

Efficacy of Glyphosate and its Mixtures against Weeds under Young Rubber Forest Plantation

M.A. AHMAD FAIZ*

Weed infestation is a major problem during the early stages of establishment of rubber forest plantation. Currently, information on effective weed control system in young rubber forest plantation is limited. As the rubber forest plantation is often located in remote areas, a weed control system which provides longer duration of weed control is preferred. Trials were conducted to determine effective rates of glyphosate isopropylamine and its mixtures against mixed weeds. Glyphosate isopropylamine at 1.08 kg ae/ha mixed with metsulfuron methyl at 0.03 kg ai/ha, was safe and effective against weeds in rubber less than a year old. In rubber above two years old, glyphosate isopropylamine at 1.08 kg ae/ha mixed with metsulfuron methyl (0.03 kg ai/ha), fluroxypyr (0.3 kg ae/ha), dicamba (0.6 kg ae/ha) or premixed picloram + 2,4-D (0.097 kg ae/ha + 0.36 kg ae/ha) were effective. Glufosinate ammonium at 0.9 kg ai/ha gave shorter duration of control against mixed weeds compared to glyphosate (1.08 kg ae/ha) + metsulfuron methyl (0.03 kg ai/ha). Glyphosate isopropylamine (1.08 kg ae/ha) + metsulfuron methyl (0.03 kg ai/ha) at two or four rounds per year provided more effective weed control than slashing. Slashing at two or four rounds was ineffective and at two rounds per year gave rise to serious weed regeneration.

Key words: efficacy; rubber forest plantation; weed control; young rubber; glyphosate isopropylamine mixtures; mixed weeds; metsulfuron methyl; fluroxypyr; dicamba; picloram; 2,4-D; slashing

Weed management in a rubber forest plantation is critical during the first few years after planting. Neglect in weed maintenance during this initial period will result in poor growth or even mortality of the young rubber plants. Weeding frequency in rubber forest plantation has to be minimal due to remote location of the plantations and also to reduce cost. Weeding operation is mainly by application of herbicides as it is cheaper, faster and more effective than manual slashing alone. If tall weeds are also present, they should be slashed prior to application of herbicides. In

order to achieve minimal weeding frequency, appropriate herbicides or herbicide mixtures were evaluated. Glyphosate was selected as it is a systemic herbicide which can provide relatively longer duration of weed control. It is also relatively cheaper than other herbicides. Glyphosate is effective against noxious weeds such as *Imperata cylindrica*¹⁻³ and *Pennisetum polystachion*⁴⁻⁶. Efficacy of glyphosate mixtures against general weeds along the planting strips of rubber has been reported⁷⁻¹⁰. In a rubber forest plantation generally a mixed population of weeds occur.

*Rubber Research Institute of Malaysia, Malaysian Rubber Board, P.O. Box 10150, 50908 Kuala Lumpur, Malaysia.
Corresponding author: (E-mail: afaiz@lgm.gov.my / afaiz49@yahoo.com)

Since glyphosate is generally more effective on grasses, its mixtures with potential broad-leaved herbicides were therefore evaluated in order to acquire a wider spectrum of weed control. This paper reports on the effectiveness of glyphosate mixtures against mixed weeds in young rubber forest plantation.

MATERIALS AND METHODS

Trials were located in a young rubber forest plantation in Chikus, Bidor. The experimental design was a randomised complete block design with three replicates and the plot size was 800 m². Species, density and height of weeds were recorded prior to treatment. Weed kill was assessed visually based on a rating scale of 0 to 100 where 0 = no effect; and 100 = complete kill. Herbicides were evaluated either alone or mixed with other herbicides using water as carrier. The herbicides were applied at a rate of 500 L/ha using a knapsack sprayer. Percentage cover of weeds were also assessed visually prior to termination of the trials.

Evaluation of Glyphosate Isopropylamine Mixtures with Metsulfuron Methyl or Bentazone

Glyphosate at 1.08 kg ae/ha or 2.16 kg ae/ha were mixed with either metsulfuron methyl at 0.03 kg ai/ha or bentazone at 1.92 kg ai/ha. The trial was conducted against weeds comprising mainly *Chromolaena odorata* and *Trema* sp. under rubber of about three months old.

Evaluation of Glyphosate Isopropylamine Mixtures with Metsulfuron Methyl or Fluroxypyr

Glyphosate at 1.08 kg ae/ha, 2.16 kg ae/ha, or mixtures of glyphosate at 1.08 kg ae/ha

with metsulfuron methyl (0.015 kg ai/ha or 0.03 kg ai/ha) or fluroxypyr (0.15 kg ai/ha or 0.3 kg ai/ha) were evaluated under rubber of more than two years. Common weeds present were *Pennisetum polystachion*, *Digitaria ciliaris*, *Borreria latifolia* and *Asystasia gangetica*.

Evaluation of Glyphosate Isopropylamine Mixtures with Dicamba or Pre-mixed Picloram + 2,4-D

Glyphosate at 1.08 kg ae/ha, 2.16 kg ae/ha or glyphosate at 1.08 kg ae/ha mixed with either dicamba (0.3 kg ai/ha or 0.6 kg ae/ha) or pre-mixed picloram + 2,4-D (0.05 kg ae/ha + 0.18 kg ae/ha or 0.1 kg ae/ha + 0.36 kg ae/ha) were also evaluated under rubber of more than two years old. Dominant weed present was *P. polystachion*.

Evaluation of Glyphosate Isopropylamine + Metsulfuron Methyl, Glufosinate Ammonium and Slashing

Evaluation of glyphosate + metsulfuron methyl at 1.08 kg ae/ha + 0.03 kg ai/ha, glufosinate ammonium at 0.9 kg ai/ha and slashing were conducted under rubber of about three years old. Dominant weeds were *C. odorata* and *P. polystachion*.

Evaluation of Glyphosate Isopropylamine + Metsulfuron Methyl and Slashing at Two Weeding Frequencies

Glyphosate + metsulfuron methyl at 1.08 kg ae/ha + 0.03 kg ai/ha and slashing were evaluated under rubber of about two and a half years old at weeding frequencies of three or six months interval. Dominant weeds were *D. ciliaris*, *P. polystachion*, *Croton hirtus* and *Melastoma malabathricum*.

RESULTS AND DISCUSSION

Effectiveness of Glyphosate Isopropylamine Mixtures with Metsulfuron Methyl or Bentazone

Glyphosate at 2.16 kg ae/ha was significantly more effective than at 1.08 kg ae/ha at two and six weeks after treatment (*Table 1*). The weed kill at nine, thirteen and twenty-four weeks after treatment was not significantly different. Addition of metsulfuron methyl at 0.03 kg ai/ha to glyphosate at 1.08 kg ae/ha significantly improved control up to 13 weeks after treatment. However, addition of metsulfuron methyl to glyphosate at 2.16 kg ae/ha resulted in non-significant improvement in weed control. Metsulfuron methyl is generally effective on many broadleaves and its effectiveness on brush species in plantation crops has been reported¹². The woody weed *Clidemia hirta* was also susceptible to this herbicide¹¹. Improved control of general weed mixtures with glyphosate plus metsulfuron methyl has been reported and the herbicide mixture was also more effective than paraquat + metsulfuron methyl¹⁰.

Addition of bentazone to glyphosate at 1.08 kg ae/ha reduced weed kill probably due to chemical antagonism. Similarly addition of bentazone to glyphosate at 2.16 kg ae/ha did not improve weed from six to 24 weeks after treatment. However, there was slight improvement in weed control at the initial stage that could be due to the contact activity of bentazone since bentazone is a contact herbicide on broadleaves¹³. In subsequent weeks, bentazone, being a contact herbicide, could have reduced further absorption of glyphosate. Furthermore, bentazone is effective against soft broadleaves and less effective against the woody broadleaves. Weed regeneration at about 24 weeks after treatment showed that grasses were dominant compared to broadleaves in all treatments except with glyphosate + metsulfuron methyl

at 1.08 kg ae/ha + 0.03 kg ai/ha and glyphosate + bentazone at 2.16 kg ae/ha + 1.92 kg ai/ha where broadleaves dominated (*Figure 1*). The dominant grass was *P. polystachion* while the dominant broadleaf was *C. odorata*. *P. polystachion* probably emerged from seeds as it was absent initially and the long interval of no weeding allowed it to grow vigorously and dominate the plots. *C. odorata* was present initially and its partial control coupled with the long interval left unweeded encouraged it to re-establish in these plots.

Effectiveness of Glyphosate Isopropylamine Mixtures with Metsulfuron Methyl or Fluroxypyr

Glyphosate at either 1.08 or 2.16 kg ae/ha produced similar control over a period of 15 weeks (*Figure 2*). Weed control declined after 15 weeks and glyphosate at 2.16 kg ae/ha recorded significantly more effective weed control than the lower rate.

Addition of metsulfuron methyl at 0.015 or 0.03 kg ai/ha to glyphosate at 1.08 kg ai/ha also failed to improve as the mixtures recorded comparable weed control as glyphosate alone over a period of 15 weeks. Increasing the rate of metsulfuron in the mixture improved weed control significantly at 20 weeks and 25 weeks after treatment.

Addition of fluroxypyr at 0.15 kg ae/ha to glyphosate at 1.08 kg ae/ha produced lower weed control than glyphosate alone but the difference was not significant. Addition of fluroxypyr at 0.3 kg ae/ha to the glyphosate produced comparable control over a period of 15 weeks but subsequently from 20 weeks to 30 weeks after treatment, weed control improved. Fluroxypyr was effective on perennial broadleaves¹⁴ including *C. hirta*¹¹. Effectiveness of glyphosate plus fluroxypyr on general mixed weed in rubber plantations comprising grasses and broadleaves has

TABLE 1. EFFECT OF GLYPHOSATE MIXTURES WITH METSULFURON METHYL OR BENTAZONE AGAINST WEEDS IN YOUNG RUBBER

Treatment	Rate/ha	Percent control				
		2 wks	6 wks	9 wks	13 wks	24 wks
Glyphosate isopropylamine	1.08 kg ae	37	67	50	30	20
Glyphosate isopropylamine	2.16 kg ae	60	80	63	40	23
Glyphosate isopropylamine + metsulfuron methyl	1.08 kg ae + 0.03 kg ai	73	80	70	53	20
Glyphosate isopropylamine + metsulfuron methyl	2.16 kg ae + 0.03 kg ai	80	87	63	50	13
Glyphosate isopropylamine + bentazone	1.08 kg ae + 1.92 kg ai	57	60	40	13	3
Glyphosate isopropylamine + bentazone	2.16 kg ae + 1.92 kg ai	73	77	67	40	7
LSD (p=0.05)		19.7	10.0	15.5	12.3	19.8

also been reported⁹. At about 30 weeks after treatment, weed regeneration was dominated by grasses over broadleaves in all treatments (Figure 3). The dominant grass weeds after treatment with glyphosate at 1.08 kg ae/ha were *P. polystachion* and *D. ciliaris* while at rate of 2.16 kg ae/ha only *D. ciliaris* dominate. *P. polystachion* was completely killed by the higher rate of glyphosate. Dominant broadleaf after the glyphosate treatments alone was *B. latifolia*. This weed emerged after the reduction of grass infestation. The grass *D. ciliaris* dominated in plots treated with glyphosate + metsulfuron methyl. The broadleaves which regenerated include *B. latifolia*, *A. gangetica* and *C. odorata*. After glyphosate + fluroxypyr treatments, the dominant grass was *P. polystachion* while *A. gangetica* was the dominant broadleaf. *A. gangetica* emerged later and dominated the plots rapidly as it is a fast growing weed.

Effectiveness of Glyphosate Isopropylamine Mixtures with Dicamba or Pre-mixed Picloram + 2,4-D

Addition of dicamba at 0.3 kg ai/ha to glyphosate at 1.08 kg ae/ha did not improve weed control but addition of dicamba at 0.6 kg ai/ha to glyphosate improved control significantly at 10 weeks and 15 weeks after treatment while comparable control occurred at other periods (Figure 4). The higher rate of dicamba in the mixture suppressed broadleaved weeds. Dicamba is generally effective against broadleaved weeds and mixture of glyphosate plus dicamba has been reported effective against general weeds comprising grasses and broadleaves⁷⁻⁹.

Addition of pre-mixed picloram + 2,4-D at the lower rate to glyphosate showed significantly lower control initially but

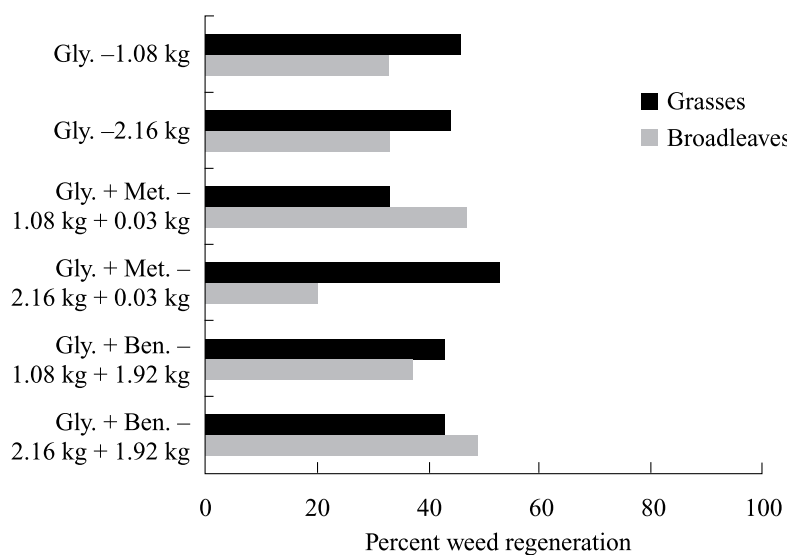


Figure 1. Weed regeneration at 24 weeks after treatment with glyphosate (Gly.) and its mixtures with metsulfuron methyl (Met.) or bentazone (Ben.) in young rubber.

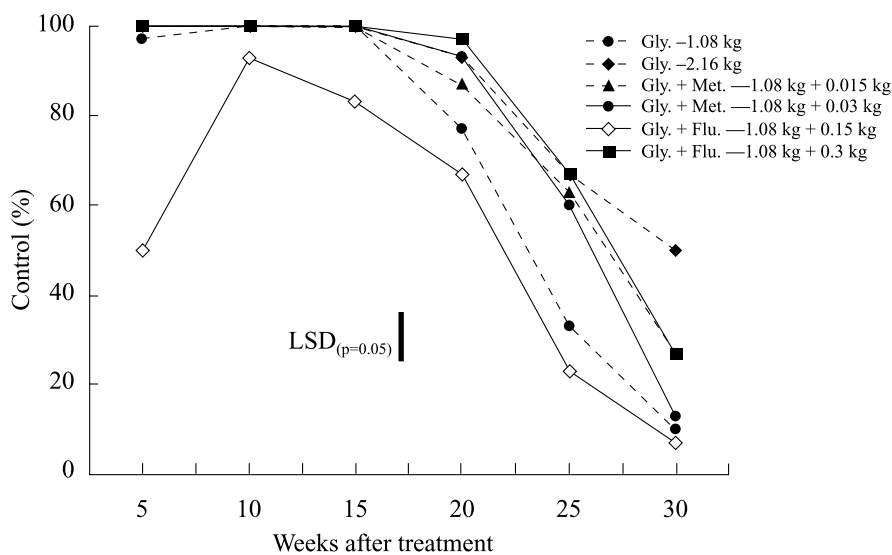


Figure 2. Effectiveness of glyphosate (Gly.) mixtures with metsulfuron methyl (Met.) or fluroxypyr (Flu.) against weeds in young rubber.

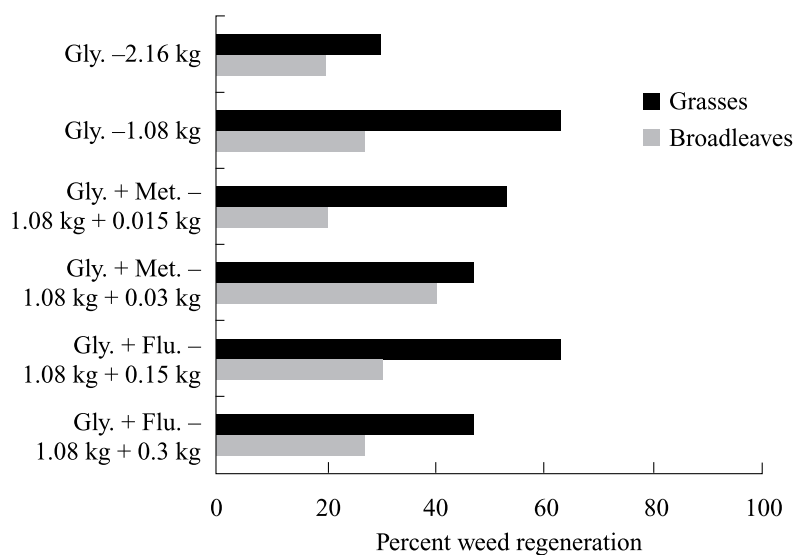


Figure 3. Weed regeneration about 30 weeks after treatment with glyphosate (Gly.) and its mixtures with either metsulfuron methyl (Met.) or fluroxypyr (Flu.) in young rubber.

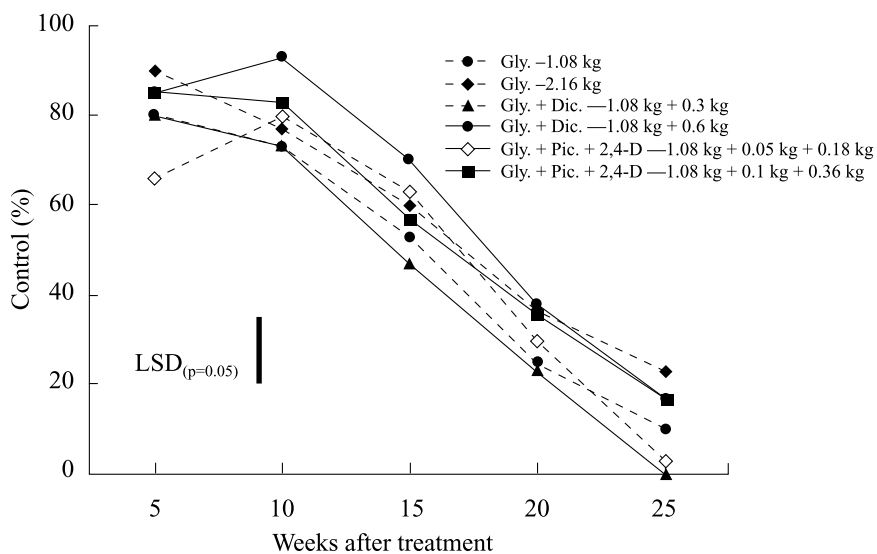


Figure 4. Effectiveness of glyphosate (Gly.) mixtures with dicambar (Dic.) or picloram (Pic.) + 2,4-D against weeds in young rubber.

comparable control in subsequent weeks. Addition of the higher rate of picloram + 2,4-D generally recorded no significant enhancement in control. Effectiveness of picloram mixed with glyphosate on general weeds had been reported^{15,16}.

Weed regeneration at about 25 weeks after treatment was dominated by grasses except in treatments with glyphosate + dicamba at 1.08 + 0.03 kg ae/ha and glyphosate + picloram + 2,4-D at 1.08 + 0.1 + 0.36 kg ae/ha where broadleaves were slightly dominant (Figure 5). *P. polystachion* was the dominant grass species in all treatments except with glyphosate at 2.16 kg ae/ha where *I. cylindrica* dominated. Dominance of *I. cylindrica* could be attributed to the initial higher percentage coverage of this weed compared to other plots. In the case of broadleaves, *B. latifolia* was dominant with all treatments due to its rapid growth.

Effectiveness of Glyphosate Isopropylamine + Metsulfuron Methyl, Glufosinate Ammonium and Slashing on Weed Control

Glyphosate + metsulfuron methyl at 1.08 kg ae/ha + 0.03 kg ai/ha resulted with significantly better weed control than glufosinate ammonium or manual weeding (Figure 6). Weed control with glufosinate ammonium or manual slashing produced similar control of weeds. Glyphosate and metsulfuron methyl are both systemic herbicides and their combination could control a wide spectrum of weeds. The slow kill and regeneration of the weeds contributed to the longer duration of weed control. Glufosinate ammonium and slashing, on the other hand, provided partial kill of weeds that resulted in faster weed regeneration and thus gave a short term weed control. Glufosinate ammonium is a non-selective contact herbicide and its efficacy against general weeds¹⁰, *I. cylindrica*¹⁷ and *Stenochlaena palustris*¹⁸ had been reported. The more effective control by glyphosate +

metsulfuron methyl compared to slashing agrees with earlier report on control of general weeds in young rubber¹⁰.

Regeneration of weeds at 20 weeks after treatment with glyphosate + metsulfuron methyl resulted with broadleaves dominating over grasses (Figure 7). The dominant broadleaf was *C. hirtus* and its dominance could probably be because it was partially killed. Emergence of the weed from seeds could also be a contributing factor. Common grass weed was *D. ciliaris*. In plots treated with glufosinate ammonium, grasses dominated over broadleaves and the dominant grass was *P. polystachion* while the dominant broadleaf was *C. hirtus*. Ineffective kill of *P. polystachion* contributed to the high regeneration of this weed. In the case of slashing, grasses dominated over broadleaves and the dominant grass was *P. polystachion* while the common broadleaf was *Drymaria* sp. Slashing provided partial kill of *P. polystachion* and the long interval without weeding allowed this weed to dominate.

Effectiveness of Glyphosate Isopropylamine + Metsulfuron Methyl and Slashing at Two Weeding Frequencies

Glyphosate + metsulfuron methyl, applied at three months interval, produced slightly more effective weed control than application at six months interval when assessed at six, nine and twelve months after treatment (Table 2). The herbicide treatments were more effective than manual slashing whether conducted at three or six months interval as manual slashing was effective for a brief period only. More serious weed regeneration occurred after slashing at six months interval. It has also been reported that manual slashing required higher frequency of weeding to achieve comparable effect as glyphosate plus dicamba¹⁰ on general weeds under young rubber. Weed succession at about

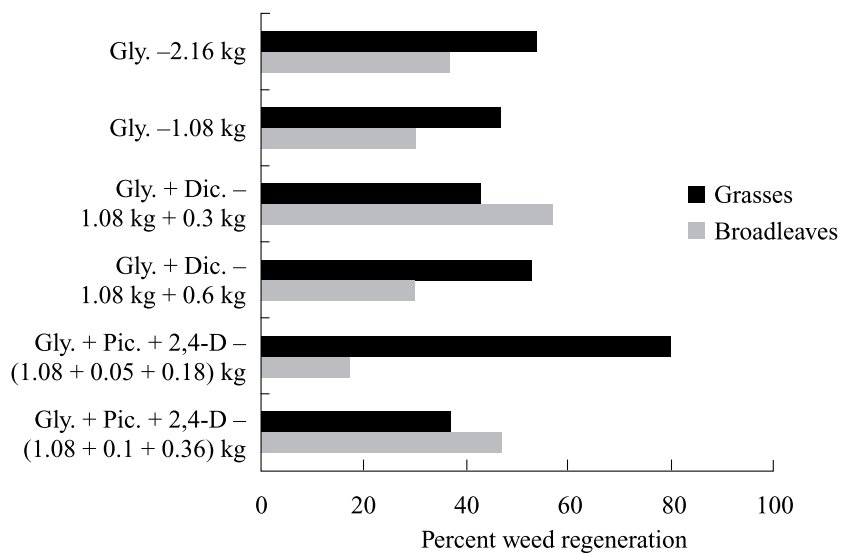


Figure 5. Weed regeneration about 25 weeks after treatment with glyphosate (Gly.) and its mixtures with either dicamba (Dic.) or picloram (Pic.) + 2,4-D in young rubber.

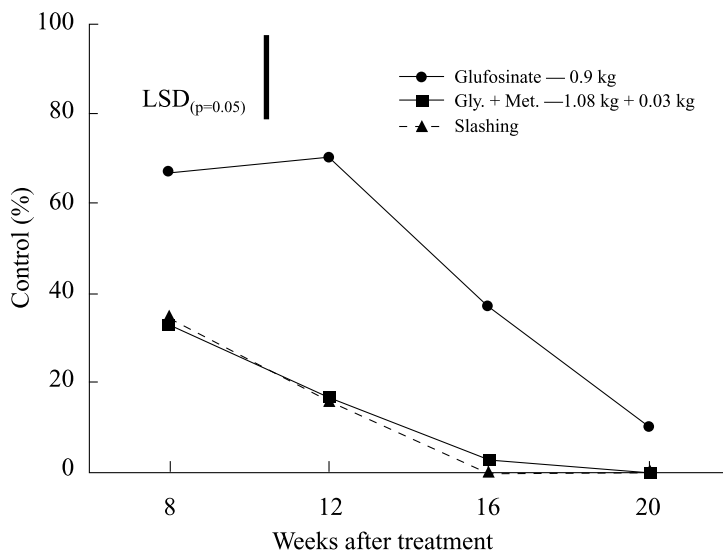


Figure 6. Effectiveness of glyphosate (Gly.) + metsulfuron methyl (Met.), glufosinate ammonium and slashing against weeds in young rubber.

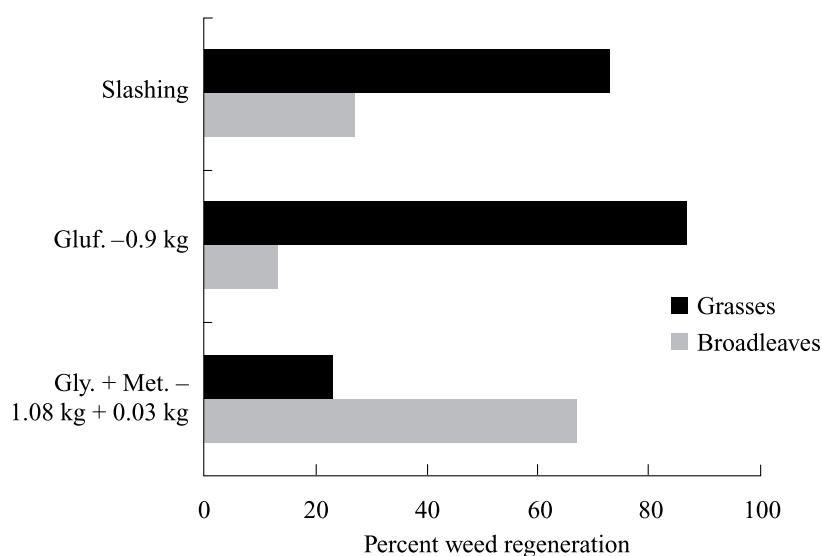


Figure 7. Weed regeneration at about 20 weeks after treatment with glyphosate (Gly.) + metsulfuron methyl (Met.) glufosinate ammonium (Gluf.) and slashing in young rubber.

TABLE 2. EFFECT OF GLYPHOSATE ISOPROPYLAMINE + METSULFURON METHYL AND SLASHING AT TWO WEEDING FREQUENCIES UNDER YOUNG RUBBER

Treatment	Rate/ha	Weeding frequency	Percent control			
			3 months	6 months	9 months	12 months
Glyphosate + metsulfuron methyl	1.08 kg ae + 0.03 kg ai	3 months	47	27	43	27
Glyphosate + metsulfuron methyl	1.08 kg ae + 0.03 kg ai	6 months	47	7	30	7
Slashing	—	3 months	0	0	0	0
Slashing	—	6 months	0	0	0	0

12 months after treatment with glyphosate + metsulfuron methyl showed that broadleaves were dominant compared to grasses (Figure 8). The dominant broadleaf was *C. hirtus* and its dominance could be attributed to its dense occurrence prior to treatment. Although it was killed by the treatment, re-emergence of this weed could be mainly from seeds. Its rapid growth allowed it to dominate in the plots. Common grass species was *D. ciliaris* which

was also present initially. It was controlled by the treatments but emerged rapidly from seeds. In the case of slashing, grasses dominate over broadleaves especially when weeded at three months interval. The dominant grass was *P. polystachion* while the dominant broadleaf was *M. malabathricum*. High density of both weeds were present initially. Slashing partially controlled these weeds and allowed them to regenerate and be established.

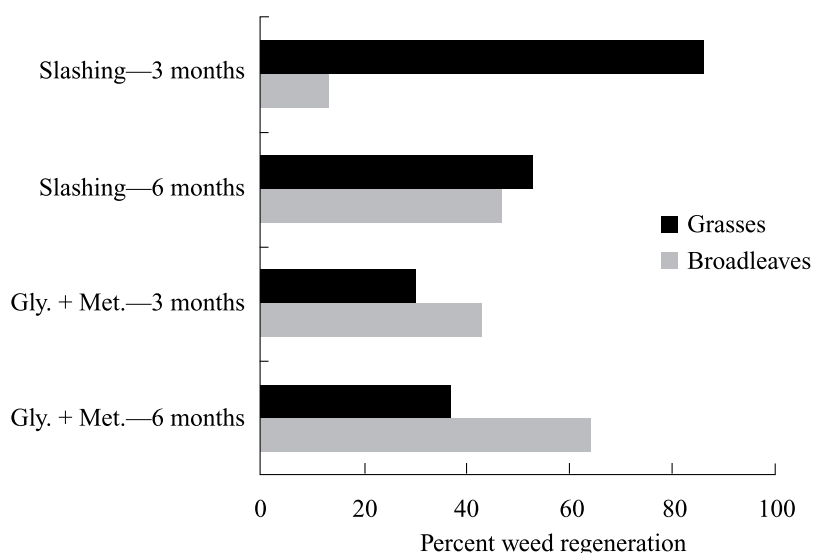


Figure 8. Weed regeneration at about 12 months after treatment with glyphosate (Gly.) + metsulfuron methyl (Met.), or slashing at three and six months intervals in young rubber.

CONCLUSION

Glyphosate isopropylamine mixed with metsulfuron methyl was effective for controlling mixed weeds comprising grasses and broadleaves in rubber forest of less than a year old. Glyphosate was not compatible with bentazone as the mixture lowered weed control. In rubber forest of more than two years, glyphosate mixtures with metsulfuron methyl, fluroxypyr, dicamba and premixed picloram + 2,4-D respectively, were effective against mixed weeds. Glufosinate ammonium was also effective but gave shorter duration of control compared to glyphosate + metsulfuron methyl. Slashing provided less effective weed control than glyphosate + metsulfuron methyl whether carried out at three months or six months.

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