah glyphosate dengan menyembur daun muda yang baru tumbuh, demi mengambil kesempatan pengaruh perlawanan bahan campuran dalam perengkat ini.

Kawalan lalang yang lebih berkesan didapati bila glyphosate digunakan bagi semua kelumpuk dan pucuk daun muda di mana banyak bulu daun terdapat, dan di bawah permukaan daun di mana banyak sekali luang stomatal terdapat. Tempat membubuh pada zahirnya menunjukkan lebih cepat resapan dan mengakibatkan pembunuhan lalang sepenuhnya. Glyphosate dalam semburan isipadu 200 l/ha memberi kawalan yang lebih berkesan terhadap lalang dari isipadu yang paling tinggi 1000 l/ha yang di uji, dan dengan dalapon tidak terdapat pengaruh pada isipadu semburan dalam percubaan ke atas 200 sehingga 1000 l/ha. Keputusan menunjukkan sebahagian besar perbelanjaan dapat dijimatkan dari 21 sehingga 29% kos buruh terutama di tanah yang berbukit bakau dan tinggi rendah dengan mengurangkan isipadu semburan bagi kedua jenis racun dengan syarat.

INTRUDUCTION

Imperata cylindrica (L.) Beauv. a noxious weed in Malaysia is ranked among the ten most troublesome weeds in the world (Holm and Herberger, 1969). Known locally as lalang, the weed has tough ramifying rhizomes and root system. The high generative power of the rhizomes and the abundant production of viable seeds by the plant have made it the most difficult weed to control in plantation crops, particularly in smallholdings. No satisfactory growth of any agricultural crop can be expected in lalang infested areas due to the high competitive ability of lalang (Greig, 1937; Jagoe, 1938; Satari, 1968; Eussen *et al.* ,1976). Among the earliest herbicides tested, sodium chlorate, calcium cynamide, copper sulphate, 2,4-D (2,4-dichlorophenoxyacetic acid), TCA (trichloroacetic acid), 2,4,5-T (2,4,5-trichlorophenoxyacetic acid), and MCPA (4-chloro-2-methylphenoxyacetic acid), were reported to be unsatisfactory or ineffective for the control of lalang (Akhurst, 1935; Derico, 1951; Jauffret, 1954). Sodium arsenite, although highly effective, proved to be a hazard to health and the environment (Anon., 1950; Arnott and Leaf, 1967; Woo, 1973).

Investigations with later herbicides such as dalapon (2,2-dichloropropionic acid, Mg/Na salt) and glyphosate N-(phosphonomethyl)glycine have shown promise (Anon.,1956; Harper, 1973; Ivens, 1973; Wong, 1973). Dalapon introduced in 1950 proved to be effective against lalang and was a safer herbicide to use especially by smallholders. More recently in 1970, glyphosate was reported to be more effective than dalapon. Due to its present high cost, this herbicide is beyond the reach of most smallholders. However, with the use of cheap additives to improve the effectiveness of herbicides, and coupled with improved application techniques, costs may be considerably reduced.

In view of the seriousness of this weed and the need for improved control, the main aim of this study was to find more effective and possibly cheaper methods of chemical control. The objectives of this study were as follows:-

- To determine the influence of ammonium sulphate on the effectiveness of glyphosate and dalapon applied to lalang foliage of different ages.

- To determine the effectiveness of glyphosate when applied to different parts of the weed.

- To evaluate the influence of spray volume on the effectiveness of the herbicides.

LITERATURE REVIEW

Distribution and Economic Importance of *Imperata cylindrica*

Imperata cylindrica (L.) Beauv. is commonly called lalang in Malaysia, alang-alang in Indonesia and cogon grass in the Philippines and the Southern States of America. In Africa, Australia and Papua New Guinea lalang is known as spear grass and blady grass. Holm and Herberger (1969), classified lalang among the ten most troublesome weeds in the world. Lalang is widespread throughout countries in Euro-Mediterranean region, Africa, India, Australia and the Far East. It is also found to have spread to several Southern States of America following its introduction from the Philippines into Alabama before 1920 as grass for cattle feed (Pendleton, 1948; Dickens and Buchanan, 1971). The persistence of lalang is mainly due to its high competitive ability and its capability to develop almost into a pure stand when left uncontrolled (Eussen *et al*., 1976). Lalang is found to grow well in all types of soils irrespective of fertility provided they are not perpetually under water (Soerjani, 1970). However, lalang growth is less vigorous at high altitudes of about 2000 m due to the low night temperatures (Santiago, 1974; Eussen and Groot, 1974). It is found in abundance in the lowlands of Malaysia where temperatures are high throughout the year.

Lalang is undoubtedly one of the most difficult weeds to control in both the cultivated and non-cultivated areas in

Malaysia, Indonesia and several other countries in the tropical regions of the world (Soerjani, 1970).

Crop losses due to lalang are heavy, and no satisfactory growth of any agricultural crop can be expected in lalang infested areas because of the intense competition by lalang (Greig, 1937; Jagoe, 1938; Satari, 1968). Rao (1970), estimated that lalang and other ubiquitous weeds together caused 90% of the world crop losses. Complete loss of young teak plants were also reported by Coster (1932). Reports also indicate that lalang suppressed yields of crops such as coconut palms (Jagoe, 1938), maize, cassava and other arable crops in Africa (Ogborn, 1972; Ivens, 1975) and coconut and rubber trees in Sri Lanka (Sandanam and Jayasinghe, 1977). In Thailand, large acreages of replanted rubber were totally unsuccessful due to heavy infestation by lalang (Strong, 1968; Harper, 1973). Malaysia and Indonesia too have their share of the problem with lalang in the rubber and oil palm plantations. In Malaysia, yields of oil palm have been shown to decline by 20% due to infestation by lalang and *Mikania cordata* (Burm.f.) B.L. Robinson, (Turner and Gillbanks 1974). Infestation during the early stages of crop growth could also result in delayed maturity of the crop (Wood, 1977). In general, lalang caused drastic retardation on growth,yellowing of the leaves and dieback of crops leading to severe losses in yields (Hubbard *et al*., 1944; Soerjani, 1970). Due to the severe suppression of crop growth by lalang, complete eradication of the weed was recommended and the planting of even rubber on land infested with the weed was forbidden (Anon, 1958).

Persistence and Spread of Lalang

Lalang flowers freely when slashed, mowed, burnt or subjected to water stress conditions and spreads by means of seeds and rhizomes. The rhizomes are important in the spread of the weed to the surroundings (Eussen and Groot, 1974). Lalang is persistent primarily due to its low top to root/rhizome ratio which provides for rapid top regrowth when cut back or burnt (Sajise, 1973). Santiago (1974), attributed its excellent survival rate to its high capacity for rhizome production as compared to *Imperata conferta* (J.S. Presl) Ohwi which has a greater capacity for leaf production. Due to its massive underground rhizome system it escapes total destruction in the event of an outbreak of fire as compared to other weeds. Fire is one of the agents that help the weed to multiply and spread as reported in Indonesia and Malaysia (Soemarwoto, 1961; Santiago, 1974). The frequent outbreaks of fire during the dry season and the rapid regeneration of lalang followed by abundant flower and seed production helps the weed to spread rapidly. Shifting cultivation was another major contributory factor to the spread of lalang in Indonesia (Eussen and Soemantri Wirjahardja, 1973). These factors have contributed to the estimated 15 to 30 million hectares of land under lalang in Indonesia (Soemarwoto, 1961). Lalang also rapidly colonises neglected land. During the Second World War, rubber estates and other cultivated lands in Malaysia were neglected and, as a result, all open and less shaded areas became predominantly infested with lalang (Anon, 1947).

Mechanical Control of Lalang

The removal of lalang rhizomes by hand digging was the most effective method commonly employed in plantations (Campbell, 1909; Coster, 1932; Rudin, 1935; Welle, 1958). However, with the rising cost of labour, hand weeding became uneconomical. This method was superceded by other mechanical means. Mechanical control with tractor drawn implements and the subsequent removal of the rhizomes was reported to give excellent control (Backer and van Slooten, 1924). Similar work done in the Gold Coast, Africa, confirmed that disc ploughing followed by six cultivations gave good control of lalang (Anon, 1951). Knox and Cole (1973), reported that double ploughing 20 cm deep in combination with a root blade cultivation (30 cm deep) controlled lalang better than double ploughing alone. Power slashing or mowing of the lalang leaves three or more times per annum also suppressed the weed (Santiago, 1974). This method, similar to hand slashing, was aimed at exhausting the food reserves in the rhizomes and reducing their vigour (Soerjani, 1970).

In Malaysia the limiting factor to tractor drawn implement is the undulating to steep terrain in most of the cultivated areas. Furthermore, a major portion of the land under plantation crops belongs to small farmers with an average farm size of 3 ha. Hence, mechanisation is uneconomical and not practical.

Chemical Control of Lalang

Early use of herbicides such as sodium arsenite, sodium chlorate, calcium cyanamide, copper sulphate and oils on lalang in rubber estates in Malaysia was first reported by the Rubber Research Institute of Malaya (Akhurst, 1935). Sodium arsenite was found by most users to be effective for the control of lalang. Greig (1937) demonstrated that sodium arsenite (18.9 kg/ha) in ten repeated applications over 10 day intervals was effective against lalang. Childs (1956) reported that lalang could be eradicated with two applications of sodium arsenite at 18.9 kg/ha followed by another two rounds (10 kg/ha) at ten day intervals and four wiping rounds using an aromatic oil fortified with DNOC (2-methyl-4,6 dinitrophenol) and PCP (sodium pentachlorophenate). Nagel (1959) in Africa reported good control of lalang with sodium arsenite at 17 kg/ha incorporated with 0.1% wetting agent.

In the absence of other suitable cheaper alternatives, sodium arsenite was widely used by most estates in Malaysia. However, sodium arsenite had caused health hazard to human beings and livestock and the risk of damage to crops. Contact of the arsenical spray on the bark of rubber trees caused cracking of the outer bark or cortex leading to open wounds and thus destroying tapping panels (Anon., 1945, 1950). Further, about 50% to 70% of the toxic residue was retained in the soil. Arnott and Leaf (1967) found lethal concentrations of sodium arsenite up to a depth of 7.6 cm in silt loam soils and also in "run off" water from sprayed areas. Uptake and accumulation of residue arsenic by crop plants was also demonstrated (Woo, 1973). Reports of arsenical poisoning particularly of domestic animals were common (Anon., 1967, 1972). There was a constant search for alternatives so that the use of sodium arsenite could be discontinued (Anon., 1961). Several chemicals such as 2,4-D(2,4-dichlorophenoxyacetic acid), TCA (trichloroacetic acid), 2,4,5-T(2,4,5-trichlorophenoxyacetic acid), and MCPA (4-chloro-2-methylphenoxyacetic acid) were tested against lalang and found to be unsatisfactory (Derico, 1951; Jauffret, 1954). Allen and Smith (1956) reported that CMU [3-(4'-chlorophenyl)-1:1-dimethyl urea] and PDU (3-phenyl-1:1-dimethyl urea) used at 75.4 kg/ha and 100.5 kg/ha respectively were ineffective against lalang and caused injury to young rubber and coconut palms.

Dalapon (2,2-dichloropropionic acid, sodium salt), introduced into Malaya in the 1950s was reported to give more effective control of lalang when used at 12.5 to 31.4 kg/ha compared to sodium arsenite or sodium chlorate (Anon., 1956). The use of diquat (1,1'-ethylene, 2,2'-dipyridylium dibromide) at 1.25 kg/ha in four applications at ten day intervals caused reduction to lalang equivalent to ten applications of sodium arsenite at 18.9 kg/ha (Holmes, 1958). Five successive applications of paraquat (1,1'-dimethyl-4,4'-dipyridylium cation as dichloride salt) at 0.63 to 1.25 kg/ha at fortnightly intervals exhausted the food reserve of the rhizomes with slight regrowth of young shoots (Sheldrick, 1961). Riepma (1963) reported that six applications of paraquat at 1.25 kg/ha gave similar results as six rounds of sodium arsenite at 18.9 kg/ha applied at intervals of two to four weeks. However, he explained that it was too expensive for practical use. Seth (1971) reported that paraquat at 0.63 kg/ha with two follow up rounds at 0.31 kg/ha on 50% regenerated lalang gave similar results as that of dalapon used once only at 18.9 kg/ha. The sequential treatment of lalang with paraquat at 0.56 kg/ha or dalapon at 6.7 to 9 kg/ha, and followed after four weeks by paraquat at 0.56 kg/ha were reported to give good control (Harper, 1973). Ivens (1973), however, demonstrated that sequential spraying of dalapon and paraquat on lalang gave no advantage over dalapon used alone, and dalapon at 15 to 20 kg/ha was reported to give excellent control of the weed for eleven months. In the same year glyphosate /N-(phosphonomethyl) glycine_7 was recommended for lalang control (Wong, 1973). Lalang growing under little or no shade required a higher dosage of glyphosate at 2.5 kg ae/ha than for lalang under shaded conditions (Wong, 1975). Currently, dalapon and glyphosate are the two major herbicides widely used for the control of lalang (Yeoh and Pushparajah, 1976).

Effect of Additives and Surfactants on the Activity of Dalapon

The efficiency of dalapon was improved by the addition of Teepol (sodium secondary alcohol sulphate) (Coomans, 1974). Subsequently, Yeoh and Pushparajah (1976), also reported that dalapon at 16.8 kg/ha with 2.8 to 4.2 l/ha of the teepol gave better control than dalapon used singly. McWhorter and Jordan (1976), also showed that the control of Johnson grass was improved when 1% of Nonoxynol (9.5)/α (p-nonylphenyl w-hydroxy-poly(oxy-ethylene)_7 was included in dalapon. However, ammonium sulphate (1.25 to 10.0 kg/ha) as an additive did not improve the control of *Agropyron repens* (L.) by dalapon (Blair, 1975). Information on the role of ammonium sulphate as additive in the control of lalang in relation to age of foliage is not known.

Age of Lalang Foliage and Effectiveness of Herbicides

Slashing of the lalang leaves prior to treatment gave variable results. The use of three to four applications of 15% oil/water emulsion containing 1% sodium PCP and 2% sodium TCA at 1260 l/ha reported to give more effective control than sodium arsenite on slashed lalang (Anon., 1953). Dalapon and paraquat when applied to slashed lalang gave inferior results (Anon., 1970). In Malaysia, dalapon at 9.5 kg/ha on unslashed lalang was reported to give the same degree of control as dalapon at 38.0 kg/ha applied to foliage regrowth obtained at three weeks after slashing (Anon., 1957). In Sri Lanka, Sandanam and Jayasinghe (1977) demonstrated that dalapon used alone at 22.4 kg/ha and in sequential application with paraquat had no apparent advantage when applied to four or eight weeks old lalang regrowth compared to the mature stand. However, Ivens (1975) reported that dalapon at 15 kg/ha gave best results when applied to lalang regrowth developing six weeks after ploughing. There is therefore, a need to further evaluate the effect of herbicides in relation to foliage age under local field conditions.

Effect of Additives and Surfactants on the Activity of Glyphosate

Turner and Loader (1972) reported that the addition of ammonium ions to foliage applied herbicides increased their activity. Mangoensoekarjo and Kadnan (1973) found that glyphosate gave improved control of lalang with the use of tetrapion as additive. The result was further supported by Ivens (1973), who showed that glyphosate (4 kg/ha) with 10 kg/ha of tetrapion gave effective control of the weed for eleven months. Blair (1975) also found that ammonium sulphate (1.25 to 10.0 kg/ha) improved the activity of glyphosate (0.25 to 2.0 kg/ha) when mixed together against A. repens. Suwunnamek and Parker (1975) confirmed that the addition of ammonium sulphate (1.25 to 10 kg/ha) to glyphosate (0.75 kg/ha) under varying conditions of light, temperature and growth stages produced synergistic response on Cyperus rotundus (L.). Turner and Loader (1975) demonstrated that ammonium sulphate increased the activity of glyphosate on A. repens and several other woody species. The addition of 5 to 10 kg/ha ammonium sulphate to 2.0 kg/ha of glyphosate was also shown to enhance the effectiveness of glyphosate in lowering the weights of haulms and tubers in potatoes (Lutman and Richardson, 1978). However, a three-way mixture of an orthophosphoric acid (2% H_3PO_4), ammonium sulphate (5% NH_2SO_4) and glyphosate (0.1 - 0.3 kg/ha) was reported to be antagonistic (Turner and Loader, 1978). The influence of additives on the activity of glyphosate on lalang foliage of different ages is not known.

Effect of Site of Application of Herbicides

The leaves and stems are the primary intercepting and absorbing organs of foliar applied herbicides. Absorption of foliar applied chemicals is usually greater through the lower than upper leaf surfaces (Currier and Dybing, 1959; Sargent and Blackman, 1962; Hull, 1970). The greater permeability of the leaf surface has been attributed, in general, to