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A Practitioner's Guide for Testing Herbicide Efficacy With the Incision Point Application (IPA) Technique on Invasive Woody Plant Species

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The Incision Point Application (IPA) method is a calibrated, hygienic, and efficient field technique for administering suppressive or lethal herbicide doses directly to the exposed vascular systems of invasive woody plant species. The IPA technique is a refinement of the more traditional "frill cut" or "hack-n-squirt" basal application methods that minimizes the cutting action to small incisions around the base of the tree at equidistant points, less than a complete girdle. It also precisely delivers known (micro) amounts of herbicide to each incision. This technique utilizes a small, sharp implement such as a hatchet for making the incision and either a veterinary draw-off syringe or calibrated dropper (see Fig. 1) for applying the metered herbicide dose. Knowing which herbicides are most effective on each target species optimizes the IPA technique, allowing applicators to carry less weight into the field and leave the smallest possible footprint in the environment.

This is a basic guide for practitioners to conduct their own experiments, testing registered, non-restricted herbicides using the IPA technique on invasive woody species of interest. Previous trials have demonstrated efficacy of triclopyr, glyphosate, imazapyr, and aminopyralid on several woody plant species (Leary et al. 2012). For each of these active ingredients there are several registered products available, but not all may be suited for using this technique (see Appendix 1 for information on these active ingredients). Before applying any herbicide, all applicators must know what is allowable according to the label. In particular, the applicator must know (i) the proper site of application (i.e., forested natural areas), (ii) the maximum allowable application rate (amount of herbicide per area), and (iii) the maximum allowable concentration for an application. In many cases, the IPA technique is best utilized with undiluted (100%) formulations (if the registered label allows for it). The calibrated delivery of micro-doses using a syringe or dropper allows for accurate accounting of how much herbicide is being applied to the target.

IPA allows practitioners to deliver precision doses of herbicide for greater efficiency and reduced environmental impact.

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Goal: Identify the most effective herbicide using the IPA technique on invasive woody plant species of interest.

Strategy: Install replicated field trials on individual species in their naturalized setting, comparing four different herbicide active ingredients.

Equipment and Resources (see Fig. 1)

- Hatchet/machete
- Droppers (4 x 1 fl oz)
- Herbicide formulations: triclopyr, glyphosate, imazapyr, and aminopyralid
- Tape measure (for circumference measurements)
- Aluminum tags and flagging
- GPS
- PPE: safety goggles and nitrile gloves
- Notebook/data sheet (Appendix 2) and pencil

Experimental Design and Installation Procedures

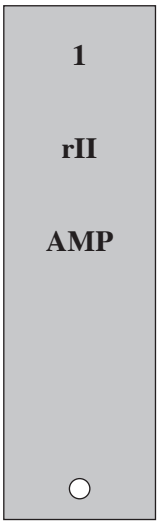
The experimental design consists of four active ingredients (Appendix 1) to be replicated a minimum of 4 times for each test species (total 16 trees). However, it is preferable to have up to 6 replicates (total 24 trees).

1. Locate 16–24 trees of relatively uniform size. Label each tree with a metal tag with an assigned number in order of recording it (e.g., 1–24). Record GPS waypoint of the location. Measure trunk circumference at 50 cm from soil surface for each tree. THE NUMBER AND CORRESPONDING CIRCUMFERENCE SHOULD BE RECORDED IN YOUR NOTEBOOK OR DATA SHEET. A SKETCH MAP OF TREE LOCATIONS IS ALSO HIGHLY RECOMMENDED.

2. Rank each tree in order from smallest to largest circumference and block each set of four sequentially ranked trees (from smallest to largest circumference sets), assigning each block a replication value (i.e., rI–rVI). Randomly assign herbicide treatments to each of the four trees per replicate (see Appendix 2 for a data sheet to use in the field). THE RANK, REPLICATION VALUE (REP), AND HERBICIDE TREATMENT SHOULD BE RECORDED IN YOUR NOTEBOOK OR DATA SHEET.

3. Determine the best incision treatment for your experiment based on the size range from smallest to largest circumference, ensuring that the space between cuts is within 10–30 cm (see Table 1 to determine the optimal number of incisions). THE NUMBER OF INCISION APPLICATIONS WILL BE THE SAME FOR ALL TREES IN THE EXPERIMENT.

Figure 1. Equipment needed for installing an IPA trial, starting from the top: hatchet, liquid droppers, tape measure, PPE glasses, GPS, label tag, PPE gloves.



Arbitary numerical value

Assigned replicate in roman numeral (rI-rVI)

3-letter acronym of herbicide treatment (in CAPITAL LETTERS)

Figure 2. Example of a tag label designating the arbitrary number, replication, and treatment.

Table 1. Matrix of tree circumferences (column) with matching incision treatments (top row) with spacing between incision of 10–30 cm.

	1-cut	2-cut	3-cut	4-cut	5-cut	6-cut	7-cut	8-cut	9-cut	10-cut
<20cm	x									
<30cm	x	x								
<40 cm		x	x							
<50 cm		x	x	x						
<60cm		x	x	x	x					
<70cm			x	x	x	x				
<80cm			x	x	x	x	x			
<90cm			x	x	x	x	x	x		
<100cm				x	x	x	x	x	x	
<110cm				x	x	x	x	x	x	x
<120cm				x	x	x	x	x	x	x
<130cm					x	x	x	x	x	x
<140cm					x	x	x	x	x	x
<150cm					x	x	x	x	x	x

4. Label trees with rep (I–VI) and the three-letter acronym of the herbicide treatment (see Appendix 1). THIS STEP MUST BE COMPLETED BEFORE OR CONCURRENTLY WITH THE ADMINISTRATION OF EACH INCISION/HERBICIDE TREATMENT.

5. Make incisions with hatchet/machete (see *Application Technique* below) at equidistant points (visually estimated) around the base of the measured trunk and approximately 20–50 cm above the soil surface. REGARDLESS OF THE SIZE DIFFERENCES ACROSS BLOCKS, ALL EXPERIMENTAL TREES MUST RECEIVE THE SAME NUMBER OF INCISIONS (AND HERBICIDE DOSES), WITHIN 10- TO 30-CM SPACINGS BETWEEN INCISIONS. *Note: any difference in efficacy between small and large trees with the same herbicide doses will be analyzed as a block effect in the experimental design*.

6. Administer 0.5 ml of undiluted treatment herbicide to each incision. *Note: Prior to installing the experiment, droppers should be calibrated at least 10 times with either a graduated cylinder or digital gram scale to calculate no. drops/ml (remember, 1 ml H_2O=1 g).*

Application Technique

1. With hatchet, make an incision at a 45° angle that penetrates just beyond the cambium layer (approximately 5 cm deep) so that it creates an intact trough/notch (Fig. 3). You may widen the notch by wiggling the blade to create slightly separate the bark from the tree (without removing it).
2. Deliver the herbicide dose to the center of the incision so that all of the herbicide is retained within the trough. This is accomplished by slowly and precisely squeezing the bottle to deliver one drop at a time. Be sure that the incision is deep enough to prevent the herbicide from overflowing at the seam.

Figure 3. Close-up of a properly made incision using a cane knife on an angle to create a clean, intact trough where the herbicide can be retained and absorbed into the vascular system.

Figure 4. Ground perspective rating defoliation of canopy quadrants (pictures from left to right): (4,4,4,4) - no defoliation; (1,2,1,2) - >50 defoliation; (1,1,1,1) - complete defoliation.

Post-Treatment Efficacy Rating and Data Recording

Canopy defoliation ratings should be recorded every 90–100 days for up to one year (total of 3–4 ratings). This particular rating method is designed for rapid visual assessment with practical interpretation. It is not uncommon to observe treatments that are apparently ineffective after 100 days but then are shown to be highly effective (complete defoliation) after 200–300 days. However, lethality may take even longer (e.g., >400 days) to confirm. A simple validation can be made by checking cambium health with a bark scrape and noting the status in the Health and/or Comments sections of the Data Sheet.

1. Visually subdivide leaf canopy into four equal quadrants. These designations can be arbitrary and different for each tree.

2. Visually rank each quadrant 1–4 for level of defoliation for a total of four rank values for each tree unit (Fig. 4; see Appendix 3).

Canopy defoliation rating system:
1 – 100% defoliation (no intact leaves, unless fully necrotic and desiccated)
2 – >50% defoliation (even if a single leaf is present in the canopy, up to 99% defoliation)
3 – <50% defoliation (mostly intact canopy with observable defoliation and/or necrosis)
4 – 0% defoliation (no observable defoliation)

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Appendix 1. Effective, Unrestricted Herbicides for Woody Species Management in Hawai'i*

Active ingredient	Max rate (lbs ae/acre)	Max conc. (v/v)	Site of application
Triclopyr (TCP)	**8**	**100**	**NC, RP, TO, AQ****
Notes: Triclopyr is in the pyridine carboxylic acid family, with a synthetic auxin mode of action. Registered products include Garlon® 3A (amine at 3 lbs ae/gal, EPA reg. no. 62719-37), Garlon® 4 Ultra (ester at 4 lbs ae/gal, EPA reg. no. 62719-527), Remedy® (ester at 4 lbs ae/gal, EPA reg. no. 62719-70), Alligare Triclopyr 4 (ester at 4 lbs ae/gal, EPA reg. no. 81927-11).			
Glyphosate (GLY)	**10.6**	**100**	**NC, RP, TO, AQ**
Notes: Glyphosate is in the glycine family, which inhibits EPSP synthase. Registered products include Roundup® Pro (3 lbs ae/gal, EPA reg. 524-475), Honcho® (3 lbs ae/gal, EPA reg. no. 524-445), Ranger® Pro (3 lbs ae/gal, EPA reg. no. 524-517), Aligare Glyphosate 5.4 (4 lbs ae/gal, EPA reg. no. 81927-8).			
Imazapyr (IMZ)	**1.5**	**100**	**NC, RP, AQ**
Notes: Imazapyr is in the imidazolinone family, with acetolactate synthase inhibition as a mode of action. Similar to glyphosate, it is a broad-spectrum herbicide with strong potential for drift injury resulting from over-application. Registered products include Stalker® (2 lbs ae/gal, EPA reg. no.241-398), Arsenal® (2 lbs ae/gal, EPA reg. no.241-346), Arsenal® (4 lbs ae/gal, EPA reg. no.241-299), Arsenal® Powerline (2 lbs ae/gal, EPA reg. no.241-431), Polaris® (2 lbs ae/gal, EPA reg. no.228-534), Polaris® AC (4 lbs ae/gal, EPA reg. no.228-570), Habitat® (2 lbs ae/gal, EPA reg. no.241-426), Alligare Imazapyr 4 SL (4 lbs ae/gal, EPA reg. no.81927-24).			
Aminopyralid (AMP)	**0.110**	**100****	**NC, RP**
Notes: Aminopyralid is in the pyridine carboxylic acid family, with a synthetic auxin mode of action. Registered products include Milestone® (2 lbs ae/gal) EPA reg. no. 62719-519), which includes a Special Local Need registration in Hawai'i for undiluted injections (EPA sec. 24c SLN no. HI-120003).			

ae - acid equivalent, NC - Non Crop, RP - Range and Pasture, TO - Turf and Ornamental, AQ - Aquatic

***Always read the label before making an application to verify the site of application, maximum use rate, and dose concentration. It is a violation of Federal law to use this product in a manner inconsistent with its labeling.**
****All aquatic pesticide applications in the state of Hawai'i must submit for a notice of intent (NOI) and permit from the Department of Health under jurisdiction of the Clean Water Act.**

Appendix 2. IPA Field Trial Installation and Rating Data Sheet (Example)

Target: *Chrysophyllum oliviforme*
Location: Waimea Valley, O'ahu
Date:
Install Date: 9/20/2013 Rate:
Application Technique:
cuts: 2 ml/cut: 0.5

Herbicide Treatment (Tx):
TCP – Triclopyr
AMP – Aminopyralid
GLY – Glyphosate
IMZ – Imazapyr

Defoliation Rating:
1 – 100% defoliation
2 – >50% defoliation
3 – <50% defoliation
4 – 0% defoliation

Observers: SPM, Ryan, and Parker

#	Circ. (cm)	Rank	Tx	Canopy Rating*				Health	GPS?	Comments
1	87	xxx	xxx	4	4	4	4	Good	42	Thick canopy
2	43	12	TCP	4	4	4	4	Good	43	"
3	39	7	GLY	4	4	4	4	Good	44	"
4	48	14	AMP	4	4	4	4	Good	45	"
5	71	20	IMZ	4	4	4	4	Good	46	"
6	50	16	GLY	4	4	4	4	Good	47	"
7	47	13	IMZ	4	4	4	4	Good	48	"
8	37	5	AMP	4	4	4	4	Good	49	"
9	40	9	GLY	4	4	4	4	Good	50	"
10	64	19	GLY	4	4	4	4	Good	51	"
11	48	15	TCP	4	4	4	4	Good	52	"
12	40	10	IMZ	4	4	4	4	Good	53	"
13	38	6	IMZ	4	4	4	4	Good	54	"
14	32	1	TCP	4	4	4	4	Good	55	", 2 side trunks
15	36	3	IMZ	4	4	4	4	Good	56	"
16	36	4	AMP	4	4	4	4	Good	57	"
17	35	2	GLY	4	4	4	4	Good	58	"
18	41	11	AMP	4	4	4	4	Good	59	"
19	50	17	TCP	4	4	4	4	Good	60	", steep slope
20	39	8	TCP	4	4	4	4	Good	61	"
21	60	18	AMP	4	4	4	4	Good	62	"
22										
23										
24										

*** Subdivide canopy into four quadrants of a pie using the incisions as your guide. Rate each quadrant with the nomenclature listed below and fill in the number with the corresponding section.**

IPA Field Trial Installation and Rating Data Sheet (Fillable)

Target:
Location:
Date:
Install Date: Rate:
Application Technique:
cuts: ml/cut:

Herbicide Treatment (Tx):
TCP – Triclopyr
AMP – Aminopyralid
GLY – Glyphosate
IMZ – Imazapyr

Defoliation Rating:
1 – 100% defoliation
2 – >50% defoliation
3 – <50% defoliation
4 – 0% defoliation

Observers:

#	Circ. (cm)	Rank	Tx	Canopy rating*				Health	GPS?	Comments
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										

*** Subdivide canopy into four quadrants of a pie using the incisions as your guide. Rate each quadrant with the nomenclature listed below and fill in the number with the corresponding section.**

Appendix 4. Other Useful References

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