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BUD DEVELOPMENT IN THE RHIZOMES OF *IMPERATA CYLINDRICA* (L.) BEAUV. AFTER GLYPHOSATE TREATMENT

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RINGKASAN

Glyphosate pada kekuatan 3.3, 6.7 and 10.0 kg bahan aktif sehektar membasmi tunas pokok *lalang* dengan amat berkesan. Reput rizom berlaku dengan luasnya di petak-petak yang dirawat dengan 6.7 dan 10.0 kg glyphosate. Enam minggu selepas rawatan pada daun, rizom dari petak-petak yang dirawat dan yang tidak dirawat, dikerat-kerat dan kemudian diletak dalam piring petri. Selepas 24 hari , keratan rizom dari petak yang dirawat dengan 3.3, 6.7 dan 10.0 kg bahan aktif sehektar telah menunjukkan bilangan rizom dan pucuk baru tumbuhan berkurangan berbanding dengan kawalan. Terdapat jumlah panjang rizom dan pucuk baru dikurangkan dengan bererti pada semua perlakuan glyphosate.

INTRODUCTION

Imperata cylindrica (L.) Beauv. or *lalang* is a weed of 35 crops in 73 countries including Malaysia (HOLM, PLUCKNETT, PANCHO and HERBERGER, 1977). It has the capacity to regenerate rapidly after the foliage has been burnt or slashed. It often colonizes large tracts of cultivated land on sedimentary soils and peat. The aggressive and persistent behaviour of this noxious weed is mainly related to its underground network of rhizomes which have buds that are capable of growing out even when herbicides are applied (WONG, 1973; LEE, 1976).

A detailed search of literature reveals little information on the development of buds after the foliar application of herbicides (ANON., 1957; 1976). Little is known of the fate of the buds and the position of the buds on the rhizomes where regrowth is likely to take place after herbicides have been applied on the shoots.

Previous work on the development of buds in sectioned rhizomes of *I. cylindrica* was based on the application of glyphosate at 2 and 5 kg a.i./ha (LEE, 1983). It is not clear if a dosage higher than 5 kg a.i./ha of glyphosate will give a complete kill of all the rhizome buds; if this happens, a 'one-shot' treatment can be used. At present, the need for a 'touch-up' application following the first one (WONG, 1976); alternatively a second application has been advocated (SOEDARSAN, NOORMANDIAS and SANTIKA, 1975; LEE, 1983).

The main objective of the present study was to assess the development of the buds on rhizomes which were sampled and sectioned six weeks after the foliar application of glyphosate in the field. Observations were also carried out on the nodal positions of the rhizome buds which developed further in intact and sectioned rhizomes.

MATERIALS AND METHODS

Experimental Site

The experiment was carried out at MARDI Station, Jalan Kebun, Kelang in December 1981 until March 1982. An area, colonized by *I. cylindrica* since 1975, was used as the experimental site. The peat had an organic matter content of 90% and a pH of 3.8. Shade trees were absent in the experimental area, and the level of water in the ditch was 15 – 35 cm below the soil surface three weeks before and after spraying.

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A randomized complete block design with four replications was employed. The treatments were G0 : Control (untreated), and G1 (3.3 kg), G2 (6.7 kg) and G3 (10.0 kg a.i./ha) of glyphosate. Plot size was 7 m x 10 m, but only the inner area of 5 m x 8 m was for evaluation of treatment effects. Three days before spraying, 30 labels were placed on green shoots in the inner area of each plot in order to facilitate sampling after spraying.

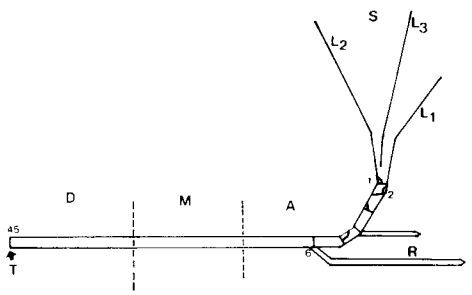
Spraying and Sampling Procedure

Glyphosate *(Roundup)* was applied from a conventional knapsack sprayer in 770 litres of tap water/hectare. There was no rain on the day of spraying. Six weeks later, rhizomes ending in labelled shoots were sampled carefully. A fork was used to tease away the peat. The soil which contained both intact and broken rhizome systems was left in a plastic tray which had been filled with some water. The tray was labelled and covered with a layer of polythene in order to prevent the desiccation of the exposed rhizomes.

Preparation of Sampled Materials

The rhizome materials were carefully washed in order to remove the soil. Ten rhizomes ending in apical shoots per treatment per replicate were selected for uniformity of the number of nodes and length. All rhizomes were severed from their most distal nodes, *i.e.* where they were attached to another rhizome *(Figure 1)*. Very thin rhizomes (less than 2 mm in diameter) were rejected.

Rhizomes of the untreated control (G0) were firm and pale yellow or white and their apical shoots were green, except for a few lower leaves which had senescened. Rhizomes of the glyphosate treatments (G1, G2 and G3) had brown apical shoots but a few were partially green; the colour of rhizomes varies from pale yellow to light brown. Completely decayed rhizomes from glyphosate-treated plots were rejected.



L1 :Lowest leaf with a lamina of more than 1 cm, subtending node 2.
L2 :Second lowest leaf subtending node 1.
L3 :Third (youngest visible) leaf.
A : Apical region of primary rhizome, nodes 1–15.
M : Mid-region, nodes 16–30.
D : Distal region, nodes 31–45.
R : A sharp secondary rhizome.
T : Point of attachment to another rhizome.

Figure 1. A primary rhizome ending in an apical shoot (S).

Scale leaves of the sampled rhizomes were removed very carefully by hand followed by the use of a pair of forceps to remove some of those that adhere very closely to the nodes and to remove the leaf sheaths. All secondary growth which was more than 5 mm in length was excised at the start of the laboratory experiment. The primary rhizome was divided into four-noded sections starting from node six till 40. All the four-noded sections from one rhizome were placed in a petri dish, lined with moist filter paper. Petri dishes with a diameter of 13.8 cm and a depth of 2.1 cm were previously sterilized in the Astell autoclave at 120°C at 1.05 kg f/cm^2 for 15 minutes and left in the oven at 100°C for one hour.

Rhizome sections were maintained by daily application of distilled water.

Numbers of Nodes and Classification of Secondary Growth

Nodes were numbered from one, which was subtended by the second lowest leaf, to the most distal node which was attached to another rhizome *(Figure 1)*. The growth from buds on a multinoded primary

rhizome with apical (primary) shoot was classified into five categories of secondary growth:

a. Bud, visible without magnification, less than 5 mm in length,
b. bud cavity, or soft and brown/black bud, less than 5 mm in length,
c. rhizome, more than 5 mm in length, which has not sprouted an apical shoot,
d. rhizome, more than 5 mm in length, which has sprouted an apical shoot, and
e. absence of secondary growth ('blind' node).

Initial Records

The length of the primary rhizomes was measured from node one until the most distal node. The number of nodes on the primary rhizome was counted prior to sectioning.

Assessment of Treatment Effects

Observations were carried out on the effects of glyphosate on the kill of the aerial shoots six weeks after spraying. The colour of the new shoots which emerged and the decay of intact rhizome systems six weeks after spraying were observed.

Prior to sectioning, observations were carried out on the regions *(Figure 1)* of the primary rhizomes which showed regrowth of new secondary shoots. Twenty-four days after sectioning, the numbers of new (secondary) rhizomes and shoots were counted and their lengths measured. Observations were carried out on the decay of the rhizome sections 24 days after sectioning.

RESULTS

Kill of Aerial Shoots

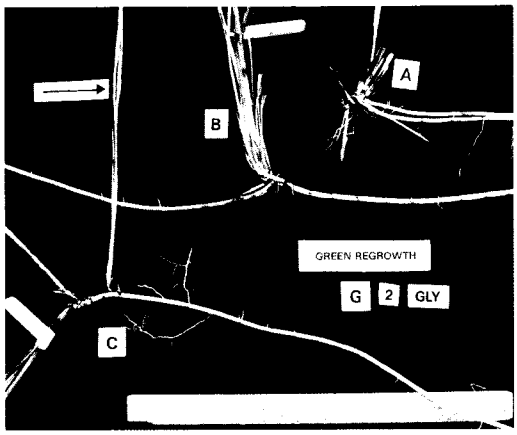
In the field, glyphosate at 3.3, 6.7 and 10.0 kg a.i./ha provided an average of 91%, 96% and 99% kill respectively of aerial shoots after six weeks. Partially green shoots were found in all the treated plots; the lower regions of the laminae were green but the tips and margins of the leaves were brown.

Regrowth of New Shoots

Chlorotic, partially-green and abnormal aerial shoots which were very close to the dead (treated and labelled prior to spraying) primary shoots were observed. When the rhizome systems were observed in the laboratory, it was found that regrowth occurred only from the apical region of the primary rhizome.

Decay of Rhizomes

Extensive decay of rhizome was observed in plots treated with 6.7 kg and 10.0 kg, but in plots treated with 3.3 kg, many rhizomes were apparently firm and pale yellow in colour *(Plate 1)*. Of special interest is the decay of the apical tips of secondary rhizomes in all the plots treated with the three dosages.



A & B : Green and chlorotic regrowth from nodes near the treated shoot.
C : Green shoot (arrowed) had emerged above ground from an apical node. Note that parent rhizome was still firm and pale yellow *i.e.* had not decayed.

Plate 1. Three rhizome systems sampled 6 weeks after treatment (glyphosate at 3.3 kg a.i./ha).

Table 1. Initial number of nodes of primary rhizome, length of primary rhizomes, number of secondary rhizomes and shoots and their total length 24 days after sectioning

Treatment (kg a.i./ha)	At start of experiment		24 days after sectioning	
	No. of nodes	Length per rhizome (cm)	Mean total no. of new rhizomes and shoots	Mean total length of new rhizomes and shoots (cm)
G0 (Untreated control)	43.4	64.5	4.15 (2.03)a	16.25a
G1 Glyphosate 3.3	43.2	61.9	1.88 (1.35)b	6.20b
G2 Glyphosate 6.7	41.8	58.9	1.33 (1.06)c	1.65c
G3 Glyphosate 10.0	44.2	63.9	0.70 (0.81)c	0.55c
L.S.D. (5%)	N.S.	N.S.	(0.28)	2.76
s.e. of a treatment mean	0.842	1.259	0.088	0.863

Figures in brackets are square root values.
Means followed by the same letter are not significantly different.

Table 2. Nodal positions of buds which developed into rhizomes or shoots 24 days after sectioning

Treatment (kg a.i./ha)	Nodes (numbered from the base of the primary shoot)																								
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
G0 (Untreated control)	*	*	*	*		*	*	*	*	*	*		*	*	*	*		*	*	*	*	*	*		*	*
G1 Glyphosate 3.3			*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*						
G2 Glyphosate 6.7						*	*	*	*	*	*		*													
G3 Glyphosate 10.0						*	*	*	*	*	*															

Bud Development in Sectioned Rhizomes

Glyphosate at the three dosages caused a significant reduction in the number of new rhizomes and shoots and their total length of new growth when compared with the untreated *(Table 1)*. New secondary rhizomes or shoots developed from nodes 6–9, 11–16, 18–21, 23–28, 30 and 31 of the primary rhizomes ending in untreated primary shoots *(Table 2)*. In contrast, bud development was restricted to fewer nodes particularly nodes 11 – 16 of rhizomes from plots treated with glyphosate.

DISCUSSION

Four aspects have provided the main interest in the present studies; the regrowth of aerial shoots, the decay of rhizomes, the number of buds capable of developing further after the spraying of glyphosate and the location of the nodes at which buds develop into rhizomes or shoots.

The results showed that regrowth of new shoots, often in clumps, occurred usually close to the treated shoots. This tendency for the buds on the apical region *(Figure 1)* of the primary rhizomes to develop further is the characteristic of this weed (SOERJANI, 1970). Buds in the mid-region of undisturbed rhizomes usually remained dormant, while buds are absent in the most distal nodes.

When a translocated herbicide like glyphosate was applied on the shoots, a good kill of the aerial parts was obtained. There is no problem in killing the aerial parts, but it is difficult to kill all the buds in the underground parts, even at 10.0 kg a.i./ hectare. This finding contrasts with that by WONG (1976) who reported the 'complete destruction of rhizomes' in plots treated with glyphosate at 5.3 kg a.i./hectare.

It is not clear as to the reasons for the regrowth of aerial shoots despite an application

of a dosage as high as 10.0 kg a.i./ha, a dosage which is uneconomic for practical purposes. One possibility is that some buds or even young rhizomes which were present at the apical region of the primary rhizome at the time of spraying were resistant to glyphosate. Glyphosate or its metabolites or both move readily from the treated leaves of *I. cylindrica* to the underground rhizomes including the buds, but the problem may well be an insufficient amount of glyphosate reaching the buds (LEE, 1983).

Rhizomes that were obtained from plots treated with glyphosate had buds which did not develop further in the intact system. It is not clear as to why these buds did not develop further under field conditions. However, one possibility might be due to the inhibitory influence of the more apically positioned shoots. Growing shoots exert dominance on other buds (SACHS and THIMANN, 1967). However, apical dominance can be overcome by fragmentation of the rhizomes. Thus, when the four-noded sections were left in petri dishes, some of the buds developed into new rhizomes or shoots. The higher the dosage of glyphosate, the greater the reduction in the number of buds which developed further.

The extra shoot formation in clumps after the application of glyphosate at 3.3 kg might be a result of damage to the primary shoot species, with subsequent disruption of apical dominance. Similar effects of extra tillering at the base of the shoots treated with glyphosate (less than 1 kg/ha) have been reported for couch grass (CASELEY, 1972) and nutgrass (PARKER, 1976).

The decay of the apical tips of rhizomes in the intact systems six weeks after the application of glyphosate seems to suggest the preferential movement of the herbicide or its metabolites or both to the active physiological 'sinks'. Using ^{14}C-labelled glyphosate various workers have shown that it accumulated preferentially in nodes near the rhizome tip of various weed species, for example, couch grass (CLAUS and BEHRENS, 1976), Johnson grass (KELLS and RIECK, 1979) and 'lalang' (LEE, 1983). Although glyphosate was applied on the shoots, the apical tips of the secondary rhizomes were most susceptible to glyphosate, compared with the mid and distal sections of the secondary rhizomes. Since the tips are sites of the apical meristems *i.e.* 'active sinks', the herbicide had moved from the shoots to the stronger sinks at the apical tips of rhizomes. This finding supports the concept of translocation from source to active sinks (PARKER, 1964).

The present results are not without applied significance. A 'one-shot' application of glyphosate at 3.3, 6.7 or 10.0 kg a.i./ha did not provide a complete kill of all the axillary growth of all rhizomes. Thus, for practical purposes, repeated application should be carried out and the initial dosage could be 2.2 – 3.8 kg a.i./hectare. The finding that buds at nodes 8 – 17 and 19 – 25 were capable of growing out when the rhizomes were fragmented six weeks after glyphosate treatment indicated that a pool of dormant buds with potential for regrowth exists in this noxious weed. In the farms, it is not uncommon for farmers to hoe the land after application of herbicides to the weed. This process of fragmentation of the rhizome systems causes the development of the rhizome buds resulting in early reinfestation of the weed. A systematic approach of retreating regrowth by using split applications of glyphosate would help considerably in suppressing regrowth.

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ABSTRACT

Glyphosate at 3.3, 6.7 and 10.0 kg a.i./ha provided very effective kill of the aerial shoots. Extensive decay of rhizomes occurred in plots treated with glyphosate at 6.7 and 10.0 kilogrammes. Six weeks after foliar treatment, rhizomes from untreated and glyphosate-treated plots were sectioned and placed in petri dishes. Twenty-four days after sectioning, rhizome sections from plots treated with glyphosate at 3.3, 6.7 and 10.0 kg a.i./ha showed a significant reduction in the number of new rhizomes and shoots when compared to the untreated control. There was a significant reduction in the total length of new rhizomes and shoots by all glyphosate treatments.

REFERENCES

ANON. (1957). Dowpon – lalang and grass eradicant. *Plrs' Bull. Rubb. Res. Inst. Malays.* ***29***, 27–30.

——— (1976). Effective and efficient control of *Imperata cylindrica* (lalang). *Plrs' Bull. Rubb. Res. Inst. Malays.* ***145***, 83–9.

CASELEY, J.C. (1972). The effect of environmental factors on the performance of glyphosate against *Agropyron repens. Proc. 11th Brit. Weed Control Conf., Brighton, 1971,* pp. 641–7.

CLAUS, J.S. and BEHRENS, R. (1976). Glyphosate translocation and quackgrass rhizome bud kill. *Weed Sci.* ***24***, 149–52.

HOLM, L.G., PLUCKNETT, D.L., PANCHO, J.V. and HERBERGER, J.P. (1977). *Imperata cylindrica* (L.) Beauv. In *The World's Worst Weeds: Distribution and Biology* pp. 62–71. Honolulu: University of Hawaii Press.

KELLS, J.J. and RIECK, C.E. (1979). Effects of illuminance and time on accumulation of glyphosate in Johnsongrass *(Sorghum halepense). Weed Sci.* ***27***, 235–7.

LEE, S.A. (1976). Weed studies in pineapple growing areas. M. Agric. Sc. Thesis, University of Malaya. 150 pp.

——— (1983). Control of *Imperata cylindrica* (L.) Beauv. Ph.D. Thesis, University of Cambridge. 212 pp.

PARKER, C. (1964). Some experience of testing new herbicides on perennial weeds in pots. *Proc. 7th Brit. Weed Control Conf., Brighton, 1964,* pp. 546–52.

——— (1976). Effects on the dormancy of plant organs. In *Herbicides: Physiology, biochemistry, ecology* (ed. AUDUS, L.J.), pp. 165–90. London: Academic Press.

SACHS, T. and THIMANN, K.O. (1967). The role of auxins and cytokinins in the release of buds from dominance. *Am. J. Bot.* ***54***, 136–44.

SOEDARSAN, A., NOORMANDIAS, K. and SANTIKA, H. (1975). Glyphosate versus dalapon for alang-alang control. *Proc. 3rd Indonesian Weed Sc. Conf., Bandung, 1974,* pp. 427–36.

SOERJANI, M. (1970). Alang-alang *Imperata cylindrica* (L.) Beauv. Pattern of growth as related to its problem of control. Ph. D. Thesis, Gajah Mada University, Jogjakarta. *Biotrop. Bull. No.* ***1***, 88 pp.

WONG, P.W. (1973). Roundup (Glyphosate) : a new broad spectrum post-emergence weedicide with potential utility in oil palm and rubber. *Proc. Int. Oil Palm Conf., Kuala Lumpur, 1972,* pp. 214–26.

——— (1976). Use of Roundup (Glyphosate) for lalang control prior to planting oil palms and rubber. *Proc. Malays. Int. Agric. Oil Palm Conf., Kuala Lumpur, 1976,* 6 pp.

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