

GERMINATION, RHIZOME SURVIVAL AND CONTROL OF *IMPERATA CYLINDRICA* (L.) BEAUV. ON PEAT

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RINGKASAN

Biji benih *Imperata* (alang) mempunyai 84.5% cambah selepas tiga minggu mengalami 15/35°C suhu berselang. Tiap pucuk ibu mengeluarkan 181.3 pucuk selepas 6½ bulan diladang. Selepas 12½ bulan, 71.9% rizem didapati dipermukaan tanah 15 cm manakala 28.1% yang lain didapati diantara 15 dan 30 cm dalam. Kajian factorial keatas kedalaman x panjangnya rizem menunjukkan bahawa rizem yang disemai pada 10 cm dalam atau lebih tidak tumbuh. Kajian corak tumbuhan rizem menunjukkan 2 hingga 4 rizem dikeluarkan dibawah tempat pucuk. Glyphosate pada 2.5-3.7 kg/ha boleh mengawal rumput dengan berkesan untuk lebih kurang selama 5 bulan. Dari 3 campuran kimia yang dikaji untuk kesan synergistik dengan glyphosate, sulphate of ammonia sahaja yang kelihatan menggalakkan.

INTRODUCTION

Imperata cylindrica (L.) Beauv. cv. Major has been identified as one of the ten most important weeds in the world (HOLM and HERBERGER, 1969). Research on the patterns of rhizome growth has been documented by SOERJANI (1970) while the chemical control has been investigated in various countries, viz: Malaysia (ANON, 1957; RIEPMA, 1963; LEE, 1974), Indonesia (SIMANJUNTAK, 1963) and Africa (IVENS, 1973).

Most of the investigations were made on soils of low organic matter and pH of 4.5 and above. Very little studies were conducted on *Imperata* on peat, which has an organic matter contents of 85-95% and a pH of 3.4-4.0. Lowering of soil pH has been reported to increase its growth (SOERJANI, 1970).

A weed survey in Selangor and Johore showed that *Imperata* is common on cultivated peat (LEE, 1976). Knowledge of its seed germination, rhizome growth and survival would be useful in the formulation of long-term control programme while the evaluation of glyphosate, a comparatively new herbicide in Malaysia, would provide some basic information for large-scale control of *Imperata*.

In the present investigations, *Imperata cylindrica* was studied for its germination, shoot production and depth of rhizome penetration. The possibilities of rhizome control through deep burial and the use of additives with glyphosate for sheet *Imperata* were also studied.

MATERIALS AND METHODS

Germination studies

Seeds collected from *Imperata cylindrica* inflorescence at MARDI Research Station, Jalan Kebun were left in the laboratory at room temperature ($30 \pm 3^\circ\text{C}$) for 2 days and counted in replicates of 100 seeds. There were 6 treatments, each replicated 4 times. The first two treatments consisted of seeds with and without glumes germinated at alternating temperatures of

15°C (8 hrs.) and 35°C (16 hrs.) in a growth chamber (Model E7H, Controlled Environments Ltd.). The remaining 4 treatments consisted of 4 depths of sowing on virgin peat soil (pH 3.4) in polybags placed in a "greenhouse" with polythene roofing.

Shoot production

Twenty shoots, each about 15 cm tall and bearing 3 leaves were planted at MARDI Station, Jalan Kebun. Planting distances were 1.5 x 1.5 m and there were 4 rows with 5 shoots/row. Various crops have been planted previously in this field which had been limed to bring the pH to 4.0. The number of shoots was counted at 6½ months by subdividing the area covered by shoots into 15 subplots.

Depth of penetration of rhizomes

The same plots were studied for the depth of penetration of rhizomes. At 12½ months after planting, 6 locations were chosen. At each locations, an area of 30 cm x 45 cm was demarcated and dug to various depths – 15 cm, 30, 45 and 60 cm. At each depth, the rhizomes were cut carefully and brought to the laboratory for measurement of length.

Pattern of rhizome growth

Ten rhizome fragments each 10 cm long were planted in the field which had received fertilizers application previously. Observations on the production of the young rhizome network and shoots were made for 3 months.

Depth of burial x rhizome length

Rhizomes with apices and scale leaf intact were collected from the top 15 cm of the soil and left in moistened plastic bags for about 2 hours while awaiting transplanting. The factorial experiment consisted of 4 depths of burial (1.25, 5.00, 10.00 and 20.00 cm) and 3 rhizome lengths (2.5, 10.00 and 17.5 cm) with 3 replications. Six rhizome fragments/treatment were buried in wooden trays filled with old cultivated peat which had been fertilised previously. Soil pH was 4.0. Watering was carried out on the day of planting and observations were made on the number of rhizomes which have germinated and the survival of the young shoots after 2 and 4 months.

Chemical control

The experiment was conducted on a dense stand of *Imperata cylindrica* growing on uncultivated peat for several years. Soil pH was 3.5–3.7. The average height of the weed was 1 m and the experimental area was unshaded.

Treatments consisted of two dosages of glyphosate, and glyphosate in combination with urea, sulphate of ammonia and 2, 4-Dichlorophenoxyacetic acid (*Table 4*). Each treatment was replicated four times and the plots, each 3.5 m x 7.0 m, were arranged in a randomised complete block design.

Before spraying, 7 pegs were placed in each plot in order to act as sampling locations. A wooden frame of size 30 cm x 45 cm was used as a quadrat for counting the number of green and brown shoots at 2 days before spraying and at 3 months after spraying. Spraying was carried with an 18-litre knapsack sprayer at a volume of 1100 litres of water per hectare. No wetting agent was added.

Visual assessment of the overall control by the herbicide treatments was made monthly for 6 months.

RESULTS AND DISCUSSION

Germination studies

In the field each inflorescence of *Imperata* has a low percentage of seeds usually, the rest being empty glumes. In this experiment, the sample of glumes had 8.6% seeds but the germination was fairly good at the surface of peat and at 1.9 cm deep (*Table 1*). Therefore, under favourable conditions in the field, it is likely that the wind-dispersed seeds are capable of germinating well when they come to rest on the soil surface of newly-cleared peat. Cultural practices, for example slashing, which favour flowering, should therefore be avoided.

In the laboratory, a seed germination of 84.5% was obtained under alternating temperatures of 15/35°C, which are comparable to soil temperatures of 23/35°C under actual field conditions. Under favourable conditions, a germination of 95% could be obtained (SANTIAGO, 1965).

TABLE 1. EFFECT OF TEMPERATURE, GLUME REMOVAL AND DEPTH OF SOWING ON THE PERCENTAGE GERMINATION OF "SEEDS" OF *IMPERATA CYLINDRICA*

Temperature	With/without glumes	Depth of sowing (cm)	% germination at various weeks				
			2	3	4	10	24
15/35°C	Without	0	80.5	84.5	84.5	84.5	84.5
	With*	0	0	0	0	0	0
30 ± 3°C	With*	0	0	0	4.5	6.5	6.5
		1.9	0	0	1.0	3.0	3.0
		3.8	0	0	0	0	0
		5.7	0	0	0	0	0

*Only 8.6% of the sample had seeds enclosed within the glumes.

Shoot production

The vegetative reproductive capacity, as measured by the number of shoots, was 3626 shoots after 6½ months, i.e. 181.3 shoots per original shoot. The area covered by these shoots was 74.2 m² and was roughly oblong, the longest and widest distances being 13.5 m and 9.8 m respectively. The density of shoots was 48.8/m², which much lower than the normal 75–90 shoots/m² for established *Imperata* of about 3 years on peat.

The above results emphasised the importance of early control as *Imperata* has high vegetative reproductive capacity and it spreads rapidly by rhizomes.

Depth of penetration of rhizomes

After 12½ months, no rhizomes was found penetrating below 30 cm while 71.9% of the rhizomes occurred in the top 15 cm (*Table 2*). The total length – 88.99 m of rhizomes/m² – represented the amount produced from the original 20 shoots.

TABLE 2. TOTAL LENGTH OF RHIZOMES AT VARIOUS DEPTHS WITHIN 1 METRE FROM THE PARENT SHOOTS AFTER 12½ MONTHS

Depth (cm)	Total length (m)* /m ²	s.e. (±)	Percentage*
0-15	58.90	6.37	71.9
15-30	30.09	7.53	28.1
30-45	0	0	0
45-60	0	0	0
Total	88.99		100.0

*Mean of 6 replicates

The observation that most of the rhizomes occurred in the surface 15 cm of the soil compared favourably with the results obtained by SAINT BEZARD (1969). Depth of penetration rarely exceeds 40-60 cm (SOERJANI, 1970) while COSTER (1932) reported that penetration was up to 15 cm in an impervious soil and 40 cm in a light soil.

The results of this study indicated that mechanical ploughing on 1 year-old *Imperata* was only necessary up to 30 cm in order to up-lift the rhizomes to the surface for normal manual removal.

Pattern of rhizome growth

The apical bud forms a shoot after 2 weeks. Subsequently, 2 rhizomes would grow from the buds in the nodes adjacent to the apical bud. Up to 4 rhizomes may be produced from the original rhizome fragment. At 8 weeks, one rhizome has produced a shoot 15 cm long while another has produced a shoot 30 cm long in another direction (*Fig. 1*). By 12 weeks, a young rhizome network with a total rhizomes length of 1 metre is formed (*Fig. 2*). With 6 loci of shoots at this stage and the usual production of 2 rhizomes from each locus, the asexual reproductive capacity of the weed is immense. Therefore it is important to destroy the rhizome network as early as possible.

Depth of burial x rhizome length

At depths of 10 cm and below, no rhizomes germinated and observation carried out after 6 months showed their decay. Rhizomes planted 5 cm deep showed a lower germination and produced less green shoots than those planted 1.25 cm deep after 2 months but these differences were non-significant after 4 months (*Table 3*).



Figure 1. The original rhizome produced a clump of shoots (right) while two separate rhizomes have produced shoots 20 cm (left) and 15 cm (centre) away.

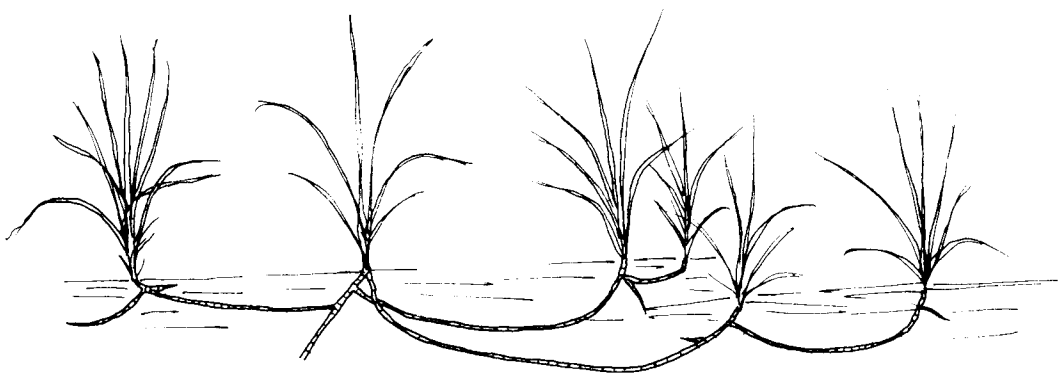


Figure 2. A young rhizome network after 12 weeks.

Rhizomes which were 2.50 cm long did not germinate after 2 months. Differences in the germination and shoot production between 10.00 cm and 17.50 cm rhizomes were non-significant. Some of the green shoots died at the fourth month and this was attributed to the drought which persisted for 10 days at 2½ months after planting. Despite the drought, 27.8% of the initial number of 10 cm rhizomes survived after 4 months as compared to 75.0% after 2 months.

The significance of this study is that deep burial of rhizomes was effective in killing rhizome fragments which are up to 17.50 cm long. Under field conditions, such fragments are normally found as a result of hoeing or mechanical operations.

TABLE 3. EFFECT OF DEPTH OF BURIAL AND RHIZOME LENGTH ON THE GERMINATION

Treatments	Period	No. of germinated rhizomes/plot		No. of green shoots /germinated rhizome	
		2 mth	4 mth	2 mth	4 mth
Depth	1.25 cm	1.44	1.89	1.50	0.53
	5.00 cm	0.45*	1.11	0.45	0.33
F value		*	n.s.	**	n.s.
Length	2.50 cm	0	0.83	0	1.00
	10.00 cm	4.5	1.67	1.36	2.00
	17.50 cm	4.0	2.00	1.56	0.86
F value		*	n.s.	**	n.s.
Depth x length (interaction)		n.s.	n.s.	**	n.s.

n.s = non-significant @ P = 0.05

* = significant @ P = 0.05

** = significant @ P = 0.01

Vertical bar indicates that the differences between the treatments were non-significant.

Chemical control

Glyphosate at 3.7 kg/ha provided the highest reduction in the number of green shoots (i.e. number of green shoots after 3 months minus number before spraying) and it was significantly higher than urea + glyphosate but not significantly higher than sulphate of ammonia + glyphosate or 2, 4-D + glyphosate or 2.5 kg glyphosate (*Table 4*). As expected, the 3 additives without combination with glyphosate provided very little kill. Urea and sulphate of ammonia probably have toxic effects on the shoots while 2, 4-D Amine, which is normally used for broadleaf weeds, had little effect on *Imperata*.

The lowest number of green shoots after 3 months was achieved by glyphosate at 3.7 kg/ha and it was significantly lower than urea + glyphosate but not lower than sulphate of ammonia + glyphosate or 2, 4-D + glyphosate (*Figs. 3 & 4*).

When considering both the final number of green shoots and their reduction after 3 months, best results were obtained by glyphosate at 3.7 kg/ha followed by glyphosate at 2.5 kg/ha and sulphate of ammonia + glyphosate (*Figs. 3 & 4*).



Figure 3. The kill produced by glyphosate at 2.5 kg/ha after 5 weeks.



Figure 4. The kill produced by 11.2 kg sulphate of ammonia + 1.8 kg glyphosate after 5 weeks.

TABLE 4. INFLUENCE OF ADDITIVES AND GLYPHOSATE ON THE NUMBER OF GREEN SHOOTS AND THEIR REDUCTION AFTER 3 MONTHS

Dosages of herbicides and additive (kg a.i./ha)	Reduction* in the number of green shoots/m ²	Number of green shoots/m ²
2.5 Gly	116.25	10.50
3.7 Gly	133.00	7.75
11.2 Urea	20.25	104.00
11.2 Urea + 1.8 Gly	92.25	42.25
11.2 S.A.	25.50	102.75
11.2 S.A. + 1.8 Gly	120.25	11.00
3.6 2,4-D	22.25	99.75
3.6 2,4-D + 1.8 Gly	100.25	38.25
Least significant Difference (5%)	36.56	30.60
Least significant Difference (1%)	49.80	41.60
Standard Error (±)	17.6	14.7

*Difference in the number of shoots between 3 months and 2 days before spraying.

Gly = Glyphosate

S.A. = Sulphate of Ammonia

2, 4-D = Amine salt of 2, 4-D-Dichlorophenoxyacetic acid.

Of the 3 additives, only sulphate of ammonia showed promise and although it was mixed with a lower concentration of glyphosate (i.e. 1.8 kg/ha) it produced results which were very similar to a higher concentration of glyphosate alone (i.e. 2.5 kg/ha). Cost reduction is therefore achieved.

Of the 3 additives, only sulphate of ammonia showed promise. Since the *Imperata* did not receive any fertilizers previously and during the experiment, it was possible that sulphate of ammonia had a rejuvenating effect on the foliage of *Imperata*, resulting in a better kill.

In this experiment, visual observation showed that symptoms induced by glyphosate developed slowly over 1 month and the number of green shoots reached a minimum between the fourth and fifth month. Oil wiping at the fourth or fifth month or a repeat spray was required to extend the duration of control (LEE, 1976).

The overall results showed that glyphosate at 2.5 to 3.7 kg a.i./ha control *Imperata* for about 5 months and that sulphate of ammonia appears to be promising as an additive for glyphosate. Further studies on a large scale are recommended.

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SUMMARY

Imperata cylindrica seeds had a germination of 84.5% after 3 weeks under alternating temperatures of 15/35°C. Each parent shoot produced 181.3 shoots after 6½ months in the field. After 12½ months, 71.9% of the rhizomes occurred in the surface 15 cm of soil while the remaining 28.1% occurred between 15 and 30 cm. The study of the pattern of rhizome growth showed that a young rhizome network is established after 10-14 weeks with 2-4 rhizomes below each locus of shoots. The factorial experiment on the depth of burial x rhizome length showed that rhizomes buried at 10 cm or more did not germinate. Glyphosate at 2.5-3.7 kg/ha provided very effective control for 5 months. Of the three additives studied for synergistic effects with glyphosate, only sulphate of ammonia appears promising.

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