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EVALUATION OF HERBICIDE APPLICATORS

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ABSTRACT

A field trial was laid out in rubber to test the relative efficacies of ULV spraying with HV spraying on weed control with 4 herbicides. The sprayers were LOCDA, BOCDA, and LOK with 30, 15 and 400-500 litres of spray volume per hectare respectively. The herbicides were Gramaxone (@ 2.5 l/ha), Gramaxon + Fernoxone (@ 2.5 l + 1.25 kg/ha), Dalapon (@ 5 kg/ha) and Glycel (@ 2 l/ha). There were 12 treatment combinations replicated thrice. A significant difference in weed control was observed due to herbicide applicator interaction. It indicated that Dalapon and Glycel sprayed with LOCDA and LOK gave similar narrow leaf control. While with BOCDA, the effect was similar with Glycel, but with Dalapon the duration of control was lower. Further Glycel sprayed by LOCDA gave significantly better prolonged overall weed control. With Gramaxone, LOK and LOCDA produced equivalent overall weed control up to 30 DAS whereas BOCDA gave lower level of control. However, Gramaxone + Fernoxone combination sprayed with LOK was significantly better than both the CDA's . The experimental results justify the substitution of conventional LOK sprayers with LOCDA sprayers for spraying Glycel, Dalapon and Gramaxone with considerable saving in the spray volume and mandays, thus making spraying herbicides easier and cheaper.

INTRODUCTION

The current weed control measures have high energy requirements in terms of mandays. The increasing labour costs and scarcity will render the manual control measures unviable in the near future. Further the manual clean weeding will expose soils to erosion and degradation as the climate is humid tropical and terrain undulating in the rubber growing tracts. Previous experiments of Rubber Research Institute of India (Mathew *et al.*, 1984) have shown that herbicidal weed management was economical. Herbicidal weed management may also decrease soil exposure by providing a dry mulch, thus conserving soil and moisture. Conventional lever operated kanapsack (LOK) sprayers currently used in herbicidal application require high spray volumes and energy. Herbicide application with controlled droplet applicators (CDAs) has shown savings in volume of spray, application time, and easier application in difficult terrain (Jollands *et al.*, 1983; Mathew, 1979; Sin Liu and Alif, 1981).

Therefore a field experiment was conducted to test the relative efficacy of low volume (LV) spraying wih CDAs and high volume (HV) spraying with LOK sprayers using four herbicides.

MATERIALS AND METHODS

A field experiment with 12 treatments and 3 replications in R.B.D. was laid out in the inter-row spaces of a mature stand of rubber at Boyce Estate, Harrison Malayalam Ltd., Mundakayam in 1985-86. The individual plot size was 100 m^2. The treatments consisted of four herbicides sprayed by 3 different herbicide applicators. The four herbicides Gramaxone (@ 2.5 l/ha), Gramaxone + Fernoxone (@ 2.4 l/ha +

Table I. *List of herbicides used.*

S.No.	Trade Name	Common Name	Chemical Name	Formulation & Concerntration
1.	Glycel	Isophospvl Amine Salt of Glyphosphate	N–(Phosphono methyl) Glycine	Liquid– 41% W/W
2.	Dalapon	Na & Mg. Salt of Dalapon	2, 2-Dichloro Propionic Acid	WP 74% AE
3.	Fernoxone	Na Salt of 2, 4-d	(2, 4 Dichloro phenoxy) Acetic Acid	WP 80% W/W
4.	Gramaxone	Paraquat Dichloride	1, 1-Dimethyl 4, 4' Bypiridium	Liquid 24% W/W

1.25 kg/ha), Dalapon (@ 5 kg/ha) and Glycel (@ 2 l/ha) (Table I). The dosages used were of the commercial products. The sprayers used were conventional Lever Operated Knapsack sprayer (LOK), Lever Operated Controlled Droplet Applicator (LOCDA) and Battery Operated Controlled Droplet Applicator (BOCDA) (Tables II, III).

Description of sprayers

Lever Operated Knapsack Sprayer (Aspee, code SRP/19): The sprayer was equipped with a pressure regulator and pressure gauge. A flood jet nozzle WFN 40 was used. The spray tank was of 13 litre capacity (Tables II, III).

Table II. *Technical data of sprayers used.*

Data	Birky (LOCDA)	Aspee-CDA (BOCDA)	Aspee Backpak sprayer (LOK)
Weight	4.5 kg	1 kg with 11 container 3 kg with 10l container	5.4 kg
Spray Tank Capacity	5l	11-10l (modified)	13 l
Nozzle	Plastic colour coded Yellow-1.3mm (orifice Dia) Flowrate-290ml/Min Red-1.6mm (Orifice Dia) Flowrate-190ml/min	Steel Disc Discharge rate CDA75-75cc/min	Brass-flood jet WFN 40
Atomizer	Rotary type	Rotary type	Impact type
Droplet size	Flowables & EC 270-320 UM VMD WP-330-380 UM VMD	VMD-100-160 UM	VMD – 5-500 UM
Delivery Rate/ha	20 l to 30 l	15 l	200-1000 l
Swath width	1.6 M	1.2 M	30cm-60cm upto 2.1M with WFN 78
R.P.M.	1600	4000-5000	
Droplet formation	Centrifugal	Centrifugal	Hydraulic
Energy Source	Manual	Battery Powered	Manual.

Table III. *Comparative study of applicators*

	LOK	LOCDA	BOCDA
No. of Fills required to spray per effective hectare	30 – 77	Δ 6	Δ 2 With modified 10 Litre Tank
*Mandays required to spray 1 hectare	2 to $3\frac{1}{4}$	$\frac{1}{2}$ Less Physical Effort Than LOK	$\frac{1}{2}$ Less Physical effort than LOK and LOCDA
**Cost of spraying/ha	Rs.50 – 81.25	Rs.12.50/-	Rs.14/- (including Rs.1.50/- for recharging battery)
Volume of Diluent (Water)	High Hence impure water may have to be used 400 l/ha	Ultra-Low Hence clean water can be used 30 litre/ha	Ultra Low Hence clean water can be used 15 l/ha
Herbicide concentration	low	High	High
Energy source	Manually operated	Manually operated hence low maintainance	D.C. Battery has to be recharged in 2 hours.
Herbicide specificity and formulation	Weed kill good with contact and traslocated herbicides (W.P. and) Flowables	Weed kill relatively lower with contact but equivalent or better with translocated herbicides especially flowables.	

*Mandays were calculated with the formula based on the following observations and assumptions.

The time required for actual spraying of 100 m^2 of area in this trial were 4, 1, 1 & 1.5 minutes for LOK, LOCDA & BOCDA respectively. Time taken for the fills is assumed to be 10 minutes. In actual situations, it may vary widely.

$$M = \frac{(t100 \times 100) + ({}^{t}f \times {}^{n}f)}{60 \times 6}$$ where M = Mandays (6 hr) for spraying 1 hectare;

$^{t}100$ = time in minutes for spraying 100 m^2; ^{t}f = time in minutes for each fill;
^{n}f = No. of fills required for spraying 1 ha.

**C = M × W^M, where C = Cost of spraying 1 ha in Rupees
M = Manday (6 hr) for spraying 1 ha
W^M = Wages per manday multiplied by No. of mandays
Assumption: Wages per manday = Rs. 25/-

Battery Operated Controlled Droplet Applicator (Aspee-CDA, Code UL-I): The sprayer was a hand-held type with a spray head consisting of a rotary atomizer driven by a 3 watt DC motor powered by a 6V rechargeable dry battery. The power pack consisting of the battery and charger unit could be shoulder-slung. Droplet formation is by centrifugal energy generated by the spinning disc. A modified backpack spray container of 10 litre capacity was used. The spray solution is fed to the rotary atomizer by gravity flow.

Lever operated Controlled Droplet Applicator (Birky-Ciba-Geigy): The sprayer was a manual lever operated CDA with the rotary atomizer driven by air supplied to a turbine by a pneumatic

pump. The pneumatic pump and 5 litre capacity spray container are housed in a backpack. The spray solution is fed by gravity through a flow rate control nozzle into the rotary atomizer. The spray head is situated behind the operator.

Calibration: The CDA sprayers were calibrated as per the instruction manuals for the respective sprayers. The LOK sprayer was calibrated as per set procedures (Fisher and Sabio, 1984). The LOCDA was calibrated to deliver 30 litres of total spray volume per hectare and the BOCDA was calibrated to deliver 15 litres. The LOK was calibrated to deliver 400 l of total spray volume with Glycel and 500 l of total spray volume with the other 3 herbicides. All the spray volumes were inclusive of the dose of herbicides and were on par hectare basis.

Spraying technique

LOK: The area to be sprayed was demarcated into plots of 2 m × 50 m size. The spraying was done at a constant speed with the nozzle kept at 30 cm height from the ground level as far as possible. The effective swath width was 50 cm. The pressure was maintained at 15 PSI. Four passes were required to cover the area of one plot.

LOCDA: The area to be sprayed was demarcated into plots of 1.6 m × 62.5 m size. The spray head housing the spinning disc was kept at 50 cm height from the ground level. As the spray head is behind the sprayer, the operator walked away from the sprayed area. The effective swath width was 1.6 m. Spraying of each plot was completed in one pass.

BOCDA: The area to be sprayed was demarcated into plots of 1.2 m × 83.3 m size. The operator held the spray lance across and in front of his body with the spray head about 75 cm away to the side of the operator and pointing to the direction of walk. The axle of the spinning disc was at an angle of 60°C to the ground level. By such positioning the drift hazard to the operator was minimized. The height of the spray head was 50 cm from the ground level and swath width was 1.2 m. Spraying of each plot was completed in one pass.

Observations: Visual observations of weed canopy coverage were taken on 0 to 100 scale where 0 was absolute absence of weeds and 100 complete coverage of weeds. The overall weed canopy coverage were scored on the above scale before treatment imposition (pre-treatment), at 30 days after spraying (DAS), at 60 DAS and at 90 DAS. The observation were statistically analysed without transformation.

RESULTS AND DISCUSSION

Narrow leaf weeds were predominant during the pre-treatment assessment, viz., *Paspalum scrobiculatum* (L), *Axonopus compressus* (SW), *P. beaux, Digitaria sp., Ottochloa nodosa, Ischaemum muticum* and *Panicum sp.* The broad leaf flora in the pre-treatment assessment were *Chromoleana oderata* (L) K & R., *Lantana camara* (L), *Piper sp, Borreria sp., Mimosa pudica Desmodium sp* and ferns. The pretreatment weed canopy coverage was not found to be significantly differet.

Effect of the sprayers on the performance of herbicides Gramaxone: At 30 DAS, Gramaxone sprayed by LOK

Table IV. *Effect of herbicide – applicator interaction on % weed canopy coverage*

	Overall % of canopy coverage		
	30 days	60 days	90 days
Treatments	Mean SE:4.03 CD:11.8	Mean SE:2.38 CD:6.9	Mean SE:1.76 CD:5.1
T_1:S_1H_1.LOK + Gramaxone	25.0	100.0	100.0
T_2:S_1H_2.LOK + Gramaxone + Fernoxone	10.0	100.0	100.0
T_3:S_1H_3.LOK + Dalapon	23.3	90.0	93.3
T_4:S_1H_4.LOK + Glycel	20.0	86.7	93.3
T_5:S_2H_1.BO CDA + Gramaxone	40.0	100.0	100.0
T_6:S_2H_2 BO CDA + Gramaxone + Fernoxone	33.3	100.0	100.0
T_7:S_2H_3.BO CDA + Dalapon	28.3	91.7	96.7
T_8:S_2H_4.BO CDA + Glycel	25.0	90.0	91.7
T_9:S_3H_1.LO CDA + Gramaxone	30.0	100.0	100.0
T_{10}:S_3H_2.LO CDA + Gramaxone + Fernoxone	25.0	100.0	100.0
T_{11}:S_3H_3.LO CDA + Dalapon	31.7	83.3	90.0
T_{12}:S_3H_4.LO CDA + Glycel	13.3	81.7	85.0
General Mean	25.4	93.6	95.8

Table V. *Effect of herbicide – applicator interaction on % weed canopy coverage*

	% of Broadleaf canopy coverage			
	Pre-treatment	30 days	60 days	90 days
Treatments	Mean SE:5.46 CD:..	Mean SE:4.68 CD:13.7	Mean SE:3.26 CD:9.5	Mean SE:3.36 CD:9.8
T_1:S_1H_1.LOK + Gramaxone	31.7	5.0	71.7	73.3
T_2:S_1H_2.LOK + Gramaxone + Fernoxone	26.7	3.3	66.7	68.3
T_3:S_1H_3.LOK + Dalapon	18.3	23.3	90.0	88.3
T_4:S_1H_4.LOK +Glycel	21.7	20.0	86.7	93.3
T_5:S_2H_1.BO CDA + Gramaxone	26.7	16.7	68.3	70.0
T_6:S_2H_2.BO CDA + Gramaxone + Fernoxone	18.3	5.0	66.7	66.7
T_7:S_2H_3.BO CDA + Dalapon	23.3	28.3	90.0	86.7
T_8:S_2H_4.BO CDA + Glycel	28.3	25.0	90.0	83.3
T_9:S_3H_1.LO CDA + Gramaxone	23.3	5.0	70.0	70.0
T_{10}:S_3H_2.LO CDA + Gramaxone + Fernoxone	23.3	5.0	60.0	63.3
T_{11}:S_3H_3.LO CDA + Dalapon	26.7	31.7	83.3	88.3
T_{12}:S_3H_4.LO CDA + Glycel	15.0	13.3	81.7	85.0
General Mean	23.6	15.1	77.1	78.1

and LOCDA gave similar overall weed control, while Gramaxone sprayed by BOCDA gave significantly the lowest overall weed control (Tables IV, V, VI). Effective overall weed control was observed only up to 30 DAS with all the sprayers.

The effect of Gramaxone on broad leaves was similar with all the sprayers at 30, 60 and 90 DAS. At 30 DAS, Gramaxone with the 3 sprayers showed significant difference in control of narrow leaf weeds. LOK gave the best results followed by LOCDA and BOCDA respectively. At 60 and 90 DAS, all the three sprayers were at par. Considering the overall weed control, it can be seen that LOK sprayers can be replaced by LOCDA for spraying Gramaxone (Fig. 2).

Gramaxone + Fernoxone: At 30 DAS, Gramaxone + Fernoxone when sprayed with LOK gave a significantly better overall weed control as compared to LOCDA and BOCDA which were at par. At 60 and 90 DAS there was no significant difference in overall weed control with the 3 sprayers (Tables IV, V, VI). Broad leaf control with the 3 sprayers gave similar results at 30, 60 and 90 DAS.

At 30 DAS, Gramaxone + Fernoxone with the 3 sprayers gave significantly different narrow leaf control; LOK gave the best narrow leaf control followed by LOCDA and BOCDA respectively. At 60 DAS, LOK and BOCDA were at par and both significantly better narrow leaf control as compared to LOCDA. While at

Table VI. *Effect of herbicide – applicator interaction on % weed canopy coverage*

	% of Narrow leaf canopy coverage			
	Pre-treatment	30 days	60 days	90 days
Treatments	Mean SE:5.45 CD:..	Mean SE:1.18 CD:3.5	Mean SE:2.06 CD:6.0	Mean SE:2.19 CD:6.4
T_1:S_1H_1.LOK + Gramaxone	68.3	20.0	28.3	26.7
T_2:S_1H_2.LOK + Gramaxone + Fernoxone	73.3	6.7	33.3	31.7
T_3:S_1H_3.LOK + Dalapon	81.7	0	0	5.0
T_4:S_1H_4.LOK + Glycel	78.3	0	0	0
T_5:S_2H_1.BO CDA + Gramaxone	73.3	33.3	31.7	30.0
T_6:S_2H_2.BO CDA + Gramaxone + Fernoxone	81.7	28.3	33.3	33.3
T_7:S_2H_3.BO CDA + Dalapon	76.7	0	0	10.0
T_8:S_2H_4.BO CDA + Glycel	83.3	0	0	0
T_9:S_3H_1.LO CDA + Gramaxone	76.7	25.0	33.3	30.0
T_{10}:S_3H_2.LO CDA + Gramaxone + Fernoxone	76.7	20.0	40.0	36.7
T_{11}:S_3H_3.LO CDA + Dalapon	73.3	0	0	1.7
T_{12}:S_3H_4.LO CDA + Glycel	85.0	0	0	0
General Mean	77.4	11.1	16.7	17.1

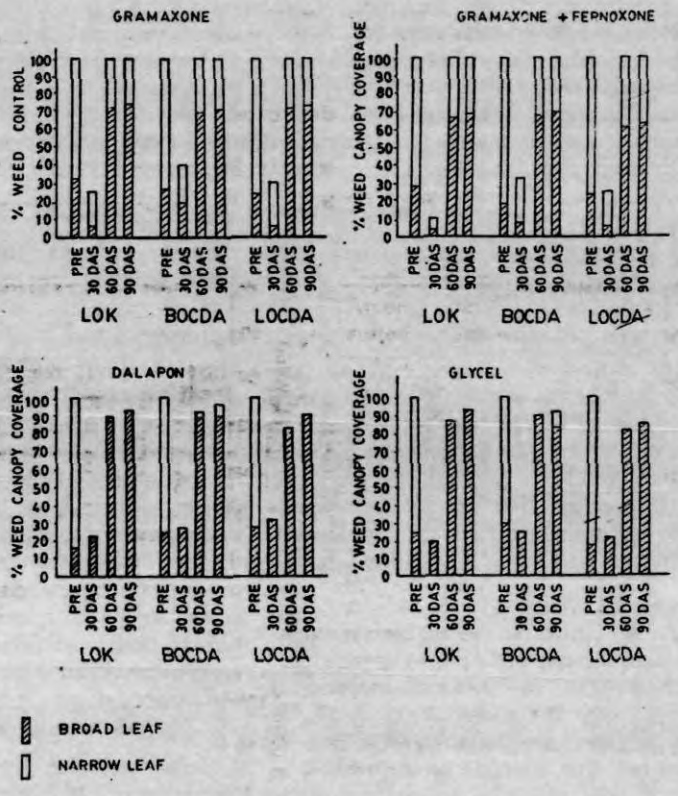


Fig. 1. Weed Flora shift at 30 DAS, 60 DAS, 90 DAS, as a function of herbicide applicator interaction.

90 DAS, BOCDA and LOCDA were at par but LOK gave significantly better narrow leaf control as compared to LOCDA.

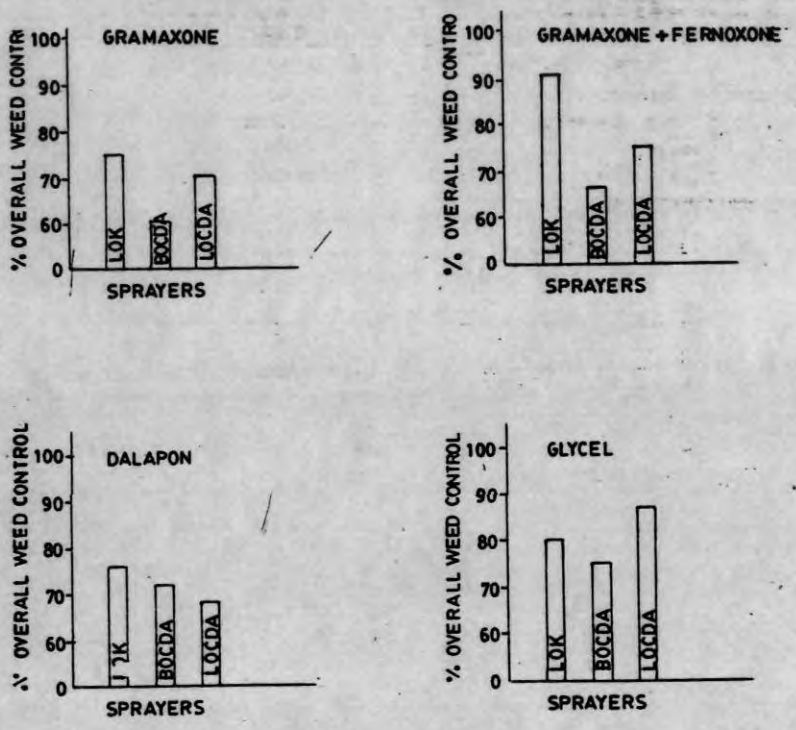
Gramaxone + Fernoxone when sprayed by LOK sprayers were observed to give better overall and narrow leaf control when compared to BOCDA and LOCDA sprayers. The inefficient overall and narrow leaf control of Gramaxone + Fernoxone when sprayed with CDA's may be due to the negative interaction of high concentration of Gramaxone and Fernoxone. From the results it also appears that in areas with predominance of broad leaf weeds, Gramaxone + Fernoxone could be effectively sprayed with CDAs (Fig. 2).

Dalapon: At 30 DAS Dalapon sprayed with LOK gave significantly

better overall weed control as compared to BOCDA and LOCDA which were at par. At 60 and 90 DAS LOK and LOCDA gave overall weed control and LOCDA was significantly better than BOCDA (Tables IV, V, VI).

At 30, 60 and 90 DAS there was no significant difference in broad leaf control between the 3 sprayers with Dalapon.

At 30 and 60 DAS no significant difference in narrow leaf control was observed between sprayers, however at 90 DAS LOK and LOCDA with Dalapon gave similar narrow leaf control and



LOK - LEVER OPERATED KNAPSACK SPRAYER
BOCDA - BATTERY OPERATED CONTROLLED DROPLET APPLICATOR
LOCDA - LEVER OPENATED CONTROLLED DROPLET APPLICATOR
DAS - DAYS AFTER SPRAYING

Fig. 2. Effect of Herbicide – applicator interaction on weed control at 30 DAS

LOCDA gave significantly better control when compared to BOCDA.

It has been observed that Dalapon sprayed with LOK sprayers gave good weed control initially but for prolonged weed control LOCDAs performed better. Therefore it can be concluded that Dalapon sprayed by LOCDA gives better and prolonged weed control (Fig. 2).

Glycel: At 30 DAS, all the 3 sprayers gave similar overall weed control with Glycel. But at 60 DAS Glycel with LOK and LOCDA gave similar overall control, while with BOCDA at 90 DAS, Glycel with LOCDA gave significantly better overall weed control as compared to LOK and BOCDA (Tables IV, V, VI). At 30 and 60 DAS all the three sprayers gave similar broad leaf control with Glycel. But at 90 DAS, LOCDA with BOCDA gave similar broad leaf control, and with BOCDA the control was significantly better than when Glycel was sprayed with LOK. Glycel with all the 3 sprayers gave similar narrow leaf control at 30, 60 and 90 DAS.

Glycel sprayed by LOCDA gave a prolonged weed control which was observed to be significantly better than the control obtained by spraying Glycel with LOK and BOCDA at 90 DAS. Therefore for effective weed control for a longer period Glycel should be sprayed by a LOCDA (Fig. 2).

The weed flora shifted towards broad leaf spectra with *Crassocephalum* sp. taking over by 60 DAS in all the treatments. Glycel and Dalapon wiped out the grasses up to 90 DAS (Fig. 1).

Herbicide spraying with CDAs could save up to 97% of the spray volume and utilized only $\frac{1}{4}$ th to 1/6th the mandays required to spray 1 ha with LOK (Table III). These factors assume greater importance in steep rubber growing tracts where water is scarce and water transport difficult. Since only low volume of water is required with CDA spraying, cleaner water can be used for spraying. A comparative study of the different applicators is summarised in Table III. Among the CDAs, LOCDA is better suited for small holders as it uses manual power for atomizing. The battery of BOCDA is not efficient. It requires recharging every 2 hours or so. LOCDA is more robustily constructed, easier to maintain and operate than BOCDA. It is very much less tiring to pump LOCDA than LOK. As the rotary atomizer in LOCDA is about a meter behind the operator drift hazard to the operator is minimal. However spray protectives are a must for operators as relatively concentrated herbicide solutions are used with the CDAs.

The following suggestions are made on the basis of observations.

1. Shields should be used with CDAs and LOK to reduce drift hazard when spraying is done in young rubber

2. Dyes should be used with CDAs as markers to distinguish sprayed swaths as droplet are invisible.

3. Multiple spray heads should be tried with CDAs to enhance swath width.

4. Oil based formulations should be tested for increasing the efficiency of herbicides with CDAs.

5. Testing of CDAs with lower dosages of herbicides.

6. Testing of CDAs with herbicides adjuvants and herbicide combinations to enhance herbicidal activity.

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