EFFICACY OF FOUR HERBICIDES APPLIED WITH A ROPE-WICK WIPER TO *ISCHAEMUM MAGNUM*

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IPOR, I.B. & TAWAN, C.S. 1993. Efficacy of four herbicides applied with a rope-wick wiper to *Ischaemum magnum*. Field studies were conducted to evaluate the effectiveness of glyphosate, imazapyr, glufosinate ammonium and paraquat dichloride applied with rope-wick wiper for the control of the grass, *Ischaemum magnum*. Control of *I. magnum* increased with increasing rates of herbicide application. Excellent control was obtained at the rates from 0.4 a.i *kg ha*$^{-1}$ of imazapyr to 1.5 a.i *kg ha* $^{-1}$ for glyphosate. Control of this grass was unsatisfactory with both glufosinate ammonium and paraquat dichloride. Regrowth occurred at the first and third week after treatment for paraquat dichloride and glufosinate ammonium respectively. Phytotoxic effects of herbicides on *I. magnum* were considerably improved by increasing the volume of application to 200 *l ha*$^{-1}$ and the number of passes during herbicide application. However, glyphosate and imazapyr could also be applied at 40 *l ha*$^{-1}$. This was evident by the excellent control of *I. magnum* at the final week of control assessment. Young plants were found to be more susceptible to herbicide treatments, probably due to better coverage and shorter distance for movement of herbicides.

Key words: *Ischaemum magnum* - rope-wick wiper - glyphosate - imazapyr - glufosinate ammonium - paraquat dichloride

IPOR, I. B. & TAWAN, C. S. 1993. Keberkesanan empat racun herba yang menggunakan teknik tali-sumbu pengelap keatas *Ischaemum magnum*. Kajian telah di jalankan untuk meneliti keberkesanan glyphosate, imazapyr, glufosinate ammonium dan paraquat dichloride dengan menggunakan kaedah tali-sumbu pengelap untuk mengawal rumput, *Ischaemum magnum*. Kawalan *I. magnum* meningkat apabila kadar penggunaan racun herba bertambah. Kawalan yang bagus di perolehi pada kadar 0.4 a.i. *kg ha*$^{-1}$ bagi imazapyr dan 1.5 a.i. *kg ha*$^{-1}$ bagi glyphosate. Kawalan di dapati kurang memuaskan apabila glufosinate ammonium dan paraquat dichloride digunakan. *I. magnum* didapati tumbuh semula pada minggu pertama dan minggu ketiga selepas penggunaan paraquat dichloride dan glufosinate ammonium. Kesan fitotoksik racun herba ke atas *I. magnum* boleh diperbaiki dengan menambahkan isipadu racun herba yang di gunakan kepada 200*l ha* $^{-1}$ serta menambahkan kekerapan penggunaannya. Walaubagaimana pun, glyphosate dan imazapyr juga dapat di gunakan pada 40 *l ha*$^{-1}$. Ini jelas kelihatan, pada minggu terakhir bila menilai kawalan pada *I. magnum*, begitu baik sekali. Tumbuhan yang lebih muda didapati lebih rentan terhadap racun herba, mungkin kerana jarak pergerakan racun lebih dekat serta menyeluruh.

Introduction

Ischaemum magnum is a perennial tussock grass with stout culms. It is an opportunistic and aggressive colonizer of open or disturbed habitats. This species is found abundantly in both full sunlight and under shade. It is found in most

agricultural areas and road verges, and is particularly well adapted to wet sites. It has been recognised as a serious weed in many crops such as oil palm, rubber, cocoa, pepper, coconut and rice. *I. magnum* was also identified as one of the most dominant species in the rehabilitation areas of degraded tropical rainforest in Bintulu (Ipor & Tawan 1992a).

It is a pernicious weed due to its extensive formation of phalanx tillers with high survival. The root system is very compact at the mature stage and forms very dense, impenetrable, practically monospecific stands. In the rehabilitation sites of degraded tropical rainforest, *I. magnum* causes adverse effects by eventually shading out the newly transplanted seedlings. Unfortunately, little information is available on the biology and control of this species. In pepper farms, hand weeding, slashing and application of paraquat dichloride are frequently used to reduce its establishment although regrowth or regeneration occurs shortly (Ipor & Tawan 1992b).

Selection of appropriate herbicides provides an effective weed control, particularly in the early stage of forest establishment (Engle *et al.* 1991, Shiver *et al.* 1991). Some herbicides such as glyphosate, imazapyr and glufosinate ammonium are non-selective, systemic and post emergence herbicides which are commonly used for general weed control and can be properly selected for weed control in agroforestry. Paraquat dichloride is the most popular contact herbicide due to its cheap price and availability in the local market. The effectiveness is strongly dependent on correct selection of technique and timing of application. One of the present techniques used for herbicide application is with rope-wick wiper. Due to the problem of crop selectivity to herbicides, wiper application is increasingly used in weed control in Southeast Asia (Davison & Parker 1983).

Trials in Indonesia have shown that *Imperata cylindrica* can be controlled by rope-wick wiper application of imazapyr and glyphosate (Bacon & Kusnanto 1984). This study was carried out to determine the best method of using a rope-wick wiper with the most appropriate herbicides on the right stage of *Ischaemum magnum* in the rehabilitation areas of degraded tropical rainforest.

Materials and methods

General procedure

The studies were conducted in the tropical rain forest rehabilitation research plots of the Universiti Pertanian Malaysia-Yokohama National University Joint Project in 1991-1992. Meranti pitis (*Shorea ovata*), meranti kawang (*S. mecistopteryx*), meranti tembaga (*S. leprosula*), bintangor (*Calophyllum* sp.), ubah (*Eugenia* sp.) and engkabang jantung (*S. macrophylla*) had been planted at density of three seedlings per square metre. The study area was heavily infested with *I. magnum* as shown in Table 1. One square metre of this area consisted of 5.3 clumps, 158.3 tillers, 23408.1 cm^2 total leaf area, 147.4 *g* leaf dry weight and 571.3 *g* stem dry weight.

Table 1. Vegetative compositions per m^2 of *I. magnum* in the study area. Data is based on the average of six quadrats, each 1 m^2

Number of clumps	=	5.3
Number of tillers	=	158.3
Total leaf area	=	23408.1 cm^2
Leaf dry weight	=	147.4 g
Stem dry weight	=	571.3 g

Herbicides were applied to the *I. magnum* using a rope-wick wiper applicator ('Weedwiper', Hectaspan Ltd. UK). The effects of glyphosate [N-(phosphonomethyl) glycine, (Roundup^R, Monsanto)], imazapyr ([isoprophylamine salt of 2 - (4 - isopropyl - 4 - methl - 5 - oxo - 2 - imidazolin - 2 - yl) nicotinic acid, (Assault^R, American Cynamid Company)], glufosinate ammonium (Basta^R, Hoechst) and paraquat dichloride (Gramoxone^R, ICI) were recorded weekly from one to six weeks after treatment as visual estimates of the percentage control relative to the unwiping; 0% indicates no effect and 100% complete dessication.

All experiments (except regrowth assessment and retention study) were arranged as a randomized complete block with treatments quadruplicated. Each replicate was represented by a 5×5 m plot. Experiments repeated and dated were combined for analysis of variance because errors for individual experiments were homogeneous and interactions involving experiment repetition were not significant. Mean differences were determined by protected LSD at the 0.05 probability level.

Herbicide concentration study

The concentrations of herbicides applied ha^{-1} were 0.20, 0.40 and 0.60 a. i. kg for imazapyr, 1.50, 2.16 and 2.50 a. i. kg for glyphosate, 0.50, 1. 00 and 2.0. a.i. kg for glufosinate ammonium, and 0.40, 0.70 and 0.90 a.i. kg for paraquat dichloride. These herbicides were applied in water with a rope-wick wiper at the volume of 40 l ha^{-1}. In the plots treated with 0.40, 2.16, 1.00 and 0.70 a.i. kg ha^{-1} for imazapyr, glyphosate, glufosinate ammonium and paraquat dichloride respectively, the grass was severed at the soil surface level immediately after the sixth week, for regrowth assessment. Regrowth in terms of number and dry weight of tillers was recorded in one metre square quadrats, six weeks after cutting. Five quadrats were randomly chosen from every plot. Data of regrowth was subjected to analysis of variance and mean values were compared with Duncan's multiple range test at the 0.05 probability level.

Volumes of application

Glyphosate (2.16 a. i. kg ha^{-1}), imazapyr (1.0 a. i. kg ha^{-1}), glufosinate ammonium (0.50 a.i. kg ha^{-1}) and paraquat dichloride (0.78 a.i kg ha^{-1}) were applied in water at the volumes of 40, 80 and 200 l ha^{-1} with rope-wick wiper.

Passes study

The effects of herbicide activity at different number of passes of the rope-wick wiper were examined. These were: one pass (sweeping at one direction only or only from right side of the culms), two passes (sweeping at two directions only or from right side and then left side of the culms) and four passes (sweeping at four direction only or from right, left, forward and backward sides of the culm). Solutions of glyphosate (2.16 a.i. *kg ha*$^{-1}$), imazapyr (1.00 a.i. *kg ha*$^{-1}$), glufosinate ammonium (0.50 a.i. *kg ha*$^{-1}$) and paraquat dichloride (0.70 a.i. *kg ha*$^{-1}$) were applied at the volume of 40 *l ha*$^{-1}$ application.

Activity of herbicides at different plant stages of I. magnum

Young and old plants of *I. magnum* were selected to determine their response to the activity of herbicides. The heights of the young and old plants were 15 - 20 *cm* and 30 - 40 *cm* respectively. Glyphosate (2.16 a.i. *kg ha*$^{-1}$), imazapyr (1.00 a.i. *kg ha*$^{-1}$), glufosinate ammonium (0.50 a.i. *kg ha*$^{-1}$) and parquat dichloride (0.70 a.i. *kg ha*$^{-1}$) were applied at 40 *l ha*$^{-1}$ with a rope-wick wiper.

Herbicide retention study

A retention study was carried out on both young (15 - 20 *cm* height) and old plants (30 - 40 *cm* height) of *I. magnum*. Imazapyr concentration was prepared at 1.0 a.i. *kg ha*$^{-1}$ in 40 *l ha*$^{-1}$ demineralized water and mixed with 0.01% (w/v) lisame red. Rope-wick wiper was used for herbicide application at one, two and four passes in the field condition. Retention of the solution was quantified by spectrophotometer as commonly reported by several workers (Hageman & Behrens 1984, Mabb & Price 1986, Ipor 1989, Rutter *et al.* 1990). The dye was washed off the plants 15 *min* after herbicide application. Retention was expressed as the amount of imazapyr retained (μg) per plant, per gram dry weight of plant and per *cm*^{2} of leaf area. Leaf area was determined with leaf area meter (V-Delta Device, U.K.). The experiment was arranged as randomized complete block with treatments quadruplicated. Each replicate was represented by a 5×5 *m* plot. In each plot, 10 plants were randomly selected for total leaf area, plant dry weight determination and retention analysis. Data was subjected to analysis of variance and mean values were compared with Duncan's multiple range test at 5% level.

Results

Herbicide concentrations

The phytotoxicity on *I. magnum* of imazapyr, glyphosate, glufosinate ammonium and paraquat dichloride generally increased with increase in herbicide concentration (Table 2). Control increased over time for both imazapyr and

glyphosate. Application at the rates of 0.40 and 0.60 *kg ha*$^{-1}$ of imazapyr and 2.16 and 2.50 *kg ha*$^{-1}$ of glyphosate provided complete control after six and two weeks of application respectively. Complete control was also obtained at the rate of 1.50 *kg ha*$^{-1}$ of glyphosate after the fifth week. Control of *I. magnum* was at maximum level at the first week of application with 2.00 *kg ha*$^{-1}$ of glufosinate ammonium and 0.90 *kg ha*$^{-1}$ of paraquat dichloride. This control was significantly higher than for the other two rates of both glufosinate ammonium and paraquat dichloride. However, control rapidly declined over the six weeks, particularly for paraquat dichloride. The overall result shows that control of *I.magnum* was significantly better with glyphosate and imazapyr than with glufosinate ammonium and paraquat dichloride. Excellent control of this grass was obtained below the recommended rates of 0.40 a.i. *kg ha*$^{-1}$ for imazapyr and 2.16 a.i. *kg ha*$^{-1}$ for glyphosate. Regrowth of plants treated with both imazapyr and glyphosate was similar and significantly less ($p < 0.05$) as compared to that of plants treated with glufosinate ammonium and paraquat dichloride (Table 3). In terms of regrowth assessment, imazapyr and glyphosate performed equally well in the control of *I. magnum.* However, the control of regrowth of *I. magnum* with glufosinate ammonium and paraquat dichloride was not significantly effected.

Table 2. Phytotoxicity to *I. magnum* over time of different rates of imazapyr, glufosinate ammonium, glyphosate and paraquat dichloride applied via a rope-wick wiper at the application volume of 40 *l ha*$^{-1}$

Herbicide	Rate	% control					
		Week after treatment					
	(a.i. *kg ha*$^{-1}$)	1	2	3	4	5	6
Imazapyr	0.20	19.3	32.4	38.8	57.4	70.3	86.9
	0.40	23.3	44.9	63.7	72.9	89.7	97.5
	0.60	53.2	59.3	82.5	91.1	98.3	98.9
Glyphosate	1.50	32.1	66.3	82.1	95.3	100	100
	2.16	82.0	100	100	100	100	100
	2.50	88.7	100	100	100	100	100
Glufosinate ammonium	0.50	48.5	36.8	41.4	39.8	35.3	27.4
	1.00	55.8	52.7	63.2	50.0	41.1	31.8
	2.00	84.4	85.2	79.8	55.1	52.9	50.3
Paraquat dichloride	0.40	50.2	38.4	21.1	15.3	10.8	9.9
	0.70	70.0	50.1	38.9	19.3	15.2	11.0
	0.90	90.8	62.1	56.2	35.2	23.7	11.3
LSD 5%		11.5					

Table 3. Dry weight ($g\ m^{-2}$) and percentage reduction relative to control of *I. magnum* six weeks after cutting

Herbicide (a. i. $kg\ ha^{-1}$)	Regrowth of *I. magnum* after cutting	
	Dry weight ($g\ m^{-2}$)*	% reduction*
Imazapyr (0.4)	46.8b	84.2a
Glyphosate (2.16)	47.0b	83.4a
Glufosinate ammonium (1.0)	242.0a	17.8b
Paraquat dichloride (0.70)	267.5a	9.4c
Nil (control)	295.0a	

*Within each column, mean values sharing the same letter are not significantly different according to Duncan's multiple range test at 5% level.

Volumes of application

The activity of all the four herbicides on *I. magnum* generally decreased with decreasing volume of application volume (Table 4). The control was not significantly different between application of 200 $l\ ha^{-1}$ and 80 $l\ ha^{-1}$ for imazapyr. The least response of imazapyr was obtained when applied at the volume of 40 $l\ ha^{-1}$.

Table 4. Phytotoxicity to *I. magnum* over time of imazapyr, glufosinate ammonium, glyphosate and paraquat dichloride applied at the volumes of 40, 80 and 200 $l\ ha^{-1}$ via a rope-wick wiper

Herbicide	Volume of application ($l\ ha^{-1}$)	% control					
		Weeks after treatment					
		1	2	3	4	5	6
Imazapyr	40	20.8	29.5	35.8	43.3	51.1	59.7
	80	21.2	39.4	49.7	68.5	76.7	83.6
	200	28.3	46.9	57.6	71.2	86.6	92.7
Glyphosate	40	70.9	87.1	90.5	98.6	100	100
	80	82.4	100	100	100	100	100
	200	88.2	100	100	100	100	100
Glufosinate ammonium	40	40.1	40.5	44.4	37.8	23.4	21.3
	80	50.0	50.3	47.6	46.5	30.0	24.6
	200	58.2	73.2	78.1	78.6	80.8	47.7
Paraquat dichloride	40	72.5	45.3	31.1	23.7	16.2	14.1
	80	78.3	48.3	38.5	33.1	11.8	9.0
	200	88.8	58.4	57.1	41.7	33.4	14.3
LSD 5%				8.8			

For glyphosate, differential effect of volumes of application was only observed within the first three weeks after application. At this interval, control at the

volume of 40 *l ha*$^{-1}$ was significantly lower than at the other two volumes of application. At the third week onwards, there was no effect of application volumes on the activity of glyphosate. Complete control was obtained from the second week onwards for the application volumes of 80 *l ha*$^{-1}$ and 200 *l ha*$^{-1}$ and also from the fifth week onwards for the application volume of 40 *l ha*$^{-1}$.

Increasing the volume of application of glufosinate ammonium seemed to delay the regrowth of *I. magnum*, such that regrowth started only five weks after application. Recovery of *I. magnum* which had been treated with 40 *l ha*$^{-1}$ and 80 *l ha*$^{-1}$ occurred after the third and second weeks of treatment respectively.

Plants treated with paraquat dichloride recovered after the first week of herbicide application although it provided satisfactory control at the first assessment. Recovery was comparatively slower at the volume of 200 *l ha*$^{-1}$ than at the volumes of 40 and 80 *l ha*$^{-1}$.

Plant stages

Old plants were generally more tolerant to all the herbicides than young ones (Table 6). For example, young plants were 100% controlled six weeks after treatment with imazapyr. For glyphosate treatment, 100% control was also achieved for both young and old plants from the fourth and sixth week respectively. However, glufosinate ammonium and paraquat dichloride gave unsatisfactory control. Treated plants started to recover after the second and first weeks of application with glufosinate ammonium and paraquat dichloride respectively.

Table 5. Phytotoxicity to *I. magnum* over time of different passes of wiper application with imazapyr, glyphosate, glufosinate ammonium and paraquat dicholride

Herbicide	Number of sweeps	% control					
		Weeks after treatment					
		1	2	3	4	5	6
Imazapyr	1	10.0	21.8	31.3	42.5	65.2	70.3
	2	9.9	21.4	39.8	56.3	79.7	87.8
	4	11.1	31.3	52.1	71.0	85.6	98.3
Glyphosate	1	41.4	50.9	58.8	61.7	50.1	57.3
	2	50.0	69.2	80.3	91.0	97.9	90.5
	4	52.3	80.3	90.4	100	100	100
Glufosinate ammonium	1	20.4	31.7	40.4	48.3	28.5	20.8
	2	38.1	48.3	47.6	53.4	35.4	30.2
	4	45.7	51.3	57.1	58.2	42.1	38.6
Paraquat dichloride	1	54.7	60.1	31.5	36.4	11.7	10.9
	2	62.8	55.3	31.9	37.2	11.2	10.8
	4	69.8	42.6	32.3	38.9	21.3	19.6
LSD 5%		10.1					

Table 6. Phytotoxicity of imazapyr, glyphosate, glufosinate ammonium and paraquat dichloride on different plant stages of *I. magnum*

Herbicide	Plant stage	% control					
		Weeks after treatment					
		1	2	3	4	5	6
Imazapyr	Young	22.3	36.4	37.9	68.8	92.7	100
	Old	13.0	25.7	35.8	49.9	61.7	86.6
Glyphosate	Young	80.1	92.3	93.8	100	100	100
	Old	48.7	69.8	78.5	82.8	91.8	100
Glufosinate ammonium	Young	39.8	61.1	32.2	25.4	20.0	11.7
	Old	35.3	42.6	30.1	25.1	18.5	10.5
Paraquat dichloride	Young	60.9	45.3	44.8	29.9	20.3	13.6
	Old	57.2	42.6	30.1	24.5	13.1	8.8
LSD 5%				6.7			

Retention study

Old plants had significantly greater quantitites of imazapyr per plant than young plants with the same number of passes (Table 7). A similar trend was also shown in terms of retention per leaf area except that there was significant improvement of deposition with increasing passes within the same plant stage. However, for the same number of passes, the retention by these old plants was 9-17 times greater than that by the young plants. The calculation based on dry weight per plant showed that the young plants accumulated more imazapyr than the old ones. The imazapyr deposited at four passes was 1.830 and 0.474 $\mu g\ g^{-1}$ dry weight for the young and old plants respectively.

Table 7. Estimated retention of imazapyr on different plant stages of *I. magnum* applied at the rate of 1.0 a.i *kg ha*$^{-1}$ with rope-wick wiper at 1, 2 or 4 passes

Plant stage	Number of passes	Estimated retention of imazapyr*		
		μg plant^{-1}	$\mu g\ cm^{-2}$	$\mu g\ g^{-1}$ dry weight plant
Young	1	45.0e	0.00138b	0.555b
	2	57.5e	0.00112b	0.884b
	4	102.5c	0.00255b	1.830a
Old	1	87.5d	0.01180a	0.446c
	2	175.0b	0.01880a	0.314c
	4	190.0a	0.02785a	0.474c

*Within each column, mean values sharing the same letter are not significantly different according to Duncan's multiple range test at 5% level.

Discussion

Results in this study demonstrated that increasing rates of herbicides and volumes of application improved the performance of the herbicides in the control of *I. magnum.* Increased activity of glyphosate as the herbicide concentration increases has also been noted by several workers (Stahlman & Phillips 1979, Jordan 1981, Buhler & Burnside 1983, Arif *et al.* 1986). Bacon (1984) also found that reduced control of *Imperata cylindrica* was obtained with decreasing total application volume. The results suggest that the performance of herbicides applied with a rope-wick wiper is ultimately controlled by the amount of herbicide absorbed and translocated by plants. Gougler and Geiger (1981) and Van Ellis and Shaner (1988) found that the uptake of glyphosate and imazapyr by isolated discs of soyabean leaves increased linearly with increasing concentration. Better uptake of herbicides would probably lead to sufficient amount of phytotoxic herbicide concentrates accumulated in the tissue.

The results obtained from these trials generally indicate that paraquat dichloride, a contact herbicide, does not work well with a rope-wick wiper because activity is restricted only to the contact area. The localised effect may have resulted from the amount of herbicide uptake into the leaf tissues. Limited movement of paraquat dichloride in the plant tissues could possibly lead to less destruction of the vegetative parts and hence promoting the regrowth of the undamaged healthy tissues. In this study, rapid regrowth occurred shortly after treatment although initially satisfactory control was obtained.

The considerable increase in *I. magnum* control at high volumes of application and increasing number of passes may be due to better coverage or retention of the herbicide solution on the plant surface. Merrit (1980) noted that contact herbicides performed less effectively at low volumes presumably because of inadequate coverage. During the control assessment, most plant leaves at or near the top canopy were completely killed by paraquat dichloride but a considerable number of green foliage remained within the canopy after treatment. It was observed that penetration of herbicide applied with rope-wick wiper on the foliage varied in depths.

Due to the dense stands of all plants that were treated in the trials, coverage or retention may be a major reason for the variable response observed. This may be particularly important for control of old *I. magnum* as a result of its prostrate and dense growth habit. Young plants are more loose and penetrable which lead to receiving better coverage than the old ones and thus more susceptible to herbicide treatment. Since movement of herbicides in young plants involves shorter distance, there is possibility for herbicide to be distributed more evenly in most parts of the plants, resulting in more effective control. Davies *et al.* (1967) reported that the stage of plant development such as ratio of young and mature leaves and leaves-stem ratio may markedly influence spray retention.

In this study, it can be concluded that imazapyr and glyphosate gave satisfactory control on *I. magnum* as compared with glufosinate ammonium and paraquat dichloride. The persistent control was evident by the least regrowth occurred at

the plots which had been treated with these herbicides. Townson and Butler (1990) also reported that these herbicides which were applied with wiper provided effective control against *Imperata cylindrica*. They argued that the excellent control by these herbicides was due to the rapid uptake and translocation through *I. cylindrica*. This phenomenom may have happened in *Ischaemum magnum*. The results of these experiments also suggest that rates lower than those recommended for imazapyr (0.40 a.i. *kg* ha^{-1}) and glyphosate (2.16 a.i. *kg* ha^{-1}) could be used without loss of *I. magnum* control. This would require application at the high volume of 200 *l* ha^{-1}. The advantage of using lower herbicide rate at higher volume of application is that the possibility of phytotoxicity problem on neighboring crop seedlings is less and the herbicide is well distributed on the vegetative parts of the weed.

The results demonstrated the potential safety of rope-wick wiper to be used in the field, particularly with high density of crop planting. The rope-wick is designed to wet weeds sufficiently with the herbicide, but does not allow the chemical to drip elsewhere (Cooper *et al.* 1981, Lutman 1979). Ordinary knapsack sprayers or controlled droplet applicators frequently cause drift problem which is detrimental when applied in the vicinity of sensitive crops. Control of weeds by using rope-wick wiper could reduce the cost of weed management, environmental hazard and operator exposure (Davison & Parker 1983). The proper technique of herbicide application is important due to the high and increasing cost of weed control in forest plantation as a result of expensive cost of labour and herbicides.

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