

Ίσως είναι ήδη αργά.

Πολλοί θα έχουν ίσως παρατηρήσει ότι τον τελευταίο καιρό το πράσινο σε αστικούς κήπους, παρτέρια, χαλάσματα, κατά μήκος λεωφόρων, πάρκα και όπου αλλού υπάρχει λίγο χώμα, αλλά ακόμα και ανάμεσα σε πλάκες πεζοδρομίων, μάρμαρα και το πιο σημαντικό σε αρχαιολογικούς χώρους, έχει αυξηθεί σημαντικά, ίσως για μεγάλη χαρά των Δημάρχων και των αυτοαποκαλούμενων «οικολόγων», χωρίς να έχει ξοδευτεί ούτε ένα €. Το πιο προσεκτικό μάτι ίσως θα έχει παρατηρήσει ότι το πράσινο αυτό οφείλεται στην ανάπτυξη ενός και μόνο είδους δένδρου του Αϊλανθου (*Ailanthus altissima*) γνωστού και ως βρωμοκαρυδιά ή βρωμούσα. Ασφαλώς και είναι όμορφο να ζεις σε ένα πράσινο περιβάλλον, στην περίπτωση όμως της βρωμοκαρυδιάς χρειάζεται πολύ προσοχή, όπως θα εξηγήσω παρακάτω.

Το χειρότερο είναι όταν διάφοροι «αδιάβαστοι» που μπορεί να είναι και υποτιθέμενοι ειδικοί επιστήμονες, προτείνουν τη χρήση του φυτού για αναδασώσεις ή ανάπλαση πρασίνου ή και προστασία των δασών από φωτιές.



Αυτό το δέντρο είναι περίπου δέκα ετών και έχει φτάσει το ύψος πέντε ορόφων, δηλαδή τα 15 m.

Το επιστημονικό όνομα της βρωμοκαρυδιάς, όπως έχει επικρατήσει να ονομάζεται στην Ελλάδα (προφανώς λόγω της έντονης δυσάρεστης μυρωδιάς του και την ομοιότητά της με την καρυδιά, για όσους έχουν πολύ φαντασία), είναι *Ailanthus altissima* ή *A. glandulosa* ενώ στις Αγγλόφωνες χώρες αναφέρεται ως Shumak tree ή Tree-of-heaven (δένδρο του Παράδεισου, λόγω της γρήγορης ανάπτυξής του σε ύψος).

Για την Ιστορία.

Ο Αϊλανθος προέρχεται από την Κίνα όπου είναι αυτοφυές το οποίο, αν και όχι και τόσο διαδεδομένο σ' αυτή τη χώρα, έχει εξαπλωθεί πολύ στην Αμερική και την Ευρώπη ενώ δεν υπάρχουν συγκεκριμένες πληροφορίες για τις άλλες ηπείρους. Τα ιστορικά δεδομένα ανα-

φέρουν ότι αρχικά το φυτό μεταφέρθηκε στη Μ. Βρετανία ως καλλωπιστικό και στη συνέχεια από εκεί μεταφέρθηκε το 1784 στη Φιλαδέλφεια από κάποιον κηπουρό. Το 1840 το φυτό ήταν ήδη αρκετά διαδεδομένο στις ΗΠΑ ως καλλωπιστικό και ήταν διαθέσιμο από φυτώρια. Σύμφωνα με ανεπιβεβαιώτες πληροφορίες, στην Ελλάδα ο Αϊλανθος φυτεύτηκε για πρώτη φορά στον Εθνικό κήπο (τότε Βασιλικό) από το Βασιλιά Όθωνα.

Αϊλανθος είναι και το δένδρο που αναφέρεται στο βιβλίο της Betty Smith «Ένα δένδρο γεννιέται στο Μπρούκλιν», όπου το δένδρο αυτό αναφέρεται ως πολύ ανθεκτικό.



Το φθονόπωρο τα θηλυκά φυτά έχουν ακόμα τα φύλλα τους μαζί με τους καρπούς που θα παραμείνουν όλο το χειμώνα, μέχρι την άνοιξη, οπότε και θα πέσουν.

Περιγραφή του φυτού:

Είναι δίοικο φυλλοβόλο δένδρο (υπάρχει δηλαδή αρσενικό και θηλυκό φυτό), ανήκει στην οικογένεια Simaroubaceae και μπορεί σε μερικά χρόνια να φτάσει σε ύψος 30 m (κάτι που το έχω διαπιστώσει με τα ίδια μου τα μάτια). Ο κορμός του είναι λείος φαιού χρώματος ενώ οι νεαροί βλαστοί έχουν καφεκόκκινο χρώμα. Τα φύλλα είναι μεγάλα σύνθετα που ξεπερνούν το 1 m σε μήκος αποτελούμενα από 11-25 αντίθετα διαταγμένα φυλλάρια. Κάθε φυλλάριο διαθέτει μια, μέχρι μερικές αδενώδεις τρίχες (μη ανθικά νεκτάρια). Την Άνοιξη το φυτό αναπτύσσει ταξιανθίες από μικρά κιτρινοπράσινα άνθη στις άκρες των βλαστών. Οι επίπεδοι περιστραμμένοι καρποί (σαμάρες) αναπτύσσονται στα θηλυκά φυτά το καλοκαίρι και παραμένουν στο φυτό για πολλούς μήνες (μέχρι την επόμενη άνοιξη). Η ελαφριά κατασκευή που διαθέτουν τους επιτρέπει να μεταφέρονται με τον άνεμο σε μεγάλες αποστάσεις. Έχει υπολογιστεί ότι ένα ενήλικο δένδρο μπορεί να παράγει μέχρι 325.000 σπέρματα το χρόνο. Το ξύλο της βρωμοκαρυδιάς είναι μαλακό και ημίλευκο προς ανοιχτό καστανό χρώμα το οποίο όμως δεν έχει καμιά ιδιαίτερη χρησιμότητα παρά μόνο για την παραγωγή κάρβουνου και αυτό κακής ποιότητας. Όλα τα μέρη του φυτού και ειδικότερα τα άνθη, αναδύουν δυνατή δυσοσμία ενώ δημιουργεί προβλήματα σε ότι βρίσκεται κάτω από το δένδρο (πεζοδρόμια, αυτοκίνητα, μπαλκόνια κλπ.) λόγω της κολλώδους ουσίας που παράγουν.

Η βρωμοκαρυδιά αναπαράγεται πολύ εύκολα είτε εγγενώς είτε αγενώς, δηλαδή είτε από σπέρματα είτε με μοσχεύματα. Το φυτό αυτό δεν έχει ιδιαίτερες απαιτήσεις σε θρεπτικά συστατικά ενώ μπορεί να αναπτύσσεται σε πολύ φτωχά εδάφη χωρίς πολλές απαιτήσεις σε νερό ενώ χρειάζεται πολύ φως. Η ανάγκη του σε φως καλύπτεται από την πολύ γρήγορη ανάπτυξη του έτσι που να επισκιάζει την υπόλοιπη βλάστηση.



Οι περίεργοι καρποί της βρωμοκαρυδιάς, που ονομάζονται σαμάρες, μπορούν να μεταφερθούν με τον αέρα για μεγάλες αποστάσεις.

Η εξάπλωσή του φυτού στην Ελλάδα.

Από όσο γνωρίζω δεν υπάρχει εμπεριστατωμένη μελέτη σχετικά με τους πληθυσμούς βρωμοκαρυδιάς στην Ελλάδα, θα έλεγα όμως ότι βρίσκεται σε όλες σχεδόν τις πόλεις λόγω του ότι το δένδρο αυτό φυτεύτηκε σε πάρκα και δρόμους ενώ είναι ήδη έντονη η παρουσία του κατά μήκος των εθνικών οδών και επαρχιακών δρόμων. Προσωπικά παρατήρησα συστάδες φυτών βρωμοκαρυδιάς ακόμα και σε απομακρυσμένες χαράδρες της Λακωνίας (καλοκαίρι 2006). Σε ορισμένους απεριποίητους δρόμους στις νησίδες και στις άκριες των δρόμων της Αθήνας και στα περίχωρά της, δε θα ήταν υπερβολή αν λέγαμε ότι ο πληθυσμός της βρωμοκαρυδιάς αποτελεί το κυρίαρχο είδος.



Λεπτομέρεια και μέγεθος του καρπού της βρωμοκαρυδιάς.

Πλησιάζοντας στη Θεσσαλονίκη από την Αθήνα, οι βρωμοκαρυδιές εμφανίζονται μερικά χιλιόμετρα έξω από την πόλη.

Στον κόμβο της Μαλακάσας η βρωμοκαρυδιά έχει πλέον διεισδύσει στο πευκοδάσος.

Το καλοκαίρι του 2008 με λύπη μου διαπίστωσα την ύπαρξη, ευτυχώς μόνο μερικών δεκάδων δένδρων, στην πανέμορφη Τζιά κοντά στον όρμο Οτζιά, όπου προφανώς κάποιος τις φύτεψε χωρίς βέβαια να γνωρίζει τις συνέπειες. Ας μην ξεχνάμε ότι μεγάλο μέρος του νησιού έχει

ενταχθεί στο πρόγραμμα Natura, λόγω της πλούσιας και μοναδικής του βλάστησης (πολλά ενδημικά φυτά).

Πρέπει να σημειωθεί ότι το φυτό, σύμφωνα με μελέτες που έχουν γίνει, είναι πολύ ανθεκτικό στη ατμοσφαιρική, χημική και σωματιδιακή ρύπανση.

Από οικολογικής πλευράς αναφέρεται ως πολύ επιθετικό είδος και όπου φυτρώσει σύντομα γίνεται το επικρατές είδος σχηματίζοντας αδιαπέραστες συστάδες.

Έχει αποδειχθεί επιστημονικά ότι η βρωμοκαρυδιά παράγει τοξικές ουσίες (κουασσινοειδή) που παρεμποδίζουν την ανάπτυξη άλλων φυτών, ένα φαινόμενο γνωστό ως αλληλοπάθεια. Το ριζικό σύστημα είναι πολύ επιθετικό και μπορεί να προκαλέσει καταστροφές σε θεμέλια και υπόγειες σωληνώσεις, όπως αποχετεύσεις σωλήνες ύδρευσης ή καλώδια τηλεφώνου και παροχής ηλεκτρικού ρεύματος.

Ιδιαίτερα καταστροφική είναι η δράση του σε αρχαιολογικούς χώρους και άλλα διατηρητέα κτίρια κυρίως λόγω της ικανότητας που έχει να αναπτύσσεται σε φτωχά εδάφη αλλά όπου υπάρχει άπλετο φως.



Αυτή η πανέμορφη μαρμάρινη βρύση, η μοναδική μαρμάρινη βρύση που έχει απομείνει στην Αθήνα από την τουρκοκρατία, απομεινάρι του κτήματος του βοεβόδα της Αθήνας Χασεκή, κοσμεί τον κήπο του Γεωπονικού Πανεπιστημίου της Αθήνας. Όπως όμως και πολλά άλλα ιστορικά μνημεία της χώρας μας έχει δεχτεί και αυτό την επίθεση της βρωμοκαρυδιάς. Φυσικά την ξερίζωσα μετά τη φωτογράφιση.



15/07/2009 Δεν πέρασαν δέκα μήνες και η βρωμοκαρυδιά της βρύσης ξαναφύτρωσε. Αυτή τη φορά συνοδευόμενη από το περδικούλι (*Parietaria judaica*).

Πιθανά προβλήματα υγείας που δημιουργεί στον άνθρωπο και στα ζώα.

Εκτός από τα οικολογικά προβλήματα έχουν αναφερθεί και προβλήματα υγείας που προκαλεί ο Αϊλανθος στον άνθρωπο. Έχει αναφερθεί ότι σε υπαλλήλους επιφορτισμένους με την κοπή αυτών των δένδρων εμφανίστηκε μυοκαρδίτιδα η οποία οφειλόταν στην επαφή πληγών από τριβή στο δέρμα με τον οπό των δένδρων.

Το φυτό αναφέρεται ως αλλεργιογόνο για τον άνθρωπο.

Η βιβλιογραφία επίσης αναφέρει ότι οι μέλισσες επισκέπτονται τα άνθη της βρωμοκαρυδιάς για τη συλλογή νέκταρος με αποτέλεσμα το μέλι να αποκτά άσχημα γεύση και οσμή τα οποία όμως ύστερα από κάποιο χρονικό διάστημα εξαφανίζονται. Δεν υπάρχουν όμως άλλες μελέτες σχετικά με το ενδεχόμενο ύπαρξης κουασσινοειδών στο μέλι.

Οι χημικές ενώσεις που είναι γνωστές με το όνομα κουασσινοειδή (quassinoids) έχουν εντοπισθεί και σε άλλα είδη της οικ. Simarubaceae και σε αυτά αποδίδονται θεραπευτικές ιδιότητες όπως η καταπολέμηση όγκων και η δράση τους ως ανθελονοσιακά, αντιφλεγμονώδη, εντομοκτόνα, αμοιβαδοκτόνα και ζιζανιοκτόνα.

Είναι όμως προτιμότερο να αφεθεί αυτός ο τομές στου επιστήμονες - ερευνητές παρά να αρχίσουμε να πίνουμε αφεψήματα από βρωμοκαρυδιά (βρωμοκαρυδοφραπεδιά;).

Το πρόβλημα.

Η βρωμοκαρυδιά παράγει μεγάλο αριθμό σπερμάτων (σάμαρα) με πολύ μεγάλη βλαστητική ικανότητα και τα οποία βλαστάνουν κάτω από σχεδόν οποιεσδήποτε συνθήκες και διαφορετικά εδάφη, φτωχά ή πλούσια με αποτέλεσμα να παραγκωνίζουν την τοπική βλάστηση είτε αυτή είναι φυσική είτε τεχνητή σε κήπους, παρτέρια, πάρκα κλπ.

Το φυτό αναπτύσσεται από το Μάιο μέχρι λίγο πριν αρχίσει να ρίχνει τα φύλλα του, δηλαδή τον Οκτώβριο ή ακόμα και Νοέμβριο, ανάλογα με την περιοχή και τις κλιματολογικές συνθήκες. Ο ρυθμός ανάπτυξης του φυτού είναι τρομακτικός κυρίως στα νεαρά φυτά ηλικίας ενός έως δυο ετών, στην προσπάθεια τους να επικρατήσουν στο περιβάλλον, αναπτύσσονται με ρυθμούς που εγώ μέτρησα να φτάνουν το 1.5 m σε διάστημα ενός μηνός (!) όπως προσωπικά μέτρησα στον περίβολο του Γεωπονικού Πανεπιστημίου Αθηνών και σε περιβάλλον το οποίο δεν θα θεωρούσα ιδιαίτερα φιλόξενο, όπως ανάμεσα σε πλάκες πεζοδρομίου.

Η ρητίνη του φυτού χρησιμοποιείται ως λιβάνι στους Ινδουιστικούς Ναούς.

Το φυτό δεν έχει φυσικούς εχθρούς ούτε και στην πατρίδα του την Κίνα, όπου όμως βρίσκεται σε ισορροπία με τους άλλους οργανισμούς του οικοσυστήματος.

Φυτά που προτείνονται σε αντικατάσταση του Αϊλανθου.

Ο κατάλογος των φυτών που θα μπορούσαν να αντικαταστήσουν τον Αϊλανθο θα μπορούσε να είναι πολύ μεγάλος. Δεν υπάρχει κανένας ιδιαίτερος λόγος να καταφεύγουμε σε φυτικά είδη που έχουν εισαχθεί στη χώρα μας τη στιγμή που υπάρχουν πολλά ενδημικά φυτά για τα οποία μάλιστα υπάρχουν και εμπεριστατωμένες μελέτες σχετικά με την ανθεκτικότητά τους στις κλιματολογικές ιδιαιτερότητες που επικρατούν στην Ελλάδα καθώς επίσης και στη ρύπανση, αν πρόκειται για αστικές περιοχές. Βεβαίως τα περισσότερα από αυτά τα είδη δεν έχουν την ίδια ταχύτητα ανάπτυξης και ευκολία καλλιέργειας με τον Αϊλανθο. Αν όμως δεν

θέλουμε σε 50 χρόνια η Ελλάδα να είναι ένα απέραντο δάσος από Αϊλανθους με τα ενδημικά φυτά να σπανίζουν ή να είναι προστατευόμενα είδη σε Βοτανικούς κήπου και Μουσεία, τώρα είναι η κατάλληλη εποχή να δράσουμε.

Δεν βρίσκω τίποτα κακό στο να φυτέψουμε ελιές, χαρουπιές, δάφνες και πολλά άλλα από τα φυτά της Ελληνικής φύσης.

Τρόποι αντιμετώπισης.

Το φυτό είναι «επικηρυγμένο» στις ΗΠΑ και οι δασικές υπηρεσίες εκεί προσπαθούν εδώ και αρκετά χρόνια να αντιμετωπίσουν το πρόβλημα με συνδυασμό διαφόρων τρόπων.

Για τη χώρα μας χρειάζεται πρώτα απ' όλα ενημέρωση των Υπηρεσιών πάρκων και κήπων των Δήμων σε όλη τη χώρα αλλά και του κοινού από επιστήμονες Οικολόγους [\[1\]](#) (Γεωπόνοους, Βιολόγους, Δασοπόνους) που γνωρίζουν τα προβλήματα του περιβάλλοντος περισσότερο από οποιονδήποτε άλλο.

- Να ενημερωθεί το κοινό ώστε να αναγνωρίζει το φυτό.
- Να απαγορευτεί η καλλιέργεια και διάθεση του φυτού από φυτώρια.
- Να πεισθούν οι τοπικές αρχές για τους κινδύνους που ελλοχεύουν και να λάβουν τα κατάλληλα μέτρα, έστω και αν αυτό σημαίνει μείωση του αστικού και περιαστικού πράσινου.
- Να συνειδητοποιήσει το κοινό ότι το συγκεκριμένο φυτό πρέπει να ξεριζώνεται σε πολύ μικρή ηλικία και στη θέση του να φυτεύουμε κάποιο άλλο.
- Όπου το φυτό έχει αναπτυχθεί υπέρμετρα (πολλά δένδρα) είναι σκόπιμο να κοπούν μόνο τα θηλυκά.

Θα πρέπει επίσης να ενημερωθεί το κοινό για τα πραγματικά προβλήματα που προκαλεί το δένδρο και να είναι σε θέση να το αναγνωρίζει. Θα πρέπει το κοινό να πεισθεί για τους πραγματικούς κινδύνους για το περιβάλλον αλλά ενδεχομένως και για την ίδια του την υγεία, χωρίς υστερίες και πανικό. Μια επίσκεψη στους δικτυακούς τόπους που αναφέρονται στη βιβλιογραφία στο τέλος του άρθρου, είναι αρκετή για να πείσει και τον πιο δύσπιστο.

Προσοχή όμως γιατί υπάρχουν και άλλα δένδρα που έχουν κάποιες ομοιότητες με τον Αϊλανθο. Αδιαμφισβήτητο χαρακτηριστικό του Αϊλανθου είναι οι καρποί του (σπόροι) οι οποίοι κρέμονται από το δένδρο σε τσαμπιά που αποτελούνται από μερικές εκατοντάδες σπέρματα τα οποία είναι λεπτά, λεπιοειδή και λίγο στριφτά μήκους περίπου 3 cm και πλάτος 1 cm με ένα σπέρμα στο μέσον (θυμίζουν λίγο τα σπέρματα του πεύκου με το πτερύγιο, αλλά με το σπέρμα στο κέντρο του περυγίου). Τα σπέρματα παραμένουν στα θηλυκά δένδρα όλο το χειμώνα και πέφτουν από την επόμενη άνοιξη, οπότε είναι και ώριμα για να βλαστήσουν.

ΠΡΟΣΟΧΗ: κατά την κοπή των δένδρων να χρησιμοποιούνται χονδρά αδιάβροχα γάντια , κυρίως αν υπάρχουν μικροτραυματισμοί στα χέρια.

Το φυτό είναι πιο εύκολο να καταπολεμηθεί όταν είναι ακόμα πολύ μικρό, μερικών μηνών, με το να το ξεριζώσουμε. Η συνεχής εκρίζωση και κοπή των δενδρυλλίων είναι η πιο ενδεδειγμένη μέθοδος δεδομένου ότι δεν επιβαρύνεται το περιβάλλον με χημικές ουσίες.

Τα μεγάλα δένδρα είναι ανώφελο απλά να τα κόβουμε αφού σε ελάχιστο χρόνο θα έχουν ξαναφυτρώσει. Εδώ απαιτείται η συνδρομή ειδικών όπου μετά την κοπή του δένδρου ο κομμένος κορμός στο έδαφος θα πρέπει να εμβολιαστεί με ειδικές σύριγγες με ζιζανιοκτόνα τα οποία δρουν στις ρίζες. Η μέθοδος αυτή προτιμάται από τη διάβρεξη του εδάφους με ζιζανιοκτόνα δεδομένου ότι είναι πιο αποτελεσματική, απαιτεί λιγότερη ποσότητα ζιζανιοκτόνου και δρα μόνο στο συγκεκριμένο φυτό.

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<http://www.invasive.org/search/action.cfm?q=Ailanthus%20altissima>

<http://www.lib.uconn.edu/webapps/ipane/browsing.cfm?descriptionid=30>

[1] Η Οικολογία είναι και αυτή μια επιστήμη παρόλο που το νόημα της λέξης έχει αλλοιωθεί και χρησιμοποιείται πλέον με την πολύ πλατιά έννοια αποκαλώντας οικολόγο του ανθρώπου που «αγαπάει» το περιβάλλον ενώ παράλληλα το νόημα του όρου σε πολλές περιπτώσεις έχει εντελώς αλλοιωθεί π.χ. Κόμμα οικολόγων, οικολογικά προϊόντα, μέχρι και οικολογικά σουβλάκια! (εννοώντας χωρίς κρέας!!!).

ΠΡΟΣΟΧΗ ΣΤΗ ΧΡΗΣΗ ΤΟΥ GARLON (δραστική ουσία tryclopyr) ΓΙΑΤΙ ΠΡΟΚΕΙΤΑΙ ΓΙΑ ΠΟΛΥ ΙΣΧΥΡΗ ΚΑΙ ΓΕΝΙΚΑ ΕΠΙΒΛΑΒΗ ΓΙΑ ΤΟ ΠΕΡΙΒΑΛΛΟΝ ΟΥΣΙΑ ΑΝ ΔΕΝ ΧΡΗΣΙΜΟΠΟΙΗΘΕΙ ΣΩΣΤΑ ΚΑΙ ΜΕ ΦΕΙΔΩ, ΜΟΝΟ ΓΙΑ ΤΗΝ ΚΑΤΑΠΟΛΕΜΗΣΗ ΤΗΣ ΒΡΩΜΟΚΑΡΥΔΙΑΣ. ΔΙΑΒΑΣΤΕ ΜΕ ΠΡΟΣΟΧΗ ΤΙΣ ΟΔΗΓΙΕΣ ΧΡΗΣΗΣ (ΓΑΝΤΙΑ, ΜΑΣΚΑ, ΕΡΓΑΛΕΙΑ, ΠΡΟΦΥΛΑΞΕΙΣ κλπ.) !!!

ΕΙΝΑΙ ΔΥΣΤΥΧΩΣ ΣΧΕΔΟΝ ΤΟ ΜΟΝΟ ΖΗΖΑΝΙΟΚΤΩΝΟ ΠΟΥ ΜΠΟΡΕΙ ΝΑ ΚΑΤΑΠΟΛΕΜΗΣΕΙ ΤΗΝ ΒΡΩΜΟΚΑΡΥΔΙΑ, ΤΟΣΟ ΣΑΝ ΜΙΚΡΟ ΌΣΟ ΚΑΙ ΣΑΝ ΜΕΓΑΛΟ ΔΕΝΔΡΟ.

GARLON® 4EC

Δοσολογία

Βάτα: αναμίξτε 150 - 200 κ.εκ. Garlon 4EC σε 100 λίτρα νερού και ψεκάστε.
Πουρνάρια και άλλα ξυλώδη: αναμίξτε 250 - 750 κ.εκ. σε 100 λίτρα νερού ανάλογα με το είδος και την ανάπτυξη του φυτού.



Τρόπος και χρόνος εφαρμογής

Ραντίστε όταν το φύλλωμα αναπτυχθεί τελείως ώστε να κατεβαίνουν στις ρίζες αρκετοί χυμοί (στους θάμνους και τα δένδρα από μέσα Μαΐου μέχρι μέσα Οκτωβρίου). Λούστε καλά φύλλωμα και κλαδιά μέχρι τη βάση, αποφύγετε όμως την υπερβολική διαρροή ψεκαστικού υγρού στο έδαφος, γι' αυτό ψεκάστε μέχρι πρώτης απορροής.



Αψέκαστο



Ψεκασμένο με Garlon 4EC

Τρόποι χρήσης της δραστικής ουσίας **triclopyr για την καταστροφή δέντρων και θάμνων σύμφωνα με τις οδηγίες σε άλλες Ευρωπαϊκές χώρες.**

Εφαρμογή στη βάση του δέντρου

Το σκεύασμα triclopyr διαλύεται σε πετρέλαιο ή παραφινικό λάδι σε αναλογία 1:1 και εφαρμόζεται με έγχυση σε τρύπες που έχουν ανοιχθεί στη βάση του δέντρου με κατεύθυνση προς τις ρίζες του.

Εποχή εφαρμογής:
Καλοκαίρι - νωρίς το
φθινόπωρο

Περιφερειακή τομή στον κορμό

Χαράσσουμε με τσεκούρι περιφερειακά τον φλοιό με κατεύθυνση από πάνω προς τα κάτω. Δημιουργείται έτσι ένα «δακτυλίδι» μέσα στο οποίο περιχύνουμε διάλυμα σκευάσματος triclopyr 48% β/ο σε αναλογία 750 κ.εκ./100 λίτρα νερό.

χωρίς αραίωση για βρωμοκαρυδιά

Σε κομμένους κορμούς

Εφαρμόζουμε το σκεύασμα triclopyr επάνω στην τομή διαλυμένο σε πετρέλαιο ή παραφινικό λάδι, σε αναλογία 1:1, όσο χρόνο η τομή είναι πρόσφατη και πριν δημιουργηθεί επουλωτικός ιστός.

Η τεχνική αυτή εφαρμόζεται όλες τις εποχές εκτός από την άνοιξη που υπάρχουν χυμοί.



GARLON® 4EC

Δραστική ουσία: Triclopyr 48% β/ο

Μορφή: Υγρό γαλακτωματοποιήσιμο



ΦΥΛΑΞΤΕ ΤΟ ΚΛΕΙΔΩΜΕΝΟ ΚΑΙ ΜΑΚΡΙΑ ΑΠΟ ΠΑΙΔΙΑ

ΑΠΑΓΟΡΕΥΕΤΑΙ Η ΕΦΑΡΜΟΓΗ ΜΕ ΑΕΡΟΣΦΕΚΑΣΜΟΥΣ

ΑΠΑΓΟΡΕΥΕΤΑΙ Η ΠΩΛΗΣΗ ΤΟΥ ΣΕ ΕΡΑΣΙΤΕΧΝΕΣ

Η χρήση φυτοπροστατευτικών προϊόντων πρέπει να γίνεται σύμφωνα με τις οδηγίες της ετικέτας.

Για αυτό πριν τη χρήση διαβάστε προσεκτικά την ετικέτα του προϊόντος.

Xn



ΕΠΙΒΛΑΒΕΣ

- Επιβλαβές σε περίπτωση κατάποσης.
- Ερεθίζει το δέρμα.
- Μπορεί να προκαλέσει ευαισθητοποίηση σε επαφή με το δέρμα.
- Επιβλαβές: μπορεί να προκαλέσει ζημιά στους πνεύμονες σε περίπτωση κατάποσης.

N



Επικίνδυνο για το περιβάλλον

- Πολύ τοξικό για τους υδρόβιους οργανισμούς, μπορεί να προκαλέσει μακροχρόνιες δυσμενείς επιπτώσεις στο υδάτινο περιβάλλον.
- Μη μολύνετε τα νερά με το σκεύασμα ή τη συσκευασία του.
- Σχετικά μη τοξικό για τις μέλισσες.
- Μπορεί να χρησιμοποιείται γύρω από τις μέλισσες με ελάχιστες ζημιές.

Για ν' αποφύγετε κινδύνους για την ανθρώπινη υγεία και το περιβάλλον ακολουθείστε τις οδηγίες χρήσης.



Αρ. έγκρ. κυκλοφορίας: 7214/26-02-80



ΕΛΑΝΚΟ ΕΛΛΑΣ

ΕΛΑΝΚΟ ΕΛΛΑΣ Α.Ε.Β.Ε.

ΑΘΗΝΑ: Μεσογείων 335

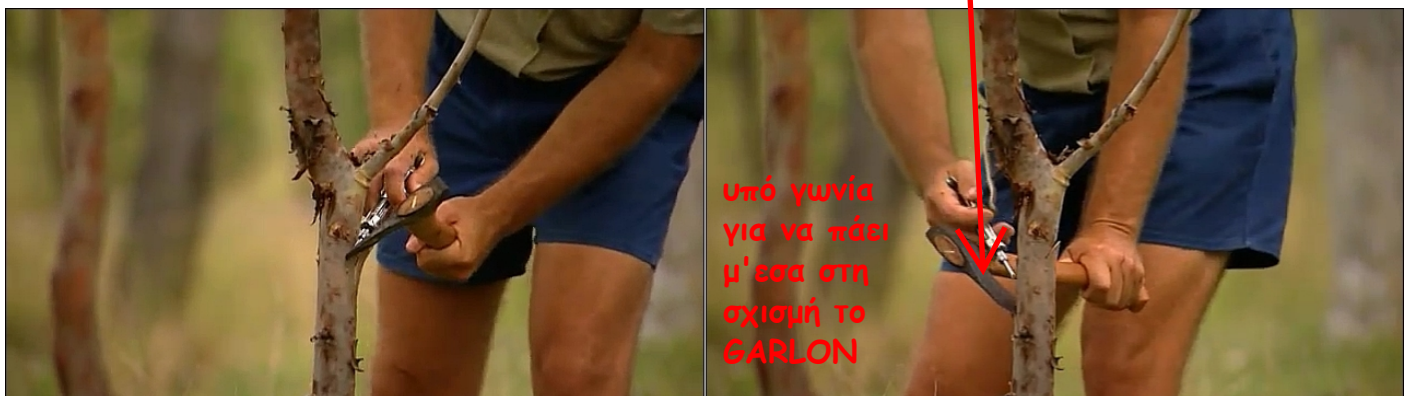
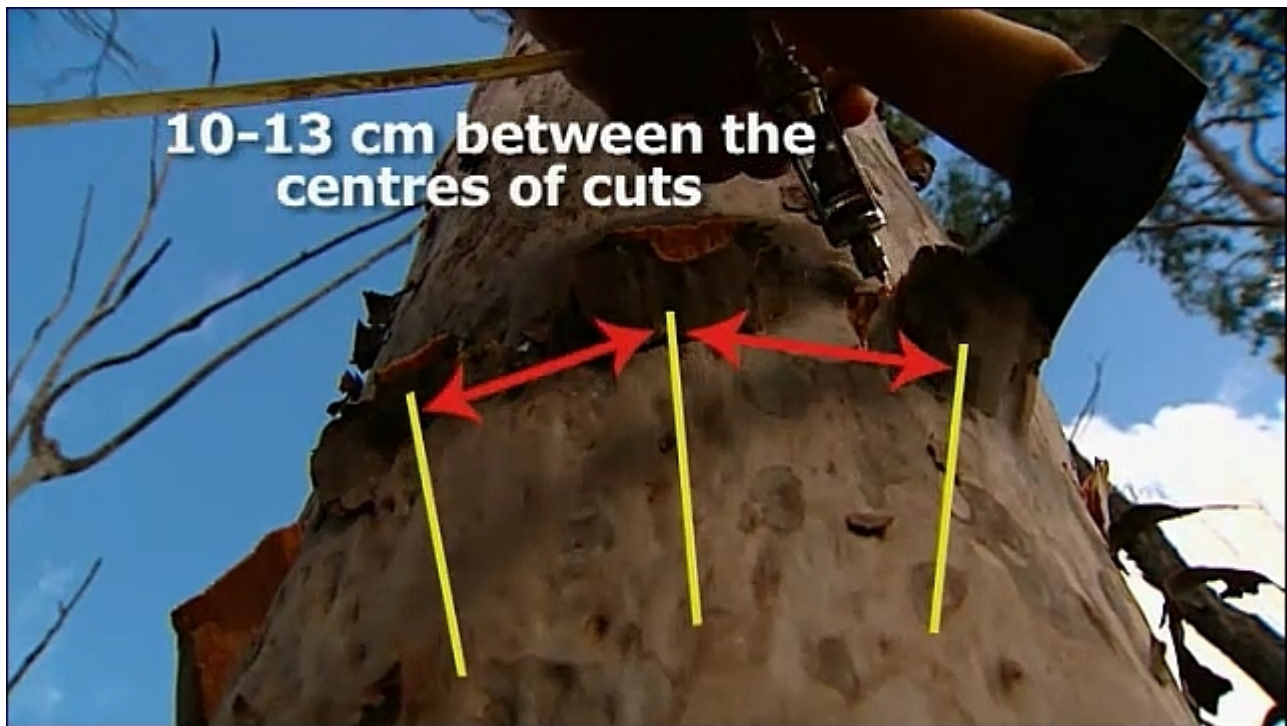
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**Χρησιμοποιείστε ΓΑΝΤΙΑ, ΜΑΣΚΑ και ΣΩΣΤΗ ΕΝΔΥΜΑΣΙΑ,
οι φωτό είναι μόνο για την οπτικοποίηση της μεθόδου επέμβασης και της χρήσης/τύπου των εργαλείων !!!**



ΠΕΡΙΣΣΟΤΕΡΕΣ ΠΛΗΡΟΦΟΡΙΕΣ ΓΙΑ ΤΗΝ ΔΡΑΣΤΙΚΗ ΟΥΣΙΑ ΠΟΥ ΕΧΕΙ ΤΟ GARLON TRICLOPYR

M. Tu, C. Hurd, R. Robison & J.M. Randall

Herbicide Basics

Chemical formula: [(3,5,6-trichloro-2-pyridinyl)oxy] acetic acid

Herbicide Family:
Pyridine (Picolinic acid)

Target Species: Broadleaf herbs and woody species

Forms: salt & ester

Formulations: EC, SL

Mode of Action: Auxin mimic

Water solubility: 430 ppm (acid), 23 mg/L (ester), 2,100,000 mg/L (salt)

Adsorption potential:
Intermediate (higher for ester than salt)

Primary degradation mech:
Microbial metabolism, photolysis, and hydrolysis

Average Soil Half-life: 30 days

Mobility Potential: Intermediate

Dermal LD50 for rabbits:
>2,000 mg/kg

Oral LD50 for rats:
713 mg/kg

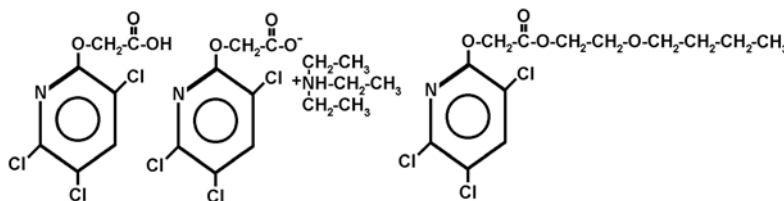
LC50 for bluegill sunfish:
148 mg/L

Trade Names: Garlon® and Access®

Manufacturers: Dow Agro-Sciences and Platte

Synopsis

Triclopyr is a selective systemic herbicide used to control woody and herbaceous broadleaf plants along right-of-ways, in forests, and in grasslands and parklands. It has little or no impact on grasses. Triclopyr controls target weeds by mimicking the plant hormone auxin, causing uncontrolled plant growth. There are two basic formulations of triclopyr - a triethylamine salt, and a butoxyethyl ester. In soils, both formulations degrade to the parent compound, triclopyr acid. Degradation occurs primarily through microbial metabolism, but photolysis and hydrolysis can be important as well. The average half-life of triclopyr acid in soils is 30 days. Offsite movement through surface or sub-surface runoff is a possibility with triclopyr acid, as it is relatively persistent and has only moderate rates of adsorption to soil particles. In water, the salt formulation is soluble, and with adequate sunlight, may degrade in several hours. The ester is not water-soluble and can take significantly longer to degrade. It can bind with the organic fraction of the water column and be transported to the sediments. Both the salt and ester formulations are relatively non-toxic to terrestrial vertebrates and invertebrates. The ester formulation, however, can be extremely toxic to fish and aquatic invertebrates. Because the salt cannot readily penetrate plant cuticles, it is best used as part of a cut-stump treatment or with an effective surfactant. The ester can be highly volatile and is best applied at cool temperatures on days with no wind. The salt formulation (Garlon 3A®) can cause severe eye damage.



Triclopyr acid

Triethylamine salt

Butoxyethyl ester

Herbicide Details

Chemical Formula: [(3,5,6-trichloro-2-pyridinyl)oxy]acetic acid

Trade Names: There are two basic formulations of triclopyr: a triethylamine salt (triclopyr amine or salt), and a butoxyethyl ester (triclopyr ester). The amine formulation is sold under the trade name Garlon 3A[®] and is marketed in garden shops and hardware stores as Turflon Amine[®] or as Brush-B-Gone[®]. The ester formulation is sold under the trade name Garlon 4[®] and is marketed in garden shops and hardware stores as Turflon Ester[®]. Other trade names include Access[®], Crossbow[®], ET[®], PathFinder II[®], Redeem[®], and Remedy[®]. These products also may be mixed with picloram or 2,4-D to increase their versatility.

Manufacturers: Dow Agrosiences (formerly known as DowElanco or Dow Chemical), Platte

Use Against Natural Area Weeds: Triclopyr is used to control broadleaf herbs and woody species (WSSA 1994). It is particularly effective at controlling woody species with cut-stump or basal bark treatments. Susceptible species include the brooms (*Cytisus* spp., *Genista* spp., and *Spartium* spp.), the gorses (*Ulex* spp.), and fennel (*Foeniculum vulgare*). Triclopyr ester formulations are especially effective against root- or stem-sprouting species such as buckthorns (*Rhamnus* spp.), ash (*Fraxinus* spp.), and black locust (*Robinia pseudoacacia*), because triclopyr remains persistent in plants until they die.

Even though offsite movement of triclopyr acid through surface or sub-surface runoff is a possibility, triclopyr is one of the most commonly used herbicides against woody species in natural areas. Bill Neil, who has worked extensively on tamarisk/saltcedar (*Tamarix* spp.) control, concluded that Pathfinder II[®], a triclopyr ester formulation by DowElanco, is the most cost effective herbicide for combating saltcedar. **On preserves across the U.S., triclopyr has provided good control of tree-of-heaven (*Ailanthus altissima*)**, salt cedar (*Tamarix* spp.), glossy buckthorn (*Frangula alnus*), common buckthorn (*Rhamnus cathartica*), sweet fennel (*Foeniculum vulgare*), Brazilian peppertree (*Schinus terebinthifolius*), and Chinese tallow tree (*Sapium sebiferum*). TNC preserves in Hawaii have successfully used triclopyr to control blackwood acacia (*Acacia melanoxylon*), bush honeysuckle (*Lonicera maackii*), Chinese banyan (*Ficus microcarpa*), corkystem passionflower (*Passiflora suberosa*), eucalyptus (*Eucalyptus globulus*), Florida prickly blackberry (*Rubus argutus*), Mexican weeping pine (*Pinus patula*), Monterey pine (*Pinus radiata*), strawberry guava (*Psidium cattleianum*), tropical ash (*Fraxinus uhdei*), and velvet leaf (*Miconia calvenscens*). Triclopyr can also be used in forest plantations to control brush without significant impacts to conifers (Kelpsas & White). Spruces (*Picea* spp.) can tolerate triclopyr, but some species of pine (*Pinus* spp.) however, can only tolerate triclopyr during the dormant fall and winter months (Jotcham et al. 1989).

Mode of Action: Triclopyr is an auxin mimic or synthetic auxin. This type of herbicide kills the target weed by mimicking the plant growth hormone auxin (indole acetic acid), and when administered at effective doses, causes uncontrolled and disorganized plant growth that leads to plant death. The exact mode of action of triclopyr has not been fully described, but it is believed to acidify and “loosen” cell walls, allowing cells to expand without normal control and

coordination. Low concentrations of triclopyr can stimulate RNA, DNA, and protein synthesis leading to uncontrolled cell division and growth, and, ultimately, vascular tissue destruction. Conversely, high concentrations of triclopyr can inhibit cell division and growth.

Dissipation Mechanisms:

Summary: Both the ester and amine formulations are degraded by sunlight, microbial metabolism, and hydrolysis. In soils, both the ester and amine formulations will degrade rapidly to the parent compound, triclopyr acid. The acid and ester formulations bind well with soils, and therefore, are not likely to be mobile in the environment. The salt however, does not readily adsorb and can be mobile. The ester can be highly volatile (T. Lanini, pers. com.).

Volatilization

Ester formulations of triclopyr can be highly volatile, and care should be taken in their application. The potential to volatilize increases with increasing temperature, increasing soil moisture, and decreasing clay and organic matter content (Helling et al. 1971).

Photodegradation

Both the ester and salt formulations are degraded readily in sunlight to the parent compound, triclopyr acid, which is also photodegradable. A study of photolysis found the half-life of triclopyr acid on soil under midsummer sun was two hours (McCall & Gavit 1986). Photodegradation can be particularly important in water. Johnson et al. (1995) found triclopyr acid dissolved in water had a half-life due to photolysis of one to 12 hours.

Microbial Degradation

Microbial metabolism accounts for a significant percentage of triclopyr degradation in soils. In general, warm, moist soils with a high organic content will support the largest microbial populations and the highest rates of herbicide metabolism (Newton et al. 1990). Johnson et al. (1995a) found that microbial degradation of triclopyr was significantly higher in moist versus dry soils, and higher at 30° C than at 15° C (DT50 is 46 days versus 98 days in dry soils, and 57 days versus 199 days in moist soils, respectively). Additionally, the presence of sunlight plays a role in the rates of microbial metabolism of triclopyr. Johnson et al. (1995a) found that microbial metabolism was slowed when soil was deprived of light.

Chemical Decomposition

Hydrolysis of both the salt and ester to the acid form occurs readily in the environment and within plants (Smith 1976). McCall and Gavit (1986) reported that the ester was converted to an acid with a half-life of three hours, and that the rate of hydrolysis in water increased with an increase in pH.

Adsorption

Adsorption temporarily or permanently immobilizes triclopyr, but adsorption is not degradation. Adsorption is more important for the immobilization of the ester than of the salt formulation. The ester binds readily with the organic component of the soil, with adsorption rates increasing as organic content increases and soil pH decreases (Pusino et al. 1994; Johnson et al. 1995a). The salt form is soluble in water and binds only weakly with soil (McCall & Gavit 1986). The

strong bond between the ester and soils accounts for the relatively low mobility of the ester in soils, whereas the salt form is much more mobile (McCall & Gavit 1986). In practice, however, both compounds are degraded rapidly to triclopyr acid, which has an intermediate adsorption capacity.

Behavior in the Environment

Summary: In soils, both formulations are degraded by photolysis, microbial metabolism, and hydrolysis to the parent compound, triclopyr acid. Triclopyr acid has an intermediate adsorption potential, limiting movement of the acid in the environment. The acid degrades with an average half-life of 30 days. In water, the salt will remain in the water column until it is degraded, which can occur in as little as a few hours under favorable conditions. The ester formulation, however, is not water-soluble and can take significantly longer to degrade in water. Within plants, both the salt and ester formulations are hydrolyzed to the acid form, and transported through the plant. Residues can persist in the plant until the tissues are degraded in the environment.

Soils

Both the ester and salt formulations degrade rapidly in soils to triclopyr acid, and thereafter, behave similarly in soils. Adsorption, photodegradation, microbial metabolism, and volatility, can all play a role in the dissipation of triclopyr from soils. The reported half-life of triclopyr in soils varies from 3.7 to 314 days, but averages 30 days, depending on the formulation applied and the specific soil and environmental conditions. If soil conditions are warm and moist, microbial metabolism can be the primary means of degradation (Newton et al. 1990).

Johnson et al. (1995a) reported an average half-life of triclopyr acid in four laboratory soils of 138 days, but this time varied significantly with soil temperature. At 15°C half-lives ranged from 64-314 days, while at 30°C half-lives were 9-135 days (Johnson et al. 1995). In Southwest Oregon, Newton et al. (1990) found 24-51% of triclopyr residues remained after 37 days in a dry and cool climate. Following an increase in warmth and moisture, however, dissipation increased dramatically and triclopyr residues exhibited a half-life of 11-25 days. In a study of triclopyr persistence in soil and water associated with rice production, triclopyr had a half-life of less than ten days in the three soil types tested (Johnson et al. 1995b). In a pasture near Corvallis, Oregon, the half-life of triclopyr acid was estimated to be 3.7 days (Norris et al. 1987).

Because of the importance of photodegradation and a decrease in the size of microbial populations with soil depth, triclopyr located deeper in the soil column (>15 cm) degrades more slowly than residues near the surface (Johnson et al. 1995a). Traces of triclopyr residues have been found at soil depths of 45 cm as late as 477 days after application (Newton et al. 1990). Sandy soils that are highly permeable may therefore, retain triclopyr longer. Most studies, however, found that triclopyr generally does not tend to move in significant quantities below the top 15 cm of soil (Norris et al. 1987; Newton et al. 1990; Stephenson 1990; Johnson et al. 1995a).

Water

In water, the two formulations can behave very differently. The water-soluble salt is degraded in the water column through photolysis and hydrolysis (McCall & Gavit 1985). The ester, however, is not water-soluble and can be persistent in aquatic environments. The ester binds to organic particles in the water column and precipitates to the sediment layers (McCall & Gavit 1986). Bound ester molecules will degrade through hydrolysis or photolysis to triclopyr acid (Smith 1976), which will move back into the water column and continue to degrade. The rate of degradation is dependent on the water temperature, pH, and sediment content.

Triclopyr acid has an intermediate soil adsorption capacity. Thus, movement of small amounts of triclopyr residues following the first significant rainfall are likely (McCall & Gavit 1986), but further leaching is believed to be minor (Newton et al. 1990; Stephenson et al. 1990; Thompson et al. 1991). Movement of triclopyr through surface and subsurface runoff in areas with minimal rainfall is believed to be negligible (Newton et al. 1990; Stephenson et al. 1990). In southwest Oregon, Norris et al. (1987) found that neither leaching nor long-distance overland water flow contributed significant amounts of the herbicide into a nearby stream, and concluded that the use of triclopyr posed little risk for non-target organisms or downstream water users. Triclopyr can, however, enter waterways via aerial drift and inadvertent overspray. When the acid was applied to rice paddy fields, residues remained in the water column and were not found in significant amounts in the soil (Johnson et al. 1995b). Degradation in water was rapid and showed a half-life of four days.

Vegetation

Both the ester and salt formulations are hydrolyzed to the acid after entering plant tissue. The acid tends to remain in plants until they die or drop leaves and begin to decay (Newton et al. 1990). Newton et al. (1990) reported that triclopyr in evergreen foliage and twigs showed remarkable persistence. Although concentrations of triclopyr in the soil will decrease quickly and remain low through the winter, levels can rise again in the spring if a new supply of contaminated foliage falls from defoliating crowns (Newton et al. 1990). The residues of some herbicides in fruit have been shown to persist up to one month (Holmes et al. 1994). There is therefore a potential for long-term exposure of triclopyr to animal species that eat wild fruit. In non-target plants, triclopyr soil residues can cause damage via root uptake (Newton et al. 1990).

Environmental Toxicity

Birds and Mammals

Triclopyr is regarded as only slightly toxic to birds and mammals. The oral LD50 for rats is 630-729 mg/kg. The LD50s for mallard ducks and bobwhite quail are 1,698 mg/kg and 2,935 mg/kg, respectively. Newton et al. (1990) predicted that triclopyr would not be present in animal forage in doses large enough to cause either acute or chronic effects to wildlife, and concluded that the tendency for triclopyr to dissipate quickly in the environment would preclude any problems with bioaccumulation in the food chain. **Garlon 3A[®]** can cause severe eye damage to both humans and wildlife, due to the high pH of its water-soluble amine salt base. Care must be taken during mixing and application to prevent accidental splashing into eyes.

In a study of the potential effects of herbicide residues on forest songbirds, sub-lethal doses of triclopyr ester (500 mg/kg in the diet for 29 days) were found to cause weight loss and behavior alterations in zebra finches (Holmes et al. 1994). In a 1987 study of triclopyr metabolism using one cow, all traces of triclopyr were eliminated from the cow's urine within 24 hours, and no residues were detected in its milk or feces. This study, however, did not track whether any triclopyr was absorbed into the cow's tissues, or whether the triclopyr recovered in the urine was still active (Eckerlin 1987).

Aquatic Species

Triclopyr acid and the salt formulation are slightly toxic to fish and aquatic invertebrates. The LC50 of the acid and the salt formulation for rainbow trout are 117 mg/L and 552 mg/L, respectively, and for bluegill sunfish 148 mg/L and 891 mg/L, respectively. The ester formulation is highly toxic to fish and aquatic invertebrates, with an LC50 (96-hour) of 0.74 mg/L in rainbow trout and 0.87 mg/L in bluegill sunfish (WSSA 1994; EPA 1998). The hydrophobic nature of the ester allows it to be readily absorbed through fish tissues where it is rapidly converted to triclopyr acid. The acid can be accumulated to a toxic level when fish are exposed to sufficient concentrations or for sufficient durations.

The extent to which the toxic effects of the ester are reduced by degradation is poorly understood. Studies have shown that the ester formulation degrades rapidly to less toxic forms (Thompson et al. 1991). Kreutzweiser et al. (1994) however, has shown that there is a significant chance of acute lethal effects to fish exposed to low level residues for more than six hours. In addition, delayed lethal effects were seen in fish exposed to high concentrations for a short duration. Considering that Thompson et al. (1991) concluded that organisms subjected to direct overspray were exposed to a high level of herbicide for short periods of time while organisms downstream were exposed to low levels for longer periods, the findings of Kreutzweiser et al. (1994) are of concern.

Nevertheless, most authors including the authors of the fish mortality study have concluded that if applied properly, triclopyr would not be found in concentrations adequate to kill aquatic organisms. As a measure of precaution, however, Kreutzweiser et al. (1991) suggest that some water bodies remain at risk of lethal contamination levels including shallow and slow moving water bodies where dissipation is slow, and heavily shaded streams that experience reduced photodegradation.

Other Non-Target Organisms

Triclopyr inhibited growth of four types of ectomycorrhizal fungi associated with conifer roots at concentrations of 1,000 parts per million (ppm) and higher (Estok et al. 1989). Some evidence of inhibition of fungal growth was detected in bioassays with as little as 100 ppm triclopyr. Typical usage in forest plantations, however, results in triclopyr residues of only four to 18 ppm on the forest floor (Estok et al. 1989).

Application Considerations:**Application Under Unusual Conditions:**

Several natural area managers have found that Garlon 4[®] and 3A[®] are effective when applied in mid-winter as a cut-stump treatment against buckthorns (*Rhamnus cathartica* and *R. frangula*). It is often easier to get to these plants when boggy soils around them are frozen. Randy Heidorn, Deputy Director for Stewardship of the Illinois Nature Preserve Commission (INPC), recommends three protocols to increase the safety of triclopyr ester application in winter:

- (1) use a mineral oil based carrier;
- (2) make sure that at the time of application, no water is at or above the ground surface, and no snow or ice is present that might serve as a route to spread the herbicide following a thaw, and;
- (3) initiate a monitoring program to assess ambient water concentrations of triclopyr ester in communities that seasonally have water at or above the ground surface with little or no discharge (i.e. bogs).

Safety Measures

The salt formulation in Garlon 3A[®] can cause severe eye damage because of the high pH of its water-soluble amine salt base. Care should be taken to prevent splashing or other accident contact with eyes.

Human Toxicology

Because studies into the carcinogenicity of triclopyr have produced conflicting results, EPA has categorized triclopyr as a “Group D” compound, or a chemical that is not classifiable as to human carcinogenicity. The salt formulation in Garlon 3A[®] can cause severe eye damage.

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REMOVING THE INVASIVE TREE *AILANTHUS ALTISSIMA* AND RESTORING NATURAL COVER

by Patrick L. Burch¹ and Shepard M. Zedaker²

Abstract. Eight herbicide treatments were applied by low-volume basal applications and compared to hand cutting for the removal of *Ailanthus altissima*. Manual cutting of *Ailanthus* stimulated resprouting and increased overall stand density. Chemical control not only removed existing trees but also prevented resprouting. When evaluated 2 years after treatment, optimal control of *Ailanthus* was achieved with a combination of Garlon 4 and Tordon K herbicides. Garlon 4 at 20% v/v alone, Garlon 4 combined with Stalker, or Stalker herbicide alone controlled *Ailanthus* better than hand cutting but were not as effective as treatments containing picloram. Removal of *Ailanthus* resulted in a shift in herbaceous species to native species of the region without reseeding with naturally occurring herbs. Manual control of *Ailanthus* should be avoided in order to prevent proliferation. Herbicide control of *Ailanthus* is the preferred method of control because it successfully kills the trees and prevents resprouting. Because major *Ailanthus* infestations occur near roadways, access with a backpack sprayer should be achievable.

Key Words. *Ailanthus*; invasive exotic tree; native vegetation; Tordon K picloram; Garlon 4 triclopyr; Stalker imazapyr; tree-of-heaven; herbicide control; manual cutting; tree ecology; allelopathy.

Ailanthus altissima (tree-of-heaven) is an invasive exotic weed tree that has become established throughout North America. The state of Virginia, U.S., currently is experiencing a rapid invasion of *Ailanthus* along highways, utility rights-of-way, pastures, and disturbed forest sites. A recent survey of interstate highways in southwestern Virginia found that 30% of the mileage along the highways was infested by *Ailanthus* (Stipes 1995). *Ailanthus* forms pure stands that shade out herbaceous growth and decrease native plant diversity. They also obstruct vistas along roadways as well as create a safety hazard by obstructing the view of drivers. A successful control method must be able to kill the *Ailanthus* stems and roots while allowing for the reestablishment of native vegetation on the site.

If ecological integrity is to be maintained in parks and other natural areas, invasive exotic species such as *Ailanthus* must be controlled within an acceptable limit. The purpose of

this study was to test the effectiveness of herbicide tank mixes as low-volume basal applications on *Ailanthus altissima*. In the study, the efficacy of several different mixtures of Garlon 4® (triclopyr ester) plus Tordon K® (picloram salt) and Garlon 4 plus Stalker® (imazapyr), as well as Garlon 4 and Stalker alone were tested to determine effective treatments on *Ailanthus*. The effectiveness of manual cutting was also tested. Basal applications utilize oil-soluble herbicide formulations applied to the target stems in an oil carrier. Because no oil-soluble formulation of picloram is registered in the United States, the mixtures that contain Tordon K require adjuvants to remain in a single phase during application.

Past research has found that basal applications of herbicide mixtures can provide selective control of unwanted hardwood stems. Herbicides have different physiological pathways and modes of action. A mixture of Garlon 4 with Tordon K or Stalker at selected rates may provide aboveground stem dieback while also allowing translocation to the roots for complete control. In many instances, herbicide mixtures have been found to provide better control than single herbicides. There are no published studies involving basal applications of herbicide mixtures on *Ailanthus altissima*.

In Virginia, Shenandoah National Park is experiencing an invasion of *Ailanthus altissima* along roadsides and in disturbed areas throughout the park. This study will provide useful information on efficient methods to control *Ailanthus altissima* while maintaining the ecological integrity of the remaining plant community.

HISTORY OF *AILANTHUS ALTISSIMA*

Ailanthus altissima (tree-of-heaven) is a native of China. For the past 250 years, *Ailanthus* has rapidly spread through many regions of the western world. *Ailanthus* was first introduced into England and France in 1751 by a missionary who mistook it for a Japan varnish tree (Feret 1985). *Ailanthus* was brought to North America from two different sources. In the east, gardeners first brought the seeds from England in the late 1700s and planted them as ornamentals (Feret 1985). The second route was through the West Coast by Chinese immigrants who probably planted the *Ailanthus* seeds because of its cultural significance and medicinal uses (Hoshovsky 1995). By the mid 1800s, *Ailanthus* was a common nursery species in the eastern United States (Hoshovsky 1995). It began on urban and rural home sites and spread along

transportation rights-of-way. Today the species can be found invading grasslands and disturbed forests throughout North America.

Ecology-Biology

Ailanthus altissima is an invasive pioneer species and rapidly spreads onto disturbed sites. The species is capable of prolific root and stump sprouting as well as producing a generous amount of seed. Both sprouts and seedlings experience rapid juvenile growth (Miller 1990). *Ailanthus* sprouts have been found to have 3 to 4 m of first-year height growth, while seedlings have been found to grow 1 to 2 m in the first year (Adamik and Braun 1957; Hu 1979; Miller 1990). This vigorous growth can continue for 4 or more years. The tree can reach a height of 15 to 24 m (Harlow et al. 1996) and does not appear to be limited by poor site conditions. It can tolerate a wide range of stoniness and pH (Miller 1990) as well as urban pollution (Feret 1985).

Ailanthus roots are shallow and spreading. Miller (1990) states that there is a general absence of a tap root. Most roots are present in the upper 46 cm of soil (Miller 1990). Roots develop near the soil surface, allowing for adventitious sprouting capability (Miller 1990). Although individual stems live only a short time (30 to 50 years), prolific seeding and sprouting ability allow for the formation of a dense thicket of stems that will persist for an indefinite amount of time. *Ailanthus* is a successful competitor with other pioneer species. If allowed to establish itself, *Ailanthus* will create a pure stand, with little opportunity for other plant species. *Ailanthus* has been found to produce allelopathic compounds in its bark and leaflets that are toxic to numerous woody and herbaceous species (Lawrence et al. 1991; Heisey 1996)

Control Methods

The methods used to control *Ailanthus* include manual, mechanical, burning, grazing, biocontrol, and chemicals (Hoshovsky 1995). No method can be deemed successful unless it can kill the roots or prevent additional sprouting.

Manual and mechanical methods include hand pulling young seedlings, cutting or chopping stems, girdling the stems, and hand digging the rootstocks (Hoshovsky 1995). Hand pulling can be performed on young seedlings but becomes impossible with a fully developed root system. Cutting and chopping stems is a common method used to control *Ailanthus*, but significant root and stump sprouting will result. Girdling the cambial tissue on the stem will kill the stem but also will lead to heavy root sprouting. Hand digging the rootstocks will control *Ailanthus*, but it is practical with small infestations only (Hoshovsky 1995). Burning and grazing can kill *Ailanthus* stems and weaken the roots, but neither method proves to be a long-term solution to the continuous sprouting.

Ailanthus altissima has very few disease and insect pests, so few biocontrol methods are currently available. Pathogens such as *Verticillium* spp. have the potential to become important fungal diseases (Feret 1985). Research is being conducted by R.J. Stipes of Virginia Tech to isolate strains of *Fusarium* spp. that may be useful as a mycoherbicide treatment.

Chemical methods are being used to control *Ailanthus*, but there is little research that provides accurate data on the different chemical application methods. Many herbicides can control or defoliate an *Ailanthus* stem. The most important criteria for any chemical treatment are successful control of root and stump sprouts and the eradication of established stems. A herbicide treatment needs to kill the *Ailanthus* stem while translocating down into the roots and preventing any further sprouting.

METHODS AND MATERIALS

Test plots were established and treated in June 1997. The plots were located along Skyline Drive at the US 33 interchange and across from mile marker 101 in Shenandoah National Park. Troublesome *Ailanthus altissima* sprouts were located along roadsides in the park for the study. Nine treatments were applied: eight low-volume basal herbicide treatments plus a manual cutting (Table 1). Aquamix, Inc. (Cloverdale, VA), Eco-Pak LLC (Selma, IN), and Arborchem Products Co. (Mechanicsburg, PA) provided ready-to-use mixtures for this study. Four replicate plots were established for each treatment.

Each plot consisted of a 5 by 5 m square, containing a targeted minimum of ten established *Ailanthus* saplings or trees. The plots were delineated with tagged PVC stakes. A buffer was left between plots to avoid effects from surrounding plots. Herbaceous cover was visually estimated pre- and post-treatment over the entire plot for the three most dominant herbaceous species as well as total species presence or absence. Sequentially numbered tags identified each *Ailanthus* tree within the 5 m plot, and diameter at breast height (dbh) was measured for each tagged tree. Treatments were randomly assigned to each numbered plot for a randomized complete split-plot design.

Low-volume basal herbicide treatments were applied with a Solo® backpack sprayer using a solid cone nozzle at approximately 30 psi. Herbicide mixtures were applied to the lower 30 to 45 cm of each stem. Solutions were applied to wet the bark but not to the point of surface runoff. Complete coverage constituted wrapping of the solution around all sides of the stem surface. Approximately 3 mL of mixture was applied per inch of stem diameter.

Manual cutting was made with brush saws approximately 3 to 6 in. above ground level at the time of herbicide application.

Six weeks after treatment, visual estimations of defoliation were made to quantify short-term treatment effects. One year after treatment, in September 1998, diameters were mea-

Table 1. Chemical treatments used to compare herbicide effectiveness with manual cutting for control of *Ailanthus* in Shenandoah National Park, Virginia.

Treatment code	Carrier system	Herbicide*	Herbicide rate (% v/v)
1	HY-Grade EC	Garlon 4	20
2	HY-Grade EC	Garlon 4	20
		Stalker	1
3	HY-Grade EC	Garlon 4	15
		Stalker	3
4	HY-Grade EC	Garlon 4	20
		Stalker	3
5	Aqumix RTU	Garlon 4	20
		Tordon K	5
6	Eco-Pak RTU	Garlon 4	20
		Tordon K	5
7	Arborchem RTU	Garlon 4	20
		Tordon K	5
8	HY-Grade EC	Stalker	9
9	Manual cutting 7–15 cm above ground		

*Garlon 4 (triclopyr @ 480 gae/L); Stalker (imazapyr @ 240 gae/L); Tordon K (picloram @ 240 gae/L).

sured of remaining live trees to determine mortality and control. Dead trees and manually cut trees were examined for stump sprouting. The percentage of control was determined using the change in diameter of live trees from 1997 to 1998 for chemical treatments according to the following:

$$\text{Control \%} = (\text{dbh 1997} - \text{dbh 1998}) / \text{dbh 1997} * 100$$

Dead trees were assigned 100% control. The percentage of control for manual cutting treatment was based on the number of stump sprouts emanating from the cut stump above groundline. Each stump sprout accounted for (–)100% control according to the following:

$$\% \text{ cut stump control} = (-)100 * (\text{number of sprouts})$$

In January 2000, a tally was taken of the number of *Ailanthus* stems in each plot and converted to the number of stems per acre.

Native grass and herbaceous species seed mixtures were considered but not applied after determining that post-treatment effects included a shift from non-native species to those common in the Shenandoah region. Data were analyzed using ANOVA, and means were separated by LSD at the $\alpha = 0.05$ significance level. Stem counts 2 years after treatment were analyzed by box plot because the treatment variance precluded use of ANOVA.

RESULTS AND DISCUSSION

Defoliation 6 weeks after treatment indicated variable effects for all treatments except manual cutting (Table 2). Defoliation ranged from 75% for the low rate (15% v/v) of Garlon 4

combined with a high Stalker rate (3% v/v), to 100% defoliation for Garlon 4 alone and in Aqumix RTU. All other treatments were intermediate in defoliation.

Herbicide treatments to *Ailanthus altissima* greatly exceeded control and mortality over that induced by manual cutting of stems. Manual cutting averaged 1.6 new stump sprouts per stem, while none of the chemical treatments produced any stump sprouts. Only 21% of cut stump trees failed to resprout, compared to 79% or greater mortality using chemical control methods.

Herbicide combinations that induced the highest mortality 1 year after treatment were Garlon 4 at 20% v/v, 20% Garlon 4 plus 5% Tordon K (in either the Aqumix RTU or Eco-Pak RTU carrier), and 9% Stalker in HY-Grade EC (Table 2).

Similarly, 20% Garlon 4 plus 1% Stalker and 20% Garlon 4 plus 5% Tordon K (Arborchem RTU) approached 100% mortality. While Arborchem RTU and 20/1 Garlon/Stalker mixtures did not result in significantly lower mortality than the aforementioned treatments, persistent live trees could be the result of incomplete application rather than chemical ineffectiveness. Chemical combinations that did not control *Ailanthus* as well as other treatments were 15% Garlon 4 plus 3% Stalker and 20% Garlon 4 plus 5% Stalker.

Garlon 4 at 20% and 9% Stalker, when applied independently, successfully controlled *Ailanthus*. When combined, the control was slightly decreased. Statistically, there were no differences among any of the RTU mixes. Garlon or Stalker alone or in mixtures with low rates (1%) of Stalker, and any of the Garlon/Tordon RTUs, provided adequate control of *Ailanthus* over manual cutting.

Overall stem reduction was assessed 2 years after treatment. ANOVA was not used due to the lack of treatment variance homogeneity. Data are presented using box plot analysis. There was no difference among the RTU mixes, but the differences among the treatments containing picloram and the others were observed with the reduction in treatment variance being very evident. While the Garlon and Garlon plus Stalker treatments were similar, all treatments reduced the overall stem count when compared to cutting alone (Figure 1). Stalker alone at 9% provided intermediate control between the RTU mixes and the Garlon + Stalker mixes.

Herbaceous species present on the plots prior to treatment consisted largely of garlic mustard (*Alliaria petiolata*) along with native herbaceous plants (Table 3). Either as a result of the removal of *Ailanthus*, or due to natural species shifts, garlic mustard, a non-native plant, was absent 1 year later and was replaced by predominantly native species. Dominant species

present over all four blocks largely consisted of native wildflowers, including Joe Pye weeds (*Eupatorium* spp.), Dutchman's pipe (*Aristolochia durior*), and jewelweed (*Impatiens capensis*), among others. Once *Ailanthus* was removed, reseeding with native herbaceous species was not necessary.

One interesting note regarding herbaceous species composition was the dominant vegetation surrounding the rock wall that lies along Skyline Drive near the US 33 interchange between the road and treatment plots. Prior to treatment (June 1997), roadside herbaceous vegetation was dominated by bouncing bet (*Saponaria officinalis*), introduced from Europe. At the time of post-treatment measurements (early September 1998), bouncing bet was either absent altogether or only a minor component of the roadside vegetation (Table 4). This finding suggests natural shifts in herbaceous vegetation independent of *Ailanthus* control.

SUMMARY AND CONCLUSION

Manual cutting of *Ailanthus* stimulated resprouting and increased overall stand density. Chemical control not only removed existing trees but also prevented resprouting by eliminating the existing root system. Optimal herbicide treatments for control of

Table 2. Treatment effects on *Ailanthus* 6 weeks after treatment and the percentage of control and mortality measured 1 year after treatment.

Treatment	Defoliation %	Control %	Mortality %
Garlon 4 20% in HY-Grade EC	100*	99.8 a	100 a
Garlon 4 20% +1% Stalker in HY-Grade EC	96.7 A	98.1 a	98.3 a
Garlon 4 15% + 3% Stalker in HY-Grade EC	77.7 B	74.1 b	79.6 b
Garlon 4 20% + 5% Tordon K in Aquimix RTU	100 A	100 a	100 a
Garlon 4 20% + 5% Tordon K in Eco-Pak RTU	94.5 A	100 a	100 a
Garlon 4 20% + 5% Tordon K in Arborchem RTU	98.8 A	98.0 a	98.7 a
Stalker 9% in HY-Grade EC	78.0 B	99.9 a	100 a
Stalker 9% in HY-Grade EC			
Manual cutting 7–15 cm above ground	100	–150 c	21.3 c
p-value	.0001	.0001	.0001

*Means followed by the same case/style letter not significantly different at $\alpha = 0.05$.

Ailanthus should include combination with 5% Tordon K. Garlon 4 at 20% v/v alone, Garlon 4 combined with Stalker, or Stalker alone controlled *Ailanthus* better than hand cutting but were not as effective as treatments containing picloram.

Removal of *Ailanthus* resulted in a shift in herbaceous species to native species of the region without having to reseed with naturally occurring herbs.

Manual control of *Ailanthus* should be avoided in order to prevent proliferation throughout the park. Herbicide control of *Ailanthus* would be the preferred method of control because it not only successfully kills the trees, but it also prevents resprouting. Because major *Ailanthus* infestations occur near roadways, access with a backpack sprayer should not be a major concern.

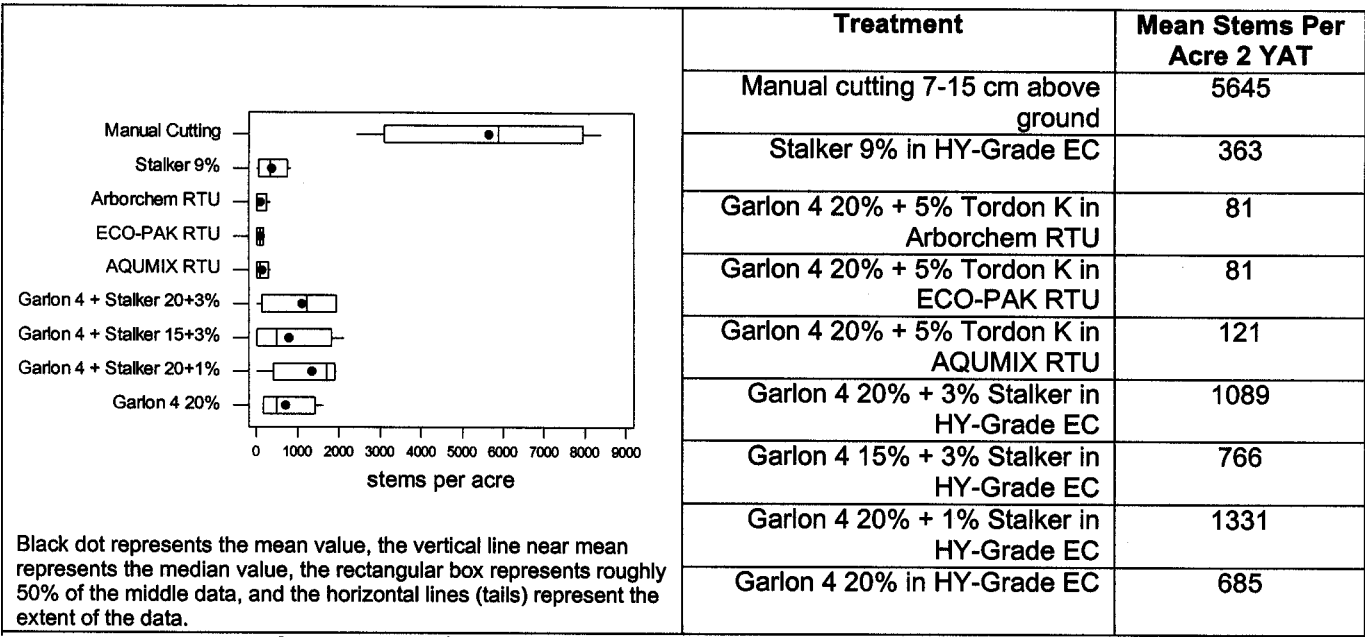


Figure 1. Box plot of stem count (number of stems per acre) as affected by treatments. Untreated is hand-cut only.

Table 3. Pre-treatment dominant herbaceous species over all four blocks by treatment for *Ailanthus* control plots on Skyline Drive in Shenandoah National Park, Virginia.

Treatment	Overall three most dominant species	Average % cover*
Garlon 4 20% in HY-Grade EC	<i>Alliaria petiolata</i> (garlic mustard)	58
	<i>Impatiens capensis</i> (jewelweed)	40
	<i>Aristolochia durior</i> (Dutchman's pipe)	40
Garlon 4 20% + 1% Stalker in HY-Grade EC	<i>Alliaria petiolata</i> (garlic mustard)	67
	<i>Osmorhiza longistylis</i> (sweet cicely)	40
	<i>Arctium minus</i> (burdock)	32
Garlon 4 15% + 3% Stalker in HY-Grade EC	<i>Alliaria petiolata</i> (garlic mustard)	57
	<i>Impatiens capensis</i> (jewelweed)	40
	<i>Hydrophyllum virginianum</i> (Virginia waterleaf)	20
Garlon 4 20% + 3% Stalker in HY-Grade EC	<i>Alliaria petiolata</i> (garlic mustard)	57
	<i>Arctium minus</i> (burdock)	30
	<i>Toxicodendron radicans</i> (poison ivy)	15
Garlon 4 20% + 5% Tordon K in CWC basal mix RTU	<i>Alliaria petiolata</i> (garlic mustard)	75
	<i>Eupatorium</i> spp. (Joe Pye weed)	27
	<i>Impatiens capensis</i> (jewelweed)	20
Garlon 4 20% + 5% Tordon K in Exacto RTU	<i>Alliaria petiolata</i> (garlic mustard)	60
	<i>Bromus sterillis</i> (bromegrass)	50
	<i>Arctium minus</i> (burdock)	20
Garlon 4 20% + 5% Tordon K in Arborchem RTU	<i>Alliaria petiolata</i> (garlic mustard)	62
	<i>Impatiens capensis</i> (jewelweed)	20
	<i>Arctium minus</i> (burdock)	20
Stalker 9% in HY-Grade EC	<i>Alliaria petiolata</i> (garlic mustard)	67
	<i>Gillenia trifoliata</i> (bowman's root)	20
	<i>Aristolochia durior</i> (Dutchman's pipe)	20
Manual cutting 3 in. above ground	<i>Alliaria petiolata</i> (garlic mustard)	67
	<i>Osmorhiza longistylis</i> (sweet cicely)	30
	<i>Arctium minus</i> (burdock)	20

*Average cover may be greater than 100% because coverage was averaged over four blocks by species.

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Table 4. Post-treatment dominant herbaceous species over all four blocks by treatment for *Ailanthus* control plots on Skyline Drive in Shenandoah National Park, Virginia.

Treatment	Overall three most dominant species	Average % cover ^z
Garlon 4 20% in HY-Grade EC	<i>Impatiens capensis</i> (jewelweed)	60
	Mixed grasses ^y	30
	<i>Eupatorium</i> spp. (Joe Pye weed)	20
Garlon 4 20% + 1% Stalker in Hy-Grade EC	Mixed grasses	40
	<i>Aristolochia durior</i> (Dutchman's pipe)	30
	<i>Impatiens capensis</i> (jewelweed)	25
Garlon 4 15% + 3% Stalker in Hy-Grade EC	<i>Arctium minus</i> (burdock)	40
	<i>Impatiens capensis</i> (jewelweed)	31
	<i>Aristolochia durior</i> (Dutchman's pipe)	20
Garlon 4 20% + 3% Stalker in HY-Grade EC	Mixed grasses	40
	<i>Impatiens capensis</i> (jewelweed)	30
	<i>Eupatorium</i> spp. (Joe Pye weed)	30
Garlon 4 20% + 5% Tordon K in HY-Grade EC	Mixed grasses	40
	<i>Impatiens capensis</i> (jewelweed)	30
	<i>Eupatorium</i> spp. (Joe Pye weed)	30
Garlon 4 20% + 5% Tordon K in CWC basal nix RTU	Mixed grasses	40
	<i>Aristolochia durior</i> (Dutchman's pipe)	40
	<i>Eupatorium</i> spp. (Joe Pye weed)	30
Garlon 4 20% + 5% Tordon K in Exacto RTU	<i>Eupatorium</i> spp. (Joe Pye Weed)	50
	<i>Impatiens capensis</i> (jewelweed)	40
	Mixed grasses	30
Garlon 4 20% + 5% Tordon K in Arborchem RTU	Mixed grasses	50
	<i>Impatiens capensis</i> (jewelweed)	40
	<i>Sanguinaria canadensis</i> (bloodroot)	30
Stalker 9% in Hy-Grade EC	<i>Impatiens capensis</i> (jewelweed)	37
	<i>Verbascum thapsus</i> (mullein)	30
	<i>Arctium minus</i> (burdock)	30
Manual cutting 3 in. above ground	<i>Impatiens capensis</i> (jewelweed)	30
	<i>Eupatorium</i> spp. (Joe Pye weed)	10
	<i>Aristolochia durior</i> (Dutchman's pipe)	5

^zAverage cover may be greater than 100% because coverage was averaged over four blocks by species.

^yMixed grasses consisted of *Danthonia*, *Poa*, *Agrostis*, *Dactylis*, *Festuca*, and *Panicum* spp.

Résumé. Huit traitements avec des herbicides ont été utilisés au moyen d'applications basales à faibles volumes et ont été ensuite comparés à la coupe manuelle pour l'éradication de l'*Ailanthus altissima*. La coupe manuelle de l'*Ailanthus* a stimulé la production de rejets et accrue la densité globale du peuplement. Le contrôle chimique n'a pas seulement éliminé les arbres existants, mais a aussi prévenu la formation de rejets. Suite à une évaluation effectuée deux années après le traitement, on a constaté que le contrôle optimum de l'*Ailanthus* était atteint avec une combinaison d'herbicides que sont le Garlon 4 et le Tordon K. Le Garlon 4 seul à 20% (v/v), le Garlon 4 combiné avec le Stalker, ou encore le Stalker seul, contrôlaient de façon supérieure l'*Ailanthus* que la coupe manuelle, mais ils n'étaient pas aussi efficaces que les traitements qui contenaient du picloram. L'éradication de l'*Ailanthus* a produit un changement des espèces herbacées indigènes vers des espèces introduites, et ce dans les régions où il n'y avait pas de réensemencement

provenant d'herbacées naturellement présentes. Le contrôle manuel de l'*Ailanthus* devrait être évité afin de prévenir la prolifération sur l'ensemble du site. Le contrôle par herbicide de l'*Ailanthus* est la méthode de contrôle préférable étant donné qu'il détruit avec succès les arbres et prévient la formation de rejets. Du fait que les infestations majeures par l'*Ailanthus* se produisent près des routes, l'accès avec un réservoir dorsal devrait être réalisable.

Zusammenfassung. Bei der Entfernung von *Ailanthus* wurde 8 verschiedene Herbizidanwendungen in einer basalen Applikation mit manuellem Rückschnitt verglichen. Manueller Rückschnitt stimulierte einen Wiederausschlag der Knospen und vergrößerte die Dichte des Bestands. Die chemische Kontrolle verminderte nicht nur vorhandene Bäume, sondern verhinderte auch das Austreiben von Knospen. In einer Bewertung nach zwei Jahren wurde eine optimale Kontrolle bei einer Kombination von Garlon 4 und Tordon K erreicht. Garlon 4 bei 20% v/v allein, Garlon 4

kombiniert mit Stalker oder Stalker alleine kontrollierte *Ailanthus* besser als manueller Rückschnitt, aber sie waren weniger effektiv als Behandlungen, die Picloram enthielten. Die Entfernung von *Ailanthus* führte zu einer Veränderung der Artenzusammensetzung zum Vorteil der endemischen Pflanzen, ohne diese nachsäen zu müssen. Die Herbizidkontrolle ist die bevorzugte Kontrollmethode, weil es auf die Dauer erfolgreich abtötet und ein Nachkeimen unterdrückt. Da größere *Ailanthus* bestände neben Straßen vorkommen, kann ein Zugriff mit Rückenspritzen empfohlen werden.

Resumen. Se compararon ocho tratamientos con herbicida en aplicaciones basales de bajo volumen comparadas con remoción manual de *Ailanthus altissima*. Las cortas manuales de *Ailanthus* estimularon el rebrote e incrementaron la densidad. El control químico no solamente eliminó los árboles existentes, sino que también previno el

rebrote. Cuando se evaluaron los tratamientos, dos años después, el control óptimo de *Ailanthus* fue mejorado con una combinación de los herbicidas Garlon 4 y Tordon H. Garlon 4 al 20% v/v solo, Garlon 4 combinado con herbicida Stalker o Stalker solo, controló *Ailanthus* mejor que las cortas manuales pero no fue tan efectivo como los tratamientos que contenían picloram. La remoción de *Ailanthus* resultó en un cambio de especies herbáceas a especies nativas de la región sin la regeneración natural de herbáceas. El control manual de *Ailanthus* debe evitarse con el fin de prevenir su proliferación en el parque. El control herbicida de *Ailanthus* es el método preferido de control. Debido a que las infestaciones de *Ailanthus* se presentan cerca de las carreteras, debe llevarse a cabo el trabajo con una mochila aspersora.

Control of *Ailanthus altissima* Using Stem Herbicide Application Techniques

Joseph M. DiTomaso and Guy B. Kyser

Abstract. Three herbicides were tested using four stem application techniques for control of both single trunks and clumps of tree-of-heaven [*Ailanthus altissima* (Miller) Swingle]. Imazapyr, triclopyr, and glyphosate were applied using cut stump, stump injection, and stem injection techniques. Imazapyr and triclopyr were also applied as a basal bark treatment. Treatments were compared against manual cutting and untreated controls. Untreated cut stems did not provide control of tree-of-heaven. Cut stump treatment with imazapyr and triclopyr (20% v/v in oil) resulted in more than 90% reduction in both vigor ratings and resprouting of single stems and clumps. In contrast, stump injection applications were ineffective with all herbicides. For stem injection treatments, undiluted imazapyr gave the best results (>95% canopy reduction), but glyphosate also provided excellent control (92% canopy reduction). Removing stems 4, 8, or 12 months after treatment did not impact the level of control with imazapic. Imazapic at half the standard rate also gave good control of multistemmed clumps. Basal bark treatments with imazapyr or triclopyr (20% v/v in oil) gave equally good results, providing nearly complete control. Triclopyr is less selective than imazapyr and thus offers a better option when desirable vegetation surrounds the stems. These results provide several effective options for the control of tree-of-heaven in both urban and riparian sites.

Key Words. *Ailanthus*; basal bark; cut stump; glyphosate; herbicide control; imazapyr; invasive tree; manual cutting; riparian; stem injection; stump injection; tree-of-heaven; triclopyr.

Tree-of-heaven [*Ailanthus altissima* (Miller) Swingle] is native to eastern Asia. In 1751, it was brought to England (Feret 1985) and in 1784 was introduced to Philadelphia in the United States as an ornamental (Wyman 1951). It was again imported to Long Island in 1790 and its use as a cultivated plant quickly expanded into the eastern and midwestern United States (Feret 1985).

It has been postulated that tree-of-heaven was first introduced to California and other western states as an ornamental in the 1800s with the Chinese who immigrated during the Gold Rush (McClintock 1981) or were used to build the western rail systems (Feret 1985). By the early 1900s, tree-of-heaven declined in popularity owing to a number of factors. It resprouts prolifically from both shallow spreading roots and cut stumps, so that once established, it is difficult to remove. In addition, the foliage produces an unpleasant odor, which is associated with headaches and nausea. The leaves or leaf leachates can also cause dermatitis with vesicular eruptions (Burrows and Tyrl 2001), and the pollen is a known allergen (Blumstein 1943).

Despite decreased popularity, tree-of-heaven escaped cultivation and expanded its range in most of the United States (Merriam 2003; DiTomaso and Healy 2006). It is currently established in urban waste areas, old dwellings and mining settlements, roadsides, utility rights-of-way, pastures, and

disturbed forest sites (Burch and Zedaker 2003). In the eastern United States, tree-of-heaven has also established in forests where it has been shown to create dense stands and outcompete native woody species (Knapp and Canham 2000; Call and Nilsen 2005). In California, it is a highly invasive tree in riparian areas as well as grassland and woodland sites (Hunter 2000, Kelly 2001). It can survive from sea level to at least 1585 m (5,231 ft) under a broad range of soil conditions but generally grows best in areas where soil moisture is not limiting (Feret 1985).

Tree-of-heaven is a shade-intolerant species that grows rapidly and quickly establishes in the gaps of forest or riparian areas (Knapp and Canham 2000). Although seedlings cannot survive under a dense canopy, root sprouts grow slowly and survive for years under an intact canopy (Kowarik 1995). Once released by the development of a gap, these clonal ramets can rapidly establish. When exposed to light, new shoots can grow up to 1.8 m (5.94 ft) in length in a single season and can eventually reach heights of nearly 18 m (59.4 ft) (Feret 1985).

Although a number of factors contribute to the competitive ability of tree-of-heaven, it may outcompete other species through the production of quassinoids that act as allelochemicals (Heisey 1990; Lawrence et al. 1991; Heisey 1996; Heisey and Heisey 2003). The most active of these compounds is

ailanthone, which is most concentrated in the root and stem bark (Heisey 1996; De Feo et al. 2003).

Control of tree-of-heaven can be difficult. Manual cutting or girdling the cambial tissue of the stem generally stimulates stump and root sprouting as a result of the loss of apical dominance, resulting in an increase in overall stand density (Kelly 2001; Burch and Zedaker 2003). Herbicides have also been tested for tree-of-heaven control in several studies. Hexazinone applied as a foliar treatment gave varied levels of control (55% to 93% at 2.4 to 9.6 kg·ha [2.1–8.6 lb·ac]) 21 months after treatment (Pritchard 1981). However, it is not registered for use near water and is not an option in riparian areas. Foliar application of the growth regulator herbicide triclopyr (Butler and Britting 1998) and glyphosate applied with a rope wick applicator to the foliage also provide control (Butler and Britting 1998).

For more mature woody plants, low-volume basal bark treatments of triclopyr, picloram, and imazapyr were used to control tree-of-heaven in Virginia (Burch and Zedaker 2003). Two years after treatment, optimal control was achieved with a combination of triclopyr and picloram. Triclopyr and imazapyr alone or in combination also gave some control, but not as effectively as combinations with picloram. Picloram is not registered for use in California nor is it registered near water in any region of the country. Thus, like hexazinone, it is not a control option in most areas of the west where tree-of-heaven has invaded riparian sites. In a California study, Kelly (2001) reported a triclopyr basal bark treatment to be very effective (98% control) on tree-of-heaven.

Large woody plants can also be controlled using a cut stump technique, in which the herbicide is applied directly to the cambial regions of the newly cut stem. It is widely recommended that application of the herbicide be made within 30 min after cutting (Tjosvold and McHenry 1986). A combination of picloram and 2,4-D as a cut stump treatment was found to be ineffective for control of tree-of-heaven (Pritchard 1981). In contrast, triclopyr and glyphosate showed good results in one study (Butler and Britting 1998) with only a few plants resprouting after a cut stump treatment. However, in another report (Kitz 1997), these same herbicides did not provide effective control with a cut stump treatment.

In our study, we examine several stem treatment techniques for the control of tree-of-heaven. We compare the effectiveness of three herbicides (triclopyr, glyphosate, and imazapyr), all with formulations registered for use in riparian habitats or systems adjacent to water. We evaluated the effectiveness of cut stump, basal bark, stem injections, and stump injection treatments as well as untreated mechanical cutting. In addition, we examine the timing of removing trees after a stem injection treatment and the timing of herbicide application after cutting the stems. The objective is to provide land managers with the most effective option for tree-of-

heaven control in sensitive habitats near water and to expand the control options available in other infested sites such as urban settings.

MATERIALS AND METHODS

Treatment Sites

The initial stem injection trial was conducted on the campus of the University of California, Davis, along the relict (now dry) south fork of lower Putah Creek at ≈15 m (≈49.5 ft) elevation. This area has a warm Mediterranean climate with a mean yearly precipitation of 480 mm (19.2 in), most of it during the winter season.

The subsequent study, designed to compare different herbicides and application techniques, was conducted on California Department of Fish and Game property along Putah Creek in western Yolo County at ≈60 m (≈198 ft) elevation. This region has a warm Mediterranean climate with a mean annual precipitation of 584 mm (23.36 in) (86% between November and March). Trees were located along a small fluvial terrace, 10 to 80 m (33 to 264 ft) distant from the creek and 5 to 10 m (16.5 to 33 ft) above the mean creek level. This infestation has been present for approximately 20 years and originated with ornamental plantings at a home site a short distance upstream. The native vegetation consisted of blue oak woodland dominated by blue oak (*Quercus douglasii*) and foothill pine (*Pinus sabiniana*) in the uplands and by Goodding's black willow (*Salix gooddingii*), California black walnut (*Juglans californica*), and seepwillow (*Baccharis salicifolia*) closer to the creek.

Treatment Parameters

The initial trial was conducted at two locations in the University of California, Davis, Riparian Preserve. For all treatments at this site, individual plants were treated as replicates with eight replicates per treatment at each site. Tree-of-heaven plants were treated with one of two commercial formulations of imazapyr by a stem injection technique (Table 1). Because it has been reported that the effectiveness of foliar treatments of imazapyr on saltcedar (*Tamarix ramosissima*) is compromised unless the plants are left uncut for 2 years after treatment (Duncan and McDaniel 1998), we compared the effect of the herbicide on plants cut below the stem injection site 4, 8, and 12 months after treatment.

At the first site, we selected trees in three size classes, small (4 to 8 cm [1.6 to 3.2 in] trunk diameter at knee height), medium (8 to 16 cm [3.2 to 6.4 in] diameter at knee height), and clumps with three to eight trunks branching below knee height. Only the clumps were left uncut. The emulsifiable concentrate formulation of imazapyr (Stalker [BASF Corp., Research Triangle Park, NC]; 239.7 g·ae [acid equivalent]/L; 2 lb·ae/gal) was used at this location. At the second site, we selected only medium trees (8 to 16 cm [3.2 to 6.4 ft] diameter at knee height). In this location, we used the water-

Table 1. Chemical techniques, location, timing, treatment, carrier, and rate used to control tree-of-heaven.

Treatment method	Treatment location	Year of October	Herbicide (trade name)	Carrier	Rate
Stem injection	University of California, Davis	1998	Imazapyr (Stalker)	None	Undiluted
		1998	Imazapyr (Habitat)	None	Undiluted
Cut stump	Putah Creek	2001	Glyphosate (Roundup Pro)	50% water	50%
		2001	Imazapyr (Chopper)	80% Hasten oil	20%
		2001	Triclopyr (Garlon 4)	80% Hasten oil	20%
Stem injection	Putah Creek	2001	Glyphosate (Roundup Pro)	None	Undiluted
		2001	Imazapyr (Chopper)	None	Undiluted
		2001	Triclopyr (Garlon 4)	None	Undiluted
Stump injection	Putah Creek	2001	Glyphosate (Roundup Pro)	None	Undiluted
		2001	Imazapyr (Chopper)	None	Undiluted
		2001	Triclopyr (Garlon 4)	None	Undiluted
Basal bark	Putah Creek	2001	Imazapyr (Chopper)	80% Hasten oil	20%
		2001	Triclopyr (Garlon 4)	80% Hasten oil	20%

soluble formulation of imazapyr (Habitat [BASF Corp., Research Triangle Park, NC]; 239.7 g·ae/L; 2 lb·ae/gal), which is registered for use in riparian areas and adjacent to water. Trees at both sites were treated on 23 October 1998, in autumn before leafdrop.

In the Putah Creek site in Yolo County, California, we tested four treatment methods for control of tree-of-heaven using three herbicides. Treatments were made shortly before leafdrop in late October 2001. Herbicides tested included the emulsifiable concentrate of imazapyr (Chopper [BASF Corp., Research Triangle Park, NC]; 239.7 g·ae/L; 2 lb·ae/gal), the ester formulation of triclopyr (Garlon 4 [DOW AgroSciences LLC, Indianapolis, IN]; 479.3 g·ae/L; 4 lb·ae/A), and glyphosate (Roundup Pro [Monsanto Co., St. Louis, MO]; 359.5 g·ae/L; 3 lb·ae/gal). Methods included stem injection, cut stump, stump injection, and basal bark treatments. In addition, we included untreated plants for each treatment. Individual trees were treated as replicates with six to eight trees per treatment. Trees were represented by three size classes (trunks <8 cm [<3.2 in] diameter, trunks >8 cm [>3.2 in], and multiple trunks). At least two trees from each size category were included in each treatment.

Because trees were randomly dispersed along each of these riparian areas, treatments at each site were organized in a complete randomized block design. Individual trees were marked with plastic flagging and numbered with aluminum tags.

Treatments Techniques

Cut Stump

Trees were cut 60 cm (24 in) above the soil surface using a chain saw. The stump cambium was treated with an herbicide solution consisting of 20% v/v Chopper in Hasten crop oil, 20% v/v Garlon 4 in Hasten oil, or 50% v/v Roundup Pro in water (Table 1). The herbicide solution was applied using a laboratory Nalgene squeeze bottle. An average of 5 mL total solution (range from 3 to 25 mL [0.09 to 0.75 fl oz] depend-

ing on tree size) was used per stump (3.6 cm [\approx 1.4 in] diameter average stump size), which wet the cambial ring short of runoff down the stem. Stumps were treated at four intervals after cutting (0, 15, 30, and 60 min).

Stem Injection

The stem injection technique, also known as hack-and-squirt, consisted of making a downward angled 4 to 8 cm long (1.6 to 3.2 in) hatchet mark (hack) in the bark 30 to 45 cm (12 to 18 in) above the soil surface and then injecting 1 mL [0.03 fl oz] of undiluted herbicide (Chopper, Garlon 4, or Roundup Pro) into the mark using a disposable 10 mL (0.30 fl oz) pipette and pipette pump (Table 1). The standard rate was one hack and herbicide treatment for every 8 cm (3.2 in) in trunk diameter. For the tree clumps, the standard dose was based on the accumulated stem diameter (total of all stems) of all trunks, but applications were made at lower rates of one-half or one-fourth the standard rate. These lower rates were used because it was considered impractical to apply herbicide to each stem within every clump. For example, a clump with four 8 cm (3.2 in) stems (standard rate of four injections, one on each stem) would receive either two injections, one each on two stems (one-half rate) or one injection on one stem (one-fourth rate). We also established control trees of all sizes, which were also marked with the hatchet but were not treated.

Stump Injection

Trees were cut with a chainsaw similar to the cut stump treatment. A hatchet mark and undiluted herbicide treatment (Chopper, Garlon 4, or Roundup Pro) was then made to the stump as described for the stem injection treatment (Table 1). The herbicide application was performed either immediately, 1 hr, 1 day, or 1 week after the tree was cut to test whether a delay between cutting and treatment would affect efficacy.

Basal Bark

Similar to the stem injection treatment, this technique left the tree standing. Only imazapyr and triclopyr were used in this

treatment, because glyphosate is not lipophilic and cannot be mixed in oil. An oil carrier is necessary to penetrate the tree bark. Either Chopper or Garlon 4 (20% in Hasten oil) was applied to cover the basal 45 cm (18 in) of the tree trunk using a bottle sprayer. Trunks were sprayed to wet but not to runoff. An average of 60 mL of total solution was applied to each tree.

Evaluations and Analysis

At the University of California, Davis, site, each tree (replicate) was visually estimated for percent crown reduction 8 (June 1999) and 21 months (July 2000) after treatment. Evaluation of percent crown reduction in all trees were based on a relative comparison of foliage canopy in an undamaged tree. In addition, measurements were made of the percentage of trees with resprouts as well as the number and height of resprouting stems.

In the Putah Creek site, visual estimates of percent canopy reduction and canopy vigor were determined in August 2002 (10 months after treatment) and August 2003 (22 months after treatment) for each tree. Vigor measurements were visual estimates based on comparison with undamaged foliage of untreated trees and ranged from 0 (dead) to 10 (undamaged). In addition, the percentage of trees that resprouted was recorded and resprout vigor, number, and height were visually evaluated or measured.

For standing-tree treatments, canopy reduction and vigor were compared across all treatments (including uncut con-

trols) using analysis of variance (ANOVA), and means were separated using the Student-Newman-Keuls (SNK) test ($\alpha = 0.05$). For stump treatments, the presence or absence of stump sprouts was compared across herbicide types, within each parent treatment technique, using logistic regression ($\alpha = 0.05$). Vigor of stump sprouts (including stumps with no sprouts, which were assigned a vigor rating of 0) was compared using ANOVA and SNK. Cut-stump subtreatments (time interval between cutting and herbicide application) were compared within each herbicide and within each parent application technique using logistic regression and ANOVA. Time subtreatments were grouped by herbicide within each parent application technique after it was determined that time interval had no effect.

RESULTS AND DISCUSSION

At the University of California, Davis site, manual cutting used alone provided little, if any, control of tree-of-heaven. By 10 months after cutting, small and large stumps produced between three and nine new basal sprouts (Table 2). By 21 months after cutting, $\approx 25\%$ to 30% of the cut trees died, but the remainder averaged ≈ 4 new sprouts per stump. These new sprouts were an average of 1.6 to 2 m (5.3 to 6.6 ft) in height. Burch and Zedaker (2003) also showed that mechanical cutting stimulated tree-of-heaven resprouting (1.6 new sprouts per stump) and increased overall stand density. They similarly showed that 21% of the cut stump trees failed to resprout.

Table 2. Tree-of-heaven control using stem injection treatment with undiluted imazapyr as an emulsifiable concentrate (Stalker) or water-soluble (Arsenal) formulation².

Treatment	Cutting date	Evaluation 8 MAT*			Evaluation 21 MAT		
		Mean number of sprouts	Mean crown reduction (%)	Percent of stumps with sprouts	Mean number of sprouts on sprouting stumps	Mean height of sprouts (m)	Crown reduction (%)
<i>Imazapyr (Stalker)</i>							
Small trees (4–8 cm diameter)	4 MAT	0	—	12.5	1.0	0.4	—
	8, 12 MAT	—	97.9 ± 5.2				
Medium trees (8–16 cm diameter)	4 MAT	0	—	1.6	—	—	99.3 ± 0.6
	8, 12 MAT	—	96.9 ± 4.4				
Clumps, 1/2 dose	—	—	84.2 ± 14.6	—	—	—	81.7 ± 18.9
Clumps, 1/4 dose	—	—	76.0 ± 8.9	—	—	—	—
Untreated small trees	4 MAT	2.75 ± 3.10	—	1.6	—	—	—
	8, 12 MAT	—	0				
Untreated medium trees	4 MAT	70.8	3.8	1.6	—	—	—
	8, 12 MAT	2.75 ± 2.50	—				
<i>Imazapyr (Habitat)</i>							
Medium trees (8–16 cm diameter)	4 MAT	0	—	8.3	1.0	0.6	—
	8, 12 MAT	—	94.8 ± 5.8				
Untreated medium trees	4 MAT	9.25 ± 4.27	—	75.0	4.0	2.0	—
	8, 12 MAT	—	26.3 ± 37.4				

*Months after treatment (4 MAT = February 1999; 8 MAT = June 1999; 12 MAT = October 1999, 21 MAT = July 2000).

Both formulations of imazapyr were very effective for the control of small and medium trees using stem injection. Crown reduction was between 95% and 98% with either the water-soluble (Habitat) or emulsifiable concentrate (Stalker) formulation of imazapyr 10 months after treatment (Table 2). Because imazapyr is known to translocate slowly, it was postulated that a single winter season would not be sufficient to allow the herbicide to circulate throughout the tree and give adequate control. With saltcedar or tamarisk (*Tamarix* spp.), it was demonstrated that plants could not be cut until two full growing seasons after foliar treatment (Duncan and McDaniel 1998). However, with tree-of-heaven there was no difference between trees cut down at 4, 8, or 12 months after treatment and no difference between the two formulations of imazapyr by 21 months after treatment. At this evaluation timing, only 12.5% and 8.3% of the Stalker- and Habitat-treated plants, respectively, had stump sprouts. In addition, sprouts were about four times fewer in number and four times smaller than resprouts from the mechanically cut trees without an herbicide treatment.

Stem injection treatment of tree clumps with half of the standard rate of Stalker gave 84% crown reduction 8 months after treatment and 99% reduction 21 months after treatment (Table 2). The quarter rate, however, gave only 82% crown reduction, which is was not considered to be satisfactory control.

Our results indicate that imazapyr applied as a stem injection treatment can be an effective method for tree-of-heaven control even with plants growing in clumps. In some cases, it also was observed that imazapyr appeared to move from treated stems to other adjacent trees, presumably through root grafts. Symptoms of imazapyr injury were evident in other untreated tree-of-heaven stems up to ≈ 5 m (16.5 ft) away from the treated stem. This phenomenon has been observed in

other trees. A similar response was noted in black oak (*Quercus kelloggii*) after a stem injection imazapyr treatment (DiTomaso et al. 2004). Despite this response within tree-of-heaven plants, we observed no injury resulting from root grafting among other species.

In our second study, we compared the effect of imazapyr, triclopyr, and glyphosate on tree-of-heaven using stem injection, stump injection, cut stump, and basal bark treatments. As was the case with the University of California, Davis, site, mechanical cutting gave very poor control with $\approx 86\%$ of the stumps producing new sprouts (Table 3). By 2003, 22 months after cutting, stumps averaged 6.0 new sprouts with a mean height of 2.4 m (7.9 ft).

Although it is widely believed that herbicide should be applied to the stump immediately after cutting (Tjosvold and McHenry 1986), our results indicate that a delay between cutting and herbicide treatment in both the cut stump and the stump injection techniques did not significantly affect the percentage of trees with sprouts (Figure 1) or the vigor of the new sprouts (Figure 2). Applying the herbicide 1 hr after cutting gave the same result as an application immediately after cutting in the cut stump treatments. In the stump injection technique, applying the herbicide 1 week after cutting also provided the same level of control as applying the stem injection immediately after cutting. Based on these results, data for different timing intervals were combined for each herbicide in the cut stump and stump injection treatments.

Using a cut stump technique, imazapyr and triclopyr both provided excellent results. Although glyphosate results were statistically better than the cut controls, they did not give adequate tree-of-heaven control. By 2003, $\approx 41\%$ of the glyphosate-treated trees resprouted and the resprouts were a similar height (2.5 m [8.3 ft]) as the untreated trees (2.4 m [7.9 ft]). Triclopyr produced slower results but was equal to

Table 3. Results for cut-tree treatments in 2001 tree-of-heaven trial^z.

		Vigor mean over all trees ^{y,x}		Percent of trees with sprouts ^w		Means for sprouts ^v					
		2002	2003	2002	2003	Vigor		Number		Height (m)	
						2002	2003	2002	2003	2002	2003
Cut stump	Glyphosate	2.5 b	4.1 b	33.5 b	40.8 b	7.5	9.9	3.9	2.9	1.0	2.5
	Imazapyr	0.0 c	0.6 c	3.1 c	9.8 c	0.5	6.3	0.0	2.8	—	0.7
	Triclopyr	1.0 bc	0.5 c	21.0 bc	6.7 c	4.3	7.5	1.8	1.5	0.4	0.6
Cut control		8.3 a	7.4 a	85.7 a	85.7 a	9.7	8.7	7.3	6.0	1.1	2.4
Stump injection	Glyphosate	6.7 a	6.6 ab	85.7 a	92.9 a	8.0	7.1	5.5	4.2	0.8	1.7
	Imazapyr	0.9 b	1.5 c	35.8 c	32.1 c	2.1	4.0	6.1	6.3	0.2	0.7
	Triclopyr	4.8 a	5.0 b	60.7 b	62.5 b	7.9	7.7	3.3	2.4	0.4	1.2
Cut control		8.3 a	7.4 a	85.7 ab	85.7 ab	9.7	8.7	7.3	6.0	1.1	2.4

^zAll evaluations made in August 2002 and 2003. Values are means over all application timings. Within each treatment group, values followed by the same letter are not different at $\alpha = 0.05$. Cut control values were used for separate comparisons with cut stump and stump injection treatments.

^yVigor is a visual evaluation scale where 0 = dead, 10 = healthy.

^xDifferences determined by analysis of variance and Student-Newman-Keuls test.

^wDifferences determined by logistic regression.

^vOnly for trees with resprouting.

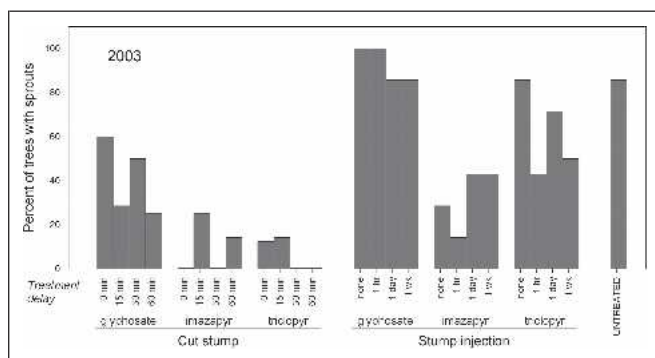


Figure 1. Effect of herbicide timing intervals for cut stump and stump injection techniques on the percent of trees with sprouts. There were no significant differences ($\alpha = 0.05$) for any of the timings within each herbicide treatment.

that of imazapyr by the second season after treatment. In 2003, sprouting occurred on only 6.7% and 9.8% of stumps treated with triclopyr and imazapyr, respectively, and vigor was significantly lower than sprouts on untreated and glyphosate-treated stumps. In those stumps that did produce sprouts after imazapyr or triclopyr treatment, the number of sprouts averaged between 1.5 and 2.8 and the sprout vigor rating showed that they were fairly healthy in the second season after treatment. This indicates that plants that do resprout are likely to recover over time and would require re-treatment by either a foliar herbicide application or a basal bark treatment.

Other reports on tree-of-heaven control with cut stump treatments have shown mixed results. Kitz (1997) noted that land managers had difficulty controlling tree-of-heaven with cut stump treatments using glyphosate and triclopyr. In contrast, Butler and Britting (1998) reported effective control with few resprouts after cut stump treatments with

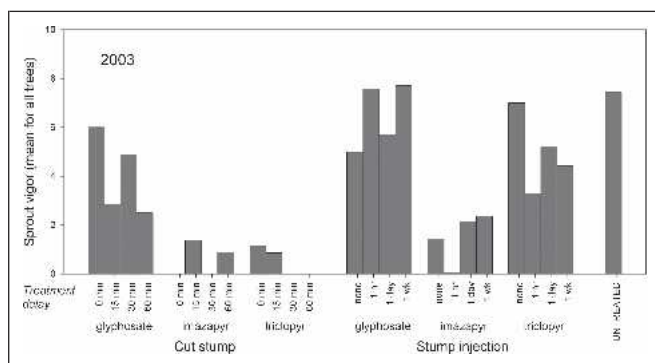


Figure 2. Effect of herbicide timing intervals for cut stump and stump injection techniques on the vigor of resprouts. There were no significant differences ($\alpha = 0.05$) for any of the timings within each herbicide treatment.

either glyphosate or triclopyr. However, neither of these studies provided quantitative data for control, efficacy, or evaluation.

We also examined the impact of mechanical cutting followed by stem injection treatment of the standing stump. By combining aspects of cut stump with stem injection treatments, we hoped to provide a method that could extend the application window after cutting. This would be advantageous in situations in which cutting and treatment operations are performed by separate teams. However, no herbicides provided adequate control of tree-of-heaven with this technique. Although imazapyr was statistically the best of the three herbicides tested, nearly 36% of the treated stumps resprouted the next season, and this value was similar in the second season after treatment (Table 3). The success of conventional stem injection treatments may depend on the vascular system remaining intact and distributing herbicide more effectively throughout the tree.

Tree-of-heaven treated by either stem injection or basal bark were left intact for the 2 year duration of this study. Herbicide-treated plants were compared with uncut control plants. Although the control plants did not receive a treatment, a few died spontaneously both in the first season (2002) and second season (2003) of the study (Table 4). Triclopyr did not provide effective control with a stem injection treatment. The level of canopy reduction and vigor with a triclopyr treatment was not statistically different from the uncut control plants in the second season after treatment. By comparison, both glyphosate and imazapyr gave good to excellent control with imazapyr proving to be the best treatment. In the second season after treatment, imazapyr resulted in 100% tree-of-heaven mortality, whereas glyphosate provided ~92% canopy reduction and a vigor rating of 1.5.

Stem injection gives land managers a number of advantages in riparian areas. For example, the treatment requires minimal equipment, applicators can treat large areas quickly, little herbicide is used, drift potential is very low, and some dead standing trees can be left for bird habitat. In addition, crews can remove the dead trees during the off-season after the leaves have senesced, when removal operations are not be encumbered by the additional weight and litter of the attached leaves.

Basal bark treatments with 20% v/v of either triclopyr or imazapyr also resulted in excellent control of tree-of-heaven. By the second season after treatment, imazapyr completely killed all treated trees, regardless of the stem size (Table 4). Triclopyr also gave complete control of larger trees, but even smaller trees that were not killed showed very low levels of canopy vigor (<2.0).

Burch and Zedaker (2003) also tested basal bark treatments for tree-of-heaven control. They likewise demonstrated 100% control with the same rate of triclopyr (Garlon 4), and

Table 4. Results for standing-tree treatments in 2001 tree-of-heaven trial^z.

Treatment method	Herbicide	Tree size	Canopy	Percent reduction	Canopy vigor ^y	
			2002	2003	2002	2003
Stem injection	Glyphosate	—	82.3 ab	91.7 a	2.3 b	1.5 b
	Imazapyr	—	99.9 ab	100.0 a	0.1 b	0.0 b
	Triclopyr	—	66.7 b	31.4 b	6.2 a	6.7 a
Basal bark	Imazapyr	<4 cm dia	100.0 a	100.0 a	0.0 b	0.0 b
		>4 cm dia	99.8 ab	100.0 a	0.1 b	0.0 b
	Triclopyr	<4 cm dia	90.0 ab	86.7 a	1.3 b	1.7 b
		>4 cm dia	100.0 a	100.0 a	0.0 b	0.0 b
Uncut control	—	—	12.5 c	27.1 b	8.8 a	7.6 a

^zAll canopy percent reduction and vigor measurements made in August of 2002 and 2003. Within each treatment group, values followed by different letters are different at $\alpha = 5\%$ (analysis of variance, Student-Newman-Keuls test).

^yVigor determined by visual evaluation on scale of 0 = dead and 10 = healthy.

they reported that 9% v/v Stalker (imazapyr) gave 100% mortality 1 year after treatment. However, their evaluation 2 years after treatment showed that combinations of triclopyr and picloram resulted in the best aboveground control and also prevented resprouting by eliminating the existing root system. As previously discussed, picloram is not registered for use in California nor is it registered for use around riparian areas in any state.

Kelly (2001) also achieved mortality of greater than 98% in tree-of-heaven with a basal bark treatment of 25% v/v Garlon 4 in oil.

Although both triclopyr and imazapyr showed similar results with basal bark applications, imazapyr has a much longer soil residual activity (field half-life of 25 to 142 days) compared with triclopyr (field half life of 10 to 46 days) (Vencill 2002). In addition, imazapyr is a broader-spectrum herbicide compared with the broadleaf selective herbicide triclopyr. Consequently, either because of overspray or because of herbicide washing off the trunk, trees treated with imazapyr often developed a “dead zone” of approximately 1 m (3.3 ft) diameter around the base of the trunk. Thus, triclopyr may be a less phytotoxic choice for basal bark applications.

Like stem injection, basal bark applications require minimal equipment and are easily performed by one person. However, this technique requires more herbicide than other treatments. Basal bark treatment of an average stem in this study (diameter 9 cm [3.6 in]) required 12 mL (0.36 fl oz) of formulated triclopyr or imazapyr compared with only 1 mL (0.03 fl oz) of herbicide product for either a cut stump or stem injection treatment.

CONCLUSIONS

The control of tree-of-heaven can be difficult, particularly in riparian areas. Mechanical cutting used alone is not a good management tool and is likely to increase the infestation.

However, the results presented here demonstrate that herbicide stem treatments can be effectively used for the control of this invasive species. All stem treatment techniques are best applied in late summer or fall, when carbohydrates are translocating to the belowground tissues, including the root buds (Tjosvold and McHenry 1986). An advantage to all of these stem application methods is the low risk of off-site movement through spray drift. However, it should be noted that under very hot conditions, some vapor drift may be expected with the ester formulations.

A cut stump technique would be most appropriate with very large trees or clumps having a well-developed bark. The bark of these plants would be difficult to penetrate with the stem injection method and would not likely absorb herbicide using a basal bark treatment. When crews are available to cut, treat, and remove the stems over a short time period, a cut stump treatment is a very efficient technique for tree-of-heaven control. We have demonstrated that both triclopyr and imazapyr are effective and both herbicides can be applied within 1 hr of cutting without loss of efficacy. Imazapyr as the water-soluble formulation Habitat is registered for use near aquatic environments and can be an excellent choice in riparian areas. In this study, we used the ester formulation of triclopyr (Garlon 4), which is not registered for use near water. However, the water-soluble formulation (Garlon 3A) is registered near water and would be expected to provide a similar level of control in a cut stump treatment.

The stem injection technique was also very effective for the control of individual tree-of-heaven trees or clumps. Either a water-soluble (Habitat) or emulsifiable concentrate (Stalker) formulation was equally effective, but only Habitat is registered near water. Glyphosate, which has formulations registered for use near water, also provided good control but was not as consistent as imazapyr. This technique can be an advantage when tree removal is not necessary at the time of treatment. It would allow crews to concentrate on treatments

in the late summer or fall and conduct tree removal at least 4 months later during the winter or early spring. Another advantage of this technique is that less herbicide is used compared with the basal bark method.

Like the stem injection method, basal bark treatments with imazapyr and triclopyr can also be used in situations in which immediate tree removal is not necessary. The technique is most appropriate in sites where numerous smaller stems (<10 cm [<4 in] diameter) are present but is not recommended in areas with large plants that have a thick bark. Like with the stem injection method, basal bark treatments require minimal equipment. Other studies have also shown triclopyr to be effective in a basal bark application, and this is probably a better choice when other desirable vegetation surrounds the trees or small clumps. It is necessary to use the ester formulation of triclopyr and the emulsifiable concentrate of imazapyr to get effective control of tree-of-heaven with a basal bark application. However, both of these formulations are not registered for use near water, so this technique is not appropriate in areas directly adjacent to aquatic sites.

Although we did directly measure the effect of cut-stem treatments on stump sprouting, we do not know what impact these treatments have on sucker sprouting from spreading roots. The effectiveness of these treatments on root sprouting would depend on the ability of the herbicide to translocate long distances. This may need to be considered in a follow-up program to ensure that the infestation does not reestablish.

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Résumé. Trois herbicides ont été testés au moyen de quatre techniques d'application pour contrôler à la fois les troncs uniques ainsi que les massifs d'ailanthe glanduleux (*Ailanthus altissima* (Miller) Swingle). L'imazapyr, le triclopyr et le glyphosate ont été appliqués au moyen des techniques d'injection dans la tige, d'injection dans la souche et d'injection sur la surface de coupe. L'imazapyr et le triclopyr ont aussi appliqués sous forme de traitement par la base sur l'écorce. Les traitements ont été comparés par rapport à une coupe manuelle et un groupe témoin sans intervention. Les tiges coupées mais non traitées n'ont pas donné de résultat quant au contrôle de l'ailanthe glanduleux. Le traitement par injection sur la surface de coupe avec l'imazapyr et le triclopyr (20% en v/v dans de l'huile) a donné plus de 90% de diminution à la fois dans les taux de vigueur et de rejets à partir des tiges uniques ou des talles de tiges. En comparaison, les applications par injection dans la souche ont été inefficaces avec tous les herbicides. Pour les traitements par injection dans la tige, l'imazapyr non dilué a donné les meilleurs résultats (>95% de réduction du couvert végétal), mais le glyphosate a aussi permis d'obtenir un excellent contrôle (92% de réduction du couvert végétal). La coupe des tiges 4, 8 ou 12 mois après le traitement n'a pas eu d'impact sur le degré de contrôle avec l'imazapyr. L'imazapyr à un taux de moitié par rapport au standard a aussi donné un bon contrôle des talles arbustives. Les traitements par la base sur l'écorce avec l'imazapyr ou le triclopyr (20% en v/v dans de l'huile) ont donné des résultats équivalents en produisant un

contrôle quasi complet. Le triclopyr est moins sélectif que l'imazapyr qui offre de ce fait une meilleure option lorsque de la végétation désirable entoure les tiges. Ces résultats donnent certaines options effectives pour le contrôle de l'ailanthe glanduleux à la fois sur les sites urbains et riverains.

Resumen. Se probaron tres herbicidas usando cuatro técnicas de aplicación al tronco para el control de árboles aislados y grupos de árboles de *Ailanthus altissima* (Miller) Swingle. Fueron aplicados Imazapyr, triclopyr, y glyphosate usando corte de tocones, inyección al tocón y técnicas de inyección al tronco. Imazapyr y triclopyr también fueron aplicados como tratamientos a la corteza basal. Los tratamientos fueron comparados contra corta manual y controles no tratados. Los tallos de cortes no tratados no dieron un control del *Ailanthus*. El tratamiento de corta de tocones con imazapyr y triclopyr (20% v/v en aceite) resultó en más del 90% de reducción en tallos y en rebrotes, tanto en árboles solos como en grupo. En contraste, las aplicaciones de inyección al tocón fueron inefectivas con todos los herbicidas. Para los tratamientos de inyección al tallo, imazapyr dió los mejores resultados (>95% de reducción de copa), pero glyphosate también dió excelente control (92% de reducción de copa). La remoción de los tallos 4, 8 o 12 meses después del tratamiento no impactó el nivel de control con imazapic. Imazapic a la mitad de la tasa estándar también dió buen control de grupos multi-tallos. Los tratamientos a la corteza basal con imazapyr o triclopyr (20% v/v en aceite) dieron igualmente buenos resultados, proporcionando casi un completo control. Triclopyr es menos selectivo que imazapyr y por tanto ofrece una mayor opción cuando hay vegetación alrededor de los tallos. Estos resultados proporcionan varias opciones efectivas para el control del *Ailanthus* en sitios riparios y urbanos.

Zusammenfassung. Es wurden drei Herbizide mit vier Applikationstechniken für die Kontrolle von Einzelbäumen und Gruppen von *Ailanthus altissima*. Imazapyr, Triclopyr und Glyphosat wurden appliziert durch einen Stammschnitt, Stumpf-injektion und Stamminjektionstechniken. Imazapyr und Triclopyr wurden auch noch als basale Rindenapplikation getestet. Die Behandlungen wurden verglichen mit Rückschnitt und unbehandelten Kontrollen. Unbehandelte Stammrückschnitte führten nicht zu einer Kontrolle von *Ailanthus*. Eine Behandlung der Stumpen mit Imazapyr und Triclopyr (20 % v/v in Öl) führte zu 90 % Rückgang bei den vorhandenen und nachgetriebenen Einzelbäumen und Gruppen. Im Kontrast waren die Stumpeninjektionen bei allen Herbiziden ohne Erfolg. Für Stamminjektionen gab es die besten Ergebnisse (<90 % Kronenreduktion) mit unverdünntem Imazapyr, aber auch Glyphosat zeigte sich sehr effektiv (92 % Reduktion). Eine Entfernung der Stämme 4, 8 oder 12 Monate nach der Behandlung hatte keinen Einfluss auf die Kontrolle durch Imazapic. Imazapic in der halben Standarddosierung führte auch zu einer guten Kontrolle von mehrstämmigen *Ailanthus*. Die basale Rindenbehandlung mit Imazapyr oder Triclopyr (20 % v/v in Öl) lieferte ähnlich gute Ergebnisse und führte fast zu einer kompletten Kontrolle. Triclopyr ist weniger selektiv als Imazapyr und bietet daher bessere Möglichkeiten, wenn erwünschte Vegetation die Stämme umgibt. Diese Ergebnisse liefern verschiedene effektive Möglichkeiten zur Kontrolle von *Ailanthus* im städtischen und ländlichen Umfeld.