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Evaluation of herbicides in context to regrowth against terrestrial form of alligatorweed

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ABSTRACT

Terrestrial form of alligatorweed has been reported as a difficult weed to control by the herbicides due to heavy regrowth. No quantitative data is available on regrowth of alligatorweed after herbicides application except visual observations. Hence a comprehensive study was conducted in pot, plot and field conditions to evaluate the effect of three most recommended herbicides in context to superficial control and regrowth. After herbicide application, superficial control of alligator weed was achieved in pot, plot and field conditions but regrowth appeared from the no killed rhizomes. In pot experiment, hundred percent superficial control of alligatorweed at 15 DAA (days after application) was noticed with 2,4-D (2.5 and 3.5 kg/ha) and glyphosate (3.5 and 4.5 kg/ha) and by 20 DAA with metsulfuron-methyl (MSM) at 0.016 and 0.020 kg/ha. In plot experiment, 2,4-D (1.5 kg/ha) and glyphosate (2.0 kg/ha) caused almost 100 percent superficial killing at 10 and 15 DAA, respectively. MSM was most effective at 0.024 kg/ha, however, 0.020 kg/ha was at par with glyphosate (3.0 kg/ha) and 2,4-D (2.0 kg/ha). In plot experiment, little regrowth was noticed in higher doses of glyphosate, 2,4-D and MSM. Repeat application of same herbicides after 90 days of first application revealed no significant difference in regrowth at 30 DAA, however significant difference appeared at 60 and 90 DAA. Effect of MSM (0.020 kg/ha) was at par with higher dose of glyphosate (3.0 kg/ha) on regrowth after repeat application. In naturally infested area, no regrowth appeared in higher doses of glyphosate (3.5 and 4.0 kg/ha) up to 180 DAA, while glyphosate (3.0 kg/ha) and 2,4-D (2.5 kg/ha) were at par with MSM (0.020 kg/ha) at 360 DAA. This information may aid in the development of more effective management of alligatorweed by herbicide application.

Key words: Alligatorweed (*Alternanthera philoxeroides*), Terrestrial form, Chemical control, Regrowth.

Alligatorweed, *Alternanthera philoxeroides* (Family: Amaranthaceae) is a native of north-eastern Argentina. It is a noxious weed in Brazil (Barreto and Torres 1999), Australia (Julien and Bourne 1988 1999, Milvain *et al.* 1995, Krake *et al.* 1999), New Zealand, UK (Arthington *et al.* 1986) and USA (Rhodes 1983) and is capable of infesting terrestrial, low land and aquatic habitats. It is a problematic weed in 30 countries and considered a serious weed in eight of these and a major weed in the others (Guneseker and Bonila 2001). Alligatorweed has been recognized as an invasive and troublesome weed in rice, corn, cotton, soybean, vegetables and fruit trees in 23 provinces of China (Lu *et al*. 2002, Ye *et al.* 2003). In China the crop production was reported to be reduced 20-63 percent (Ensbey, 2001) due to aliigatorweed. It was first reported in India from Bihar in 1965 (Maheshwari 1965) and since than it has spread to 16 more states of India and in some states it has assumed an alarming situation (Sushilkumar *et al*. 2004). In Shilong (Meghalaya, India), this weed was found abundantly on roadsides as terrestrial weed in high moisture regime area, thus threatening local biodiversity (Sushilkumar *et al.* 2004). Survey since 1994 at Jabalpur, Madhya Pradesh, India (Sushilkumar and Bhan 1996) revealed that this weed has spread from a few low land areas to almost all the lowland areas including residential colonies by 2005.

Though a few herbicides like 2,4-D, glyphosate, metsulfuron-methyl, fluridone, dicamba, dichlobenil, bentazon, propanil, pendimethalin and dichloform *etc*. have been used to control this weed in USA,Australia, Indonesia, Brazil and USA. Hitherto, no attempt has been made to evaluate herbicides against aquatic or terrestrial form of alligatorweed in Indian sub-continent in spite of its occurrence in large area since long time. Studies carried out elsewhere reported the effectiveness of herbicides on the basis of superficial percent kill of the weed or on the

visual observation of regrowth. Quantitative data on effect of herbicides in context to regrowth parameters is completely lacking. Thus a comprehensive study was conducted with following objectives (i) effect of three herbicides *viz*., 2, 4-D, glyphosate and metsulfuron-methyl against terrestrial form of alligatorweed in context to superficial kill and regrowth of the weed at different time intervals in pot, plot and natural field. (ii) to evaluate regrowth trend of alligatorweed which may aid in the development of more effective management measures by herbicide application.

MATERIALS AND METHODS

Pot, plot and field experiments

Pot, plot (rhizome-shoot transplanted in 2x2 m^2 plots at farm area of National Research Centre for Weed Science, Jabalpur, India) and field (in 10x10 m^2 area of naturally infested field) experiments were conducted to evaluate the efficacy of herbicides on terrestrial form of alligatorweed in context to regrowth parameters during 2001-2004. Jabalpur is located between 22.49^0 and 24.8^0 north latitude, 78.21^0 and 80.58^0 east longitudes and at an altitude of 411.78 meter above the mean sea level. In pot experiment, alligatorweed was established in plastic basins while in plot experiment, it was established in plots at NRCWS Research farm. After ascertaining effective doses in pot and plot experiments, amended doses were applied in naturally alligatorweed-infested area.

Establishment of weed in pot and plot conditions

Shoots along with rhizomes were collected from a natural population available in the city area. A 20 cm portion having 10 cm rhizome and 10 cm upper shoot was cut from the natural population for the establishment in the plastic basin having 0.34 m^2 area and 30 cm depth. Soil with farm yard manure in 2:1 ratio was filled up to 25 cm in each plastic basin. In each basin, 200 such shoots were buried with 10 cm rhizome portion inserted in the soil. For experiment in plot conditions, 20 cm long shoots with rhizome were established in 2 x 2 m^2 plot area for each treatment and doses. In each plot, 500 cut shoots were buried. Sufficient water was added as and when required to maintain the moisture in the basins and plots. Within 45 days, these cut rhizome-shoots formed a leaf mat above and interwoven root mat beneath the soil as occurred in natural conditions. The area taken for field study was infested with alligatorweed for last 5 years. Before spray of herbicides, initial alligatorweed population/m^2 was counted with the help of quadrates.

Herbicide treatments

In pot experiment, four doses of three herbicides *viz.* 2,4-D (0.5, 1.5, 2.5, and 3.5 kg/ha), glyphosate (1.5, 2.5, 3.5 and 4.5 kg/ha), and metsulfuron-methyl (0.008, 0.012, 0.016, 0.020 kg/ha) were tested. On the basis of percent control and regrowth in pot culture experiment during previous year (2001-2002), same herbicides were tested with decreased or increased doses during 2002-2003 in plot experiment. In plot experiment, three doses of herbicides *viz.,* 2,4-D (1.5, 2.0, 2.5 kg/ha), glyphosate (2.0, 2.5, 3.0 kg/ha), and metsulfuron-methyl (0.016, 0.020, 0.024 kg/ha) were applied to see the efficacy and regrowth. In this experiment, initially six replications were taken for each dose. After three months, repeat application of same dose of herbicide was applied in three replications and three were left unsprayed to compare the regrowth with repeat application. Based on the control efficiency of herbicides applied in pot and plot experiment at NRCWS, Jabalpur concentrations of herbicides were amended. Following doses of herbicides *viz*., 2,4-D (2.0, 2.5 and 3.5 kg/ha), glyphosate (3.0, 3.5 and 4.0 kg/ha) and metsulfuron-methyl (0.012, 0.016 and 0.020 kg/ha) were tested in naturally infested field experiment.

Evaluation of herbicides in pot, plot and naturally infested field

After 45 days of establishment, herbicide treatments were applied with a knap-sack sprayer at the rate of 500 l/ha volume with flat fan nozzle. In control, water was sprayed. The pot and plot experiments were replicated three and six times in a completely randomized block design (CRD) and randomized block design (RBD), respectively. The field experiments were replicated three times in a randomized block design (RBD). For knowing trend of percent kill of weeds after herbicide application, counting of dead plants was made at 5 days interval up to 25 and 20 days in pot and plot experiments, respectively. In field trial at naturally infested area, observations of percent kill of weed could not be taken after one observation at 5 days due to flooding of water in the experimental site at 9^{th} day due to breakage in nearby drainage system. The site could be restored in its earlier conditions only after one month. From the naturally infested site, only regrowth data was taken at 90 days interval up to 360 days and was compared with the control population to find out the effectiveness of the herbicides against alligatorweed on long-term basis. The complete population of alligatorweed was counted from pot and plot experiments but the population in naturally infested field was counted at randomly with the help of 0.25 m^2 quadrates and multiplied for 1m^2 for statistical calculations.

Regrowth study

In pot experiment, counting of newly grown shoots (regrowth) from the treated weed was made at 30 days interval. In control, total number of shoots was counted

and additional new growth over initial population was calculated and compared with regrowth of treated ones. In this experiment, height of the regrowth was also measured and compared with control to find out the vigourness of the regrowth after herbicide application. In plot experiment at farm site, regrowth from treated plots was compared with overall population in the control. In this experiment, effect of repeat application on regrowth after 90 days over the initial treated and untreated population was also made. Observations of regrowth from non-repeat and repeat application plots were taken at 30 days interval till 180 and 90 days, respectively. In naturally infested field experiment, observations on regrowth were taken at 30 days interval up to 360 days and compared with the population of alligatorweed in the control.

Statistical analysis

Data on effect of various herbicides on alligatorweed and regrowth population data obtained in pot, plot and field experiments were subjected to ANOVA using GENSTAT programme. Regrowth data of pot and plot was subjected to square root transformation. Weed biomass data of pot experiment is presented as percent of untreated control. Fisher's protected LSD test at P=0.05 was used to detect individual differences.

RESULTS AND DISCUSSION

Effect of herbicides on weed and regrowth in pot experiment

Effect of different doses of 2,4-D ethyl ester, glyphosate and metsulfuron-methyl (MSM) for above ground kill of alligator weed is given in Figure 1. 2,4-D at 2.5 and 3.5 kg/ha gave hundred percent superficial kill at 20 DAA but at 0.5 and 1.5 kg/ha could control 93 and 98 percent at 25 DAA, respectively. Glyphosate at 4.5 kg/ha resulted 100 percent control at 15 DAA while at 1.5 and 2.5 kg/ha, it could control only 31 and 37 percent at 25 DAA, respectively. Metsulfuron-methyl resulted 90 and 100 percent kill at 0.016 and 0.020 kg/ha treatments, respectively. It gave only 45 and 55 percent control at 0.008, and 0.012 kg/ha doses, by 25th day, respectively.

Dry matter of weed reflected that degradation of weed was most rapid by 2,4-D, followed by glyphosate and metsulfuron-methyl. In metsulfuron-methyl treated weed, significantly higher dry biomass was found at 15 DAA than 2,4-D and glyphosate. In lower doses of metsulfuron-methyl, dry biomass occurred up to 25 days. This slow reduction in biomass indicated that disintegration of tissues occurred slowly in metsulfuron-methyl treated alligatorweed, but in 2,4-D and glyphosate treated weed, disintegration of tissues was fast (Table 1).

Table 1. Weed control efficiency of different herbicides on terrestrial form of alligatorweed in pots.

Herbicides	Dose (kg/ha)	Mean dry biomass at different DAA (g)				Weed control efficiency at different DAA (%)			
		5	10	15	20	5	10	15	20
2,4-D	0.5	4.17	3.58	2.42	0	16.62	49.64	71.15	100
	1.5	3.67	2.97	2.37	0	26.74	58.50	71.75	100
	2.5	2.95	2.87	2.31	0	41.30	59.63	72.46	100
	3.5	2.59	2.41	0.00	0	48.30	66.10	100	100
	Control	5.01	7.11	8.39	9.8	-	-	-	-
	LSD (P=0.05)	0.50	2.15	1.33	-	3.33	32.99	8.89	100
Glyphosate	1.5	6.03	3.73	2.99	0	20.55	59.80	72.86	100
	2.5	4.41	3.36	2.68	0	41.89	63.79	75.68	100
	3.5	3.22	2.39	0.00	0	57.57	74.24	100	100
	4.5	2.15	1.77	0.00	0	71.60	80.92	100	100
	Control	7.59	9.28	11.02	12.9	-	-	-	-
	LSD (P=0.05)	0.52	0.32	0.22	-	34.70	13.74	5.26	-
Metsulfuron -methyl	0.008	6.49	5.58	5.18	4.5	19.17	45.77	57.67	64.28
	0.012	6.10	5.27	5.07	4.5	24.03	48.78	58.57	64.35
	0.016	5.56	4.22	3.62	0	30.37	58.98	70.34	100
	0.020	4.75	3.98	2.82	0	40.84	61.32	76.96	100
	Control	8.03	10.29	12.24	12.6	-	-	-	-
	LSD (P=0.05)	0.58	0.26	0.40	0.4	21.82	12.30	15.20	1 2.09

DAA - Days after application

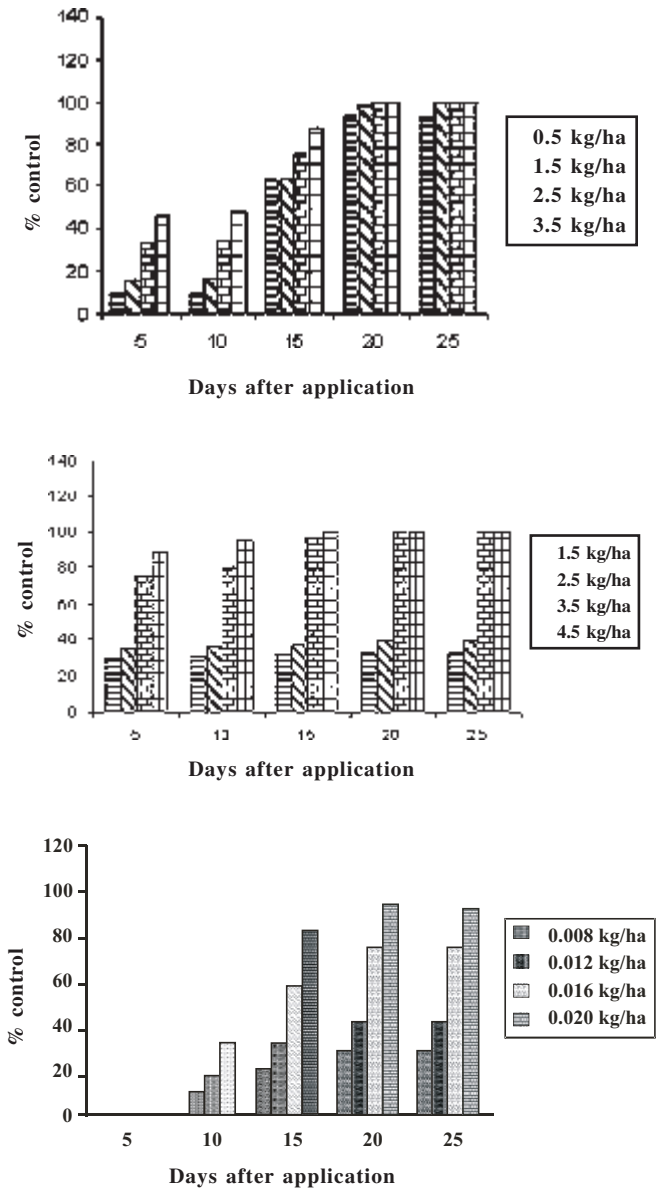


Fig. 1. Effect of 2,4-D (a), glyphosate (b) and metsulfuron-methyl (c) on superficial kill of alligator weed at different days in pot conditions.

2, 4-D ethyl ester could not check the regrowth even at higher doses (2.5 and 3.5 kg/ha) at 30 DAA. However, it could control 60, 70 and 100 percent superficial growth of alligatorweed at 0.5, 1.5 and 2.5 kg/ha doses respectively but in these treatments regrowth appeared at 20 DAA. In case of glyphosate, regrowth appeared after three weeks of application at 1.5, 2.5 and 3.5 kg/ha treatments but no regrowth was noticed at 4.5 kg/ha treatment, even after 60 days. In metsulfuron-methyl treated pots, no regrowth was appeared in higher dose (0.020 kg/ha) after 60 days while in lower doses (0.008, 0.012 and 0.016 kg/ha), regrowth appeared after 30 days (Figure 3).

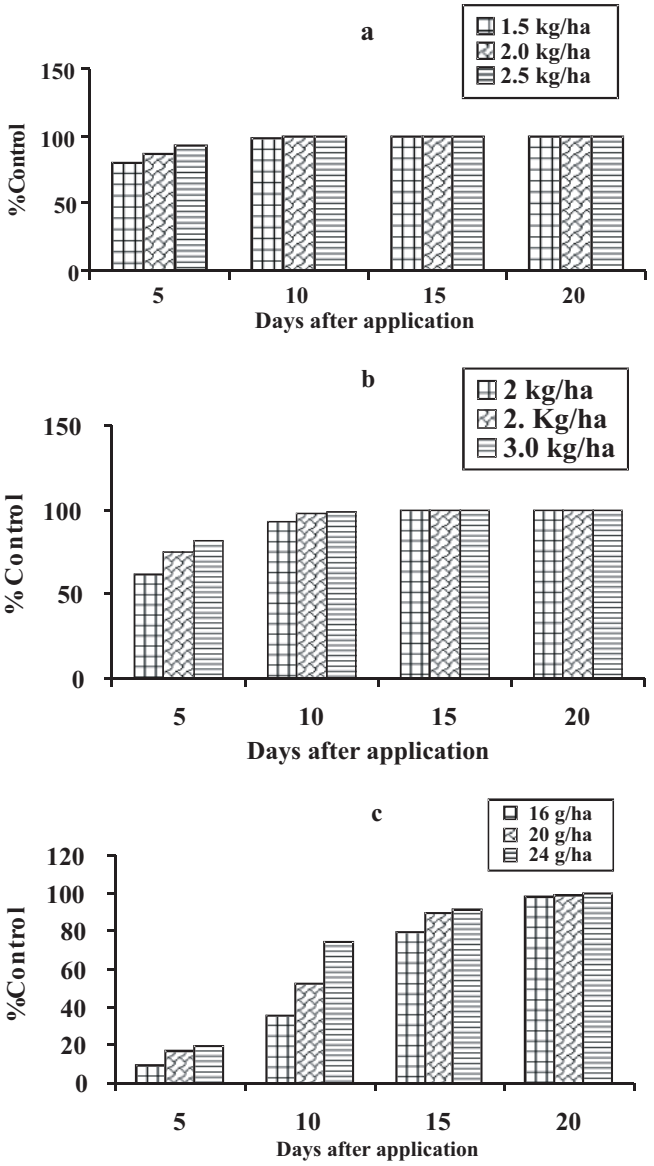


Fig. 2. Control of alligator weed by 2,4-D (a), glyphosate (b) and metsulfuron-methyl (c) at different days after application in plot experiment

The height of regrowth shoots was maximum in lower doses of 2,4-D (0.5 and 1.5 kg/ha) treated pots followed by glyphosate (1.5 and 2.5 kg/ha) and metsulfuron-methyl (0.008 and 0.012 kg/ha) as compared to high doses of these herbicides (Figure 4). The same trend remained up to 60 DAA. Pot experiment suggested need of repeat application of herbicides for good control of alligatorweed.

Effect of herbicides on weed and regrowth in plot experiment

Initially all herbicide treatments were effective against alligatorweed (Figure 2). The effect was more pronounced at 10 to 15 DAA in case of 2,4-D and glyphosate and 15 to 20 DAA of metsulfuron-methyl application. 2,4-D at 1.5

and 2.0 kg/ha and glyphosate at 2.0 and 3.0 kg/ha caused 100 percent control and reduced the dry biomass of alligatorweed completely by 15 DAA. Whereas metsulfuron-methyl was effective to control 100 percent alligatorweed at 20 DAA in all the doses but it was significantly high in higher doses (0.020 and 0.024 kg/ha) than lower dose (0.016 kg/ha). Metsulfuron-methyl was found even more effective at 0.016 kg/ha treatment if compared with the higher doses of glyphosate (3.0 kg/ha) and 2,4-D (2.5 kg/ha).

The regrowth appeared at 30 DAA in all the doses of 2,4-D and glyphosate treated plots except metsulfuron-methyl wherein regrowth appeared at 60 DAA in 0.016 and 0.020 kg/ha treatments. However still there was no regrowth in 0.024 kg/ha treatment (Table 2). No significant difference was noticed in regrowth amongst the different doses of glyphosate at 90 DAA. The regrowth trend was also not statistically significant in higher doses of 2,4-D (2.0 and 2.5 kg/ha) and metsulfuron-methyl (0.020 and 0.024 kg/ha) at 90 DAA. However, significant differences in regrowth occurred in the lower doses of 2,4-D (1.5 kg/ha) and metsulfuron-methyl (0.016 kg/ha) (Table 2).

Regrowth of alligator weed in repeat application in plot experiment

There was little regrowth of alligatorweed in all the treatments and doses in repeat application plots at 30 DAA, however, significant difference in regrowth appeared at 60 DAA, which became more pronounced at 90 DAA. Metsulfuron-methyl (0.020 kg/ha) effect was at par with higher dose of glyphosate (3.0 kg/ha) in non-repeat application but was significantly different on the basis of regrowth after repeat application. There was fast regrowth in repeat application at 90 DAA in case of 2,4-D and metsulfuron-methyl, while it was slow in glyphosate treated plots (Table 2).

Regrowth of alligatorweed in naturally infested field

No regrowth of alligatorweed was noticed at 90 and 180 DAA in the higher doses of glyphosate (3.5 and 4.0 kg/ha), respectively. However, regrowth appeared in all the doses of 2,4-D and metsulfuron-methyl at 90 DAA but it was less in higher doses of herbicides. Though there was increase in regrowth in all the treatments between 180 and 270 DAA, which was coincided with the rainy season but after that period, again regrowth population declined in all the treatments. Regrowth of alligatorweed was less in glyphosate treated plots followed by 2,4-D and metsulfuron-methyl. Glyphosate (3. kg/ha) and 2,4-D (2.5 kg/ha) were statistically (0.05 level) at par with metsulfuron-methyl (0.020 kg/ha) in controlling alligatorweed at 360 DAA (Table 3). In control plots, alligatorweed density was also found constantly decreased at each 90 days interval from initial density after treatment of the herbicides in adjoining area.

Result obtained in pot and plot experiments showed that all the three herbicides were found effective even in the lower doses but effect in lower doses was of temporary nature. In lower doses of 2,4-D, glyphosate and metsulfuron-methyl, alligatorweed was killed superficially but they did not affect older stems or rhizomes or roots. This fact has been established well by the pot and plot experiments. It was clear from the data of plot experiment that 2,4-D at 1.5, 2.0 and 2.5 kg/ha, glyphosate at 2.0, 2.5 and 3.0 kg/ha and metsulfuron-methyl at 0.016, 0.020 and 0.024 kg/ha started to affect alligatorweed by 5th day onwards and by 20th day almost 100 percent superficial control was achieved. But regrowth appeared after 30 days in all the doses of 2,4-D and glyphosate. It was only metsulfuron-methyl where no regrowth was observed at 30 DAA in any doses and only little regrowth appeared in 0.016 and 0.020 kg/ha at 60 DAA and in 0.024 kg/ha at 90 DAA. In 2,4-D (2.5 kg/ha) and glyphosate (3.0 kg/ha) treated plots, regrowth of alligatorweed was 2.5 and 8 times more than metsulfuron-methyl (0.024 kg/ha) treated plots after three months and 1.68 and 1.48 times higher after six months. In control plots, weed population was about 16 times more than the metsulfuron-methyl (0.024 kg/ha) treated plots.

Toscani *et al*. (1983) found complete control of alligatorweed for 1 year with hexazinone at 2.25 kg/ha and by applications of glyphosate in dry ditches. Langeland (1986) obtained excellent control of terrestrial form of alligatorweed with 4.52 g metsulfuron-methyl/100 liters, 0.36 kg triclopyr/100 liters and with a tank mixture of glyphosate + fluridone at 0.18 + 0.12 and 0.36 + 0.24 kg/100 litre in drainage canal system. Bowmer (1992) found good control by application of dichlobenil followed by application of metsulfuron-methyl nine month later or three sprays of metsulfuron-methyl over 18 months. Ensbey (2001) opined that many herbicides only kill the tops but do not affect older stems, rhizomes or roots. He recommended glyphosate for aquatic, dichlobenil for shallow water areas and metsulfuron-methyl for terrestrial areas. Gunesekera and Bonila (2001) tested four herbicides namely dichlobenil (67.5 kg/ha), glyphosate (360 g/l) and metsulfuron-methyl (63 g/h) and mixture of glyphosate and metsulfuron-methyl against terrestrial form of alligatorweed and glyphosate (3.24 kg/ha) against aquatic form of alligatorweed in two month interval for three times. They observed regrowth, which was controlled by repeated treatments. Melvain *et al.* (1995) obtained good control

Table 2. Effect of herbicides on regrowth of alligatorweed after herbicide application in plots.

Herbicides	Dose Kg/ha	Re growth population (DAA) (No/m^2)								
		Non-repeat application						Repeat application		
		30	60	90	120	150	180	30	60	90
2,4-D	1.5	1.93*	5.56	6.35	8.27	9.89	13.22	0.71	2.63	9.27
	2.0	0.99	5.13	5.70	7.60	9.17	12.88	0.71	1.40	8.74
	2.5	1.05	3.17	4.30	6.32	7.47	12.16	0.71	0.96	5.23
Glyphosate	2.0	2.83	8.52	8.90	10.46	11.69	12.86	0.71	4.41	8.71
	2.5	2.72	8.18	8.47	9.01	11.05	12.60	0.71	3.45	8.18
	3.0	2.38	7.04	7.66	8.50	9.48	11.47	0.71	2.95	6.16
Metsulfuron-methyl	0.016	0.71	2.77	4.09	6.63	8.62	11.09	0.71	2.91	8.14
	0.020	0.71	2.28	3.17	5.16	6.43	10.48	0.71	2.10	6.84
	0.0 24	0.71	0.71	2.79	4.05	6.14	9.71	0.71	0.71	4.68
Control	0.00	26.67	27.82	29.15	35.44	37.25	38.30	35.44	37.25	38.30
LSD (P=0.05)		1.28	1.57	1.50	1.81	1.67	0.76	1.46	1.55	0.93

* transformed values; DAA : Days after application

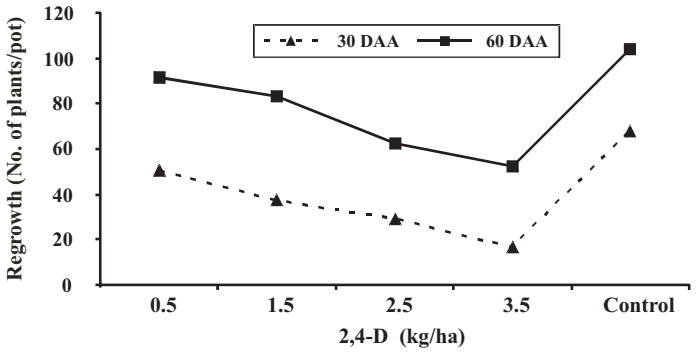
of alligatorweed by using metsulfuron-methyl in terrestrial areas and dichlobenil in areas that had terrestrial plants in shallow water. It was also observed that if only a fraction of alligatorweed population is left uncontrolled, it might again proliferate fast and re-infest the area quickly which is reflected in case of metsulfuron treated plots after 180 days at 0.024 kg/ha dose.

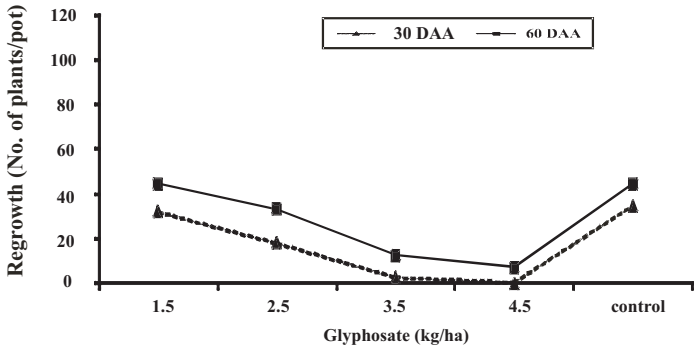
In naturally infested areas, no regrowth appeared after three and six months in glyphosate treated plots at 3.5 and 4.0 kg/ha doses, respectively. It was interesting that regrowth was higher in metsulfuron treated plots than 2,4-D treated plots. This regrowth trend of terrestrial form of alligatorweed in naturally infested area was somewhat different than the pot and plot experiments where higher regrowth was observed after three months in glyphosate and 2,4-D treated pots and plots. This regrowth pattern of terrestrial form of alligatorweed in the glyphosate treated plots dose not confirm with the studies of Milvain (1995) and Gunesekera and Bonila (2001) who reported best control of terrestrial and aquatic form of alligatorweed by metsulfuron-methyl or dichlobelin and by glyphosate, respectively. The reason of good performance by the glyphosate and 2,4-D against terrestrial form of alligatorweed in naturally infested area may be due to inundation of experimental area after 9 days of treatment due to breakage of nearby drainage system, which caused aquatic type of situation in the experimental site for next two months. Due to achieving of aquatic situation, good

Table 3 Effect of herbicides on regrowth of terrestrial form of alligatorweed in naturally infested condition

Herbicides	Dose (kg/ha)	Initial weed population (No./m^2)	Mean population of alligatorweed at different DAA (No./m^2)			
			90	180	270	360
2,4-D	2.00	557	38	54	166	71
	2.50	508	28	51	133	51
	3.50	509	27	43	73	47
Glyphosate	3.00	856	0	43	140	54
	3.50	736	0	0	115	29
	4.00	952	0	0	81	24
Metsulfuron-methyl	0.012	392	59	187	172	82
	0.016	471	39	133	156	65
	0.020	441	28	105	133	52
Control		463	345	389	253	178
LSD (0.05)		-	2	3	3	2

DAA : Days after application





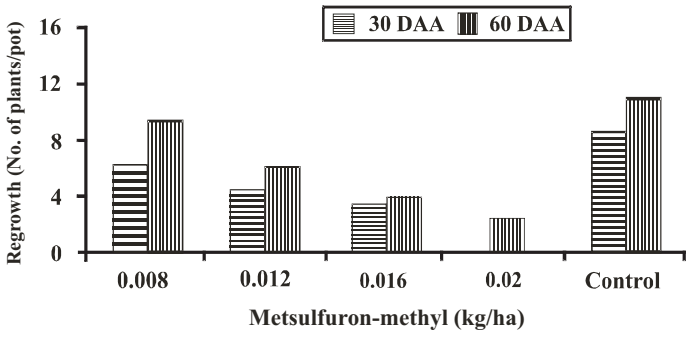
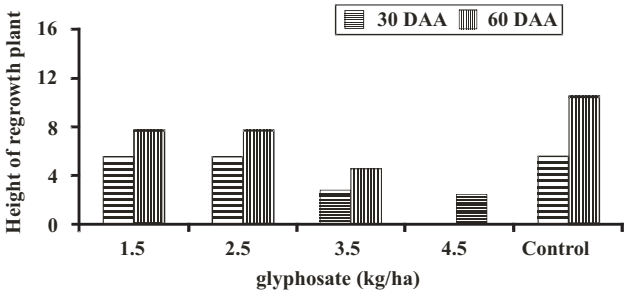
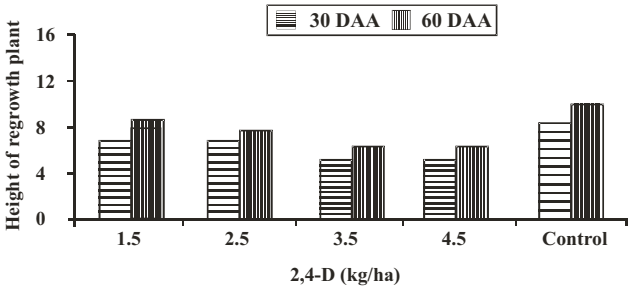


Fig. 3. Regrowth population of alligator weed in pot experiment at 30 and 60 days after application of 2,4-D, glyphosate and metsulfuron-methyl





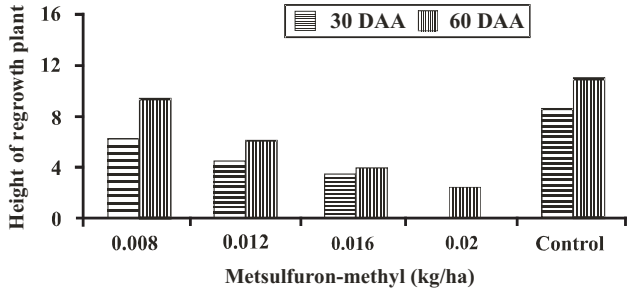


Fig. 4. Regrowth height of alligator weed in pot experiment at 30 and 60 days after application of 2,4-D, glyphosate and metsulfuron-methyl

translocation of glyphosate and 2, 4-D might have occurred which resulted longer control in the treated site hence accounted less regrowth than the metsulfuron-methyl treated plots. It was also interesting to observe that in control plots at naturally infested site, density of weed decreased constantly after herbicide applications at adjoining area. It was in contrast than pot and plot experiment where in control plot, weed population increased constantly with the time. This decrease in population in control plots in naturally infested area might be due to inundation of the plot after about one week of herbicide application which caused spread and leaching of the herbicides up to non-target site as has also been reported elsewhere (Milvain1995, Gunesekera and Bonila 2001). In pot and plot experiments, there were no such chances of herbicides leach as they were done under strict controlled conditions.

This study established quantitatively that for long-term control of alligatorweed, repeat application is necessary as was also suggested by earlier workers (Gangstad 1975, Bowmer 1992, Milvain *et al*. 1995, Gunesekera and Bonila 2001). It was also interesting to note that regrowth was higher in all the treatments and doses at 90 DAA in repeated application plots than no repeated plots. This higher regrowth trend in repeat application plots after same period of time indicate the resistant nature of alligatorweed

against the same herbicide in due course. Julien and Broadbent (1980) were also opined that alligatorweed was more resistant to herbicides than other aquatic macrophytes.

On the basis of reported data of regrowth pattern of alligator weed, metsulfuron-methyl at 0.024 kg/ha may be recommended to control terrestrial form of alligatorweed for at least six months in tropical situations. If control is required for longer time, repeat application of glyphosate (3.5 kg/ha) followed by metsulfuron-methyl at six-months interval will be recommended.

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