ENCAPSULATED HERBICIDES FOR UTILITY RIGHTS-OF-WAY AND FOREST TREE INJECTION[1]

by John J. Bollig and Shepard M. Zedaker

Abstract. Although the risk of exposure during various methods of herbicide application is generally quite low, eliminating the potential of worker exposure by encapsulating herbicides may be desirable. Therefore, three methods of injecting encapsulated herbicides - the FIC™, the Wee-Do™, and the Gelcap™ - were compared to a standard hack-and-squirt technique on two common weedy hardwood species using picloram and triclopyr. Both chemicals showed similar trends over the four injection methods, however, picloram was the more efficacious across all treatments. Mortality rates were highest for the hack-and-squirt technique, with 100% mortality using picloram and 89% mortality using triclopyr. Picloram mortality rates were 81 and 67% for the Wee-Do and FIC methods, respectively, and below 50% when formulated with triclopyr. The Gelcap never exceeded 10% mortality for either chemical. Current relative costs for materials and labor are 1:23:9:27 for the hack-and-squirt, FIC, Wee-Do and Gelcap methods, respectively. The Gelcap proved to be the easiest and most efficient alternative method of injection, however, it unfortunately had the lowest mortality rates. The FIC proved to be the most cumbersome and unreliable injection technique due to both equipment failures and engineering problems. Although the Wee-Do had some minor equipment failures, we found this tool to be the most effective alternative injection technique when considering ease of use, cost and efficacy.

Efficient and effective chemical control of arborescent vegetation has been employed throughout much of the United States in utility rights-of-way and forest management (2,7). Although the ultimate goals of these regimes may differ, their methodologies often do not. Historically, herbicides have most often been broadcast aerially or from ground-based equipment; and to a lesser extent, selectively, via basal spray applications or stem injections (2).

Applications of herbicides have always aroused public suspicion, with broadcast aerial applications being the most severely scrutinized. Without exception, though, the levels of herbicides detected in the environment following proper use have been far below the known levels of toxicological significance to humans, fish, wildlife and livestock (9), including sensitive wetland areas (6). Notwithstanding, some localities have either totally eliminated, or at the very least, substantially reduced broadcast spraying (8). In its place, completely selective measures of control are being advocated.

Among selective methods, stem injection is an increasingly popular application method. Stem injection involves making a wound in the woody stem that penetrates to the cambium, and placing a small amount of herbicide in the wound. Several different tools/methods have been available including basal injectors, breast height injectors, and the "hack-and-squirt" method using a hatchet and a squirt bottle. These methods are generally very effective, however, they vary in their efficiency of production in terms of the number of stems, basal area, and total stem circumference that can be treated in a given unit of time. All methods involve the injection of one to two ml of herbicide (diluted with water or undiluted) per 2.5 cm of diameter. Injections completely encircling the stem are sometimes used on hard to kill species. Nearly all herbicides labelled for woody plant control have been used for injection; however, picloram and triclopyr have been among the more efficacious and most commonly used (8).

Because of the proximity of applicators to the actual herbicide exchange site in selective applications, the potential of worker exposure is increased (3). Although exposures of forest workers to the herbicide solutions are generally not excessive and fall well within the accepted margins of safety (4,5), the nature of the work is such that herbicides can splash back at the worker, increasing the potential for exposure. Because protective equipment is not always employed due to its

1. Mention of a proprietary product does not constitute an endorsement by the authors or their employers.

discomfort, reducing the risk of exposure by encapsulating the herbicide may be desirable, providing efficacy and efficiency do not decline beyond acceptable margins.

Whether dangers to applicators or the public are real or imaginary, public perception will continue to direct policy concerning herbicide use. Vegetation managers need to be prepared to make well-educated decisions and adjustments that will be viewed with public and applicator favor. Therefore, the objective of this study was to compare several methods of injecting encapsulated picloram and triclopyr with a standard injection technique.

Methods

The study site was located approximately 10 km southwest of Blacksburg, VA in the ridge and valley physiographic province at an elevation of 700 meters. The site was on a minor side slope with a predominantly southern aspect. The area supported an uneven-aged mixed-oak stand typical of the ridge and valley. The stand had a dominant age class of about 60-80 years, a few older "wolf" trees, and a few higher quality small sawlog oaks.

Within this area, three methods of injecting encapsulated herbicides - the FIC™, Wee-Do™ (an early prototype of the EZ-Ject™), and the Gelcap™ - were compared to a standard hack-and-squirt technique on two common hardwood species. The FIC method was a two-step procedure utilizing an extractor, shaped like a hammer with a steel tube on one side and a broad flat head on the other, that was thrust into a tree, removing a 1.3 cm diameter core. In the second step, a crushable cylinder containing the herbicide was driven into the hole with the other side of the tool (Figure 1). The Wee-Do method utilized a four foot lance loaded with 0.22 caliber rimfire rifle casings filled with herbicide. The one-step procedure involved thrusting the end of the lance into the bole near the base of the tree where the mechanism released an auto-loaded shell into the tree (Figure 2). The Gelcap was a plastic cylinder containing the herbicide which was screwed into the tree using a portable electric drill (Figure 3).

Each of the capsules contained 0.16 grams of active ingredient of picloram or triclopyr salts, and was compared to liquid formulations of picloram and triclopyr (amine) diluted to contain the same amount of active ingredient in one ml of solution. The hack-and-squirt method was chosen as the standard because it was the only technique that could be applied with a uniform, known amount of solution per injection. The hack-and-squirt method involved making a wound at a 45° angle to the stem and using a syringe to apply one ml of herbicide solution to the center of the wound. In practice, the herbicide is applied to each wound using a squirt bottle and is not as carefully metered.

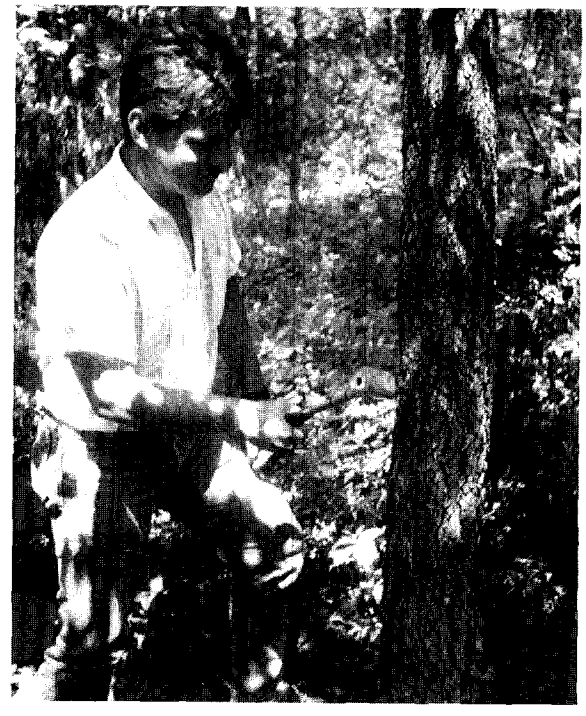

Figure 1. The FIC™ showing difficulty of application in dense stands.

Because only 100 capsules of each method/chemical combination were available, the study was limited to two common weedy hardwoods - red maple (*Acer rubrum*) and scarlet oak (*Quercus coccinea*). Red maple is representative of a thin bark, soft wood species, and scarlet oak is characteristic of a thick bark, hard wood species. In May of 1991, individual trees were randomly assigned one of the eight treatment/chemical combinations, measured for diameter at breast height

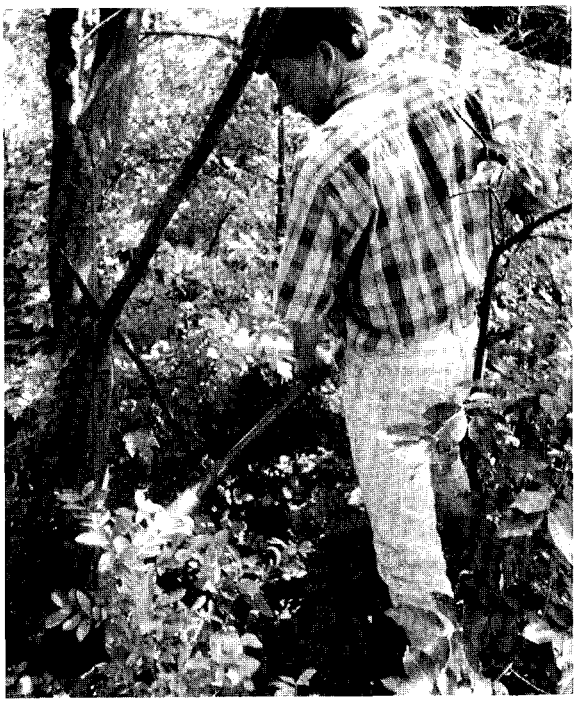

Figure 2. The EZ-Ject™ showing difficulty of application in dense stands (EZ-Ject photo substituted for the Wee-Do™).

(dbh), and treated at one injection per 2.5 cm of dbh. Trees averaged 15.0 cm dbh, limiting the number of replications per treatment combination to a maximum of eight. The experiment was designed as a completely randomized, two-factor factorial with individual trees as replicates.

Mortality was evaluated during the growing season of 1992 (one year after treatment). Assessment was limited to efficacy data and subjective utility evaluations since too few capsules were provided to collect good production efficiency data. Mortality data were analyzed by treatment and species using analysis of covariance with pretreatment diameters as the covariate. Fisher's LSD test was employed for mean separation.

Results and Discussion

Chemical and treatment evaluation. The standard hack-and-squirt technique proved to be the most efficacious treatment for both species (Table 1). This method resulted in 100% mortality when used with picloram and 89% mortality when formulated with triclopyr. Statistically, only the

Figure 3. The rechargeable portable drill used to apply Gelcaps™.

Wee-Do formulated with picloram resulted in equivalent mortality to that of the hack-and-squirt treatments. In addition, the FIC formulated with picloram was as efficacious as the Wee-Do used with picloram and the hack-and-squirt formulated with triclopyr. However, it was not as effective as the hack-and-squirt formulated with picloram.

Arithmetically, red maple was more effectively controlled than scarlet oak. However, this trend was not statistically significant (Table 1). Significant species-treatment interactions were found because the Gelcap had minimal activity on scarlet oak and no activity on red maple. Had the Gelcap been eliminated from the study, species differences would have been apparent and would have been attributed to differential bark thickness. Picloram was the more efficacious herbicide across all treatments - except for the Gelcap. Although the Gelcap formulated with triclopyr had higher mortality rates than did picloram, both mortality rates were extremely low. Consequently, the Gelcap is

Table 1. Injection method comparison for trees treated in the Summer of 1991 with triclopyr and picloram one year after treatment. Fishburn Forest, Blacksburg, VA.

Treatment	Red maple	Scarlet oak	Overall
	(percent mortality)		
Hack-and-Squirt			
triclopyr	86 ab[1]	93 a	89 AB[2]
picloram	100 a	100 a	100 A
Gelcap			
triclopyr	0 f	9 f	5 D
picloram	0 f	6 f	3 D
Wee-Do			
triclopyr	68 abc	19 ef	43 C
picloram	94 a	67 abc	81 AB
FIC			
triclopyr	46 cd	15 ef	31 C
picloram	80 ab	54 bc	67 B
Overall	58	47	

[1] Adjusted species - treatment interaction means within columns followed by the same letter(s) not significantly different at $p < 0.01$ from ANCOVA using pretreatment diameter as the covariate.

[2] Adjusted mean values within column followed by same letter(s) not significantly different at $p < 0.01$ from ANCOVA using pretreatment diameter as the covariate.

probably not a viable encapsulated herbicide application method as presently manufactured.

Assuming equipment and labor costs to be approximately equal for all four injection methods, differences in treatment costs can be attributed to capsule costs. While the hack-and-squirt has no associated encapsulation cost, herbicide costs are approximately $0.002 per cm diameter. Current minimum market prices for the encapsulated herbicides are approximately 4.5 cents (US) per cm diameter for the FIC, 1.8 cents per cm diameter for the Wee-Do, and 5.3 cents per cm diameter for the Gelcap (1).

Subjective tool evaluation. The FIC proved to be the most difficult tool for several reasons: 1) it required excessive force to drive it into scarlet oak, 2) after several applications it became stressing and more difficult to swing hard, and 3) it would be very inconvenient if the applications had to be accomplished in dense stands. Furthermore, since such a hard swing was needed to penetrate the bark, it was difficult to accurately apply the technique to trees smaller than 15 cm in diameter. One major failure arose when the steel tube extractor started to fall out of the head after about ten tree injections. Perhaps the FIC could be improved by adding a heavier head and a longer handle which would require less effort to swing.

The hack-and-squirt method required some physical strength, but not excessive amounts. This method did seem somewhat cumbersome in that, like the FIC, it required two separate steps. However, it proved much better than the FIC because the hand axe had a heavier head, longer handle, and the point of contact of the axe with the tree was greater. The improved leverage allowed for more accurate swings than did the FIC, and it was easier to use in dense stands.

Overall, the Gelcap was the easiest injection tool to use. It proved to be the least time consuming. The drill held up well over 200 injections, showing no signs of losing its charge. The drill was easy to carry through the woods and brush, and loading the caps was simple and quick. Had this method been more efficacious it would be the most practical alternative injection technique. Regarding its efficacy, we feel a major flaw was the failure of the plastic cap to penetrate the outer bark. The only chemical that made contact with the cambium was probably diffused along the hole made by the screw. If a metal cap with a sharp edge were developed, more chemical would probably reach the cambium due to a larger rupture of the bark surface. This may result in a more effective treatment.

The Wee-Do was fairly easy to use and required the least physical effort. The length of the lance posed some difficulty when maneuvering around brush and other trees. The Wee-Do had some reliability trouble involving bending parts in the head, causing some inconvenience. For example, we found it easier to load one shell at a time rather than depend on the self-loading mechanism. It may, however, have been merely out of adjustment, and would require little effort to fix. Given this

method's efficacy when used with picloram and its relatively low cost, this would be the most preferable alternative encapsulated herbicide injection technique.

Acknowledgment. The authors would like to thank Mr. Pat Burch and DowElanco, Inc., Indianapolis, IN, for their monetary and material support in this project.

Literature Cited

1. Bell, W. 1994. Personal communication with Mr. Bell, Treatment Alternatives Leader for the Vegetation Management Alternatives Program, Ontario Forest Research Institute, Sault Ste. Marie, Ontario.
2. Kidd, F. A. 1988. Application and use of herbicides in forest and industrial right-of-way sites. pp 297-312 **In** Methods of Applying Herbicides. C. G. McWhorter and M. R. Gebhardt (eds.) Weed Science Society of America Monograph Series 4. 358 p.
3. Lavy, T. L., J. S. Shepard and J. D. Mattice. 1980. *Exposure measurements of applicators spraying (2,4,5-trichlorphenoxy) acetic acid in the forest.* J. Agric. Food Chem. 28:626-630.
4. Lavy, T. L., L. A. Norris, J. D. Mattice and D. B. Marx. 1987. *Exposure of forestry ground workers to 2,4-D, picloram, and dichlorprop.* Env. Toxicol. and Chem. 6:209-224.
5. Libich, S., J. C. To, R. Frank and G. J. Sirons. 1984. *Occupational exposure of herbicide applicators to herbicides used along electric power transmission line right-of-way.* Am. Ind. Hyg. Assoc. J. 45:56-62.
6. Nickerson, N. H. 1992. *Impacts of vegetation management techniques on wetlands in utility rights-of-way in Massachusetts.* J. Arboric. 18:102-107.
7. Smith, T. K. 1984. *Determining line clearance needs at Wisconsin Power and Light Company.* J. Arboric. 10:205-208.
8. U. S. Department of Agriculture, Forest Service. 1990. Record of decision for the final environmental impact statement, Vegetation management in the Ozark/Ouachita Mountains. U. S. Dept. Agriculture, Forest Service, Southern Region, Management Bulletin R8-MB 45. March 1990.
9. Walstad, J. D. and F. N. Dost. 1984. The health risks of herbicides in forestry: a review of the scientific record. Forest Research Laboratory. Oregon State University, Corvallis. Special Publication 10. 60 p.

Research Specialist and Professor, respectively
Department of Forestry
Virginia Polytechnic Institute and State University
228 Cheatham Hall
Blacksburg, VA 24061-0324

Résumé. Trois méthodes d'injection d'herbicide en capsules — FIC, Wee-Do et Gelcap — furent comparées à une technique standard d'entaille et injection sur deux espèces communes d'arbustes ligneux, les herbicides utilisés étant le picloram et le triclopyr. Les deux composés chimiques montrèrent des tendances semblables avec les quatre méthodes d'injection; cependant, le picloram fut le plus efficace quelque soit la méthode de traitement. Le taux de mortalité le plus élevé fut obtenu avec la technique standard d'entaille et d'injection, avec des taux de 100% pour le picloram et de 89% pour le triclopyr. Les taux de mortalité avec le picloram furent de 81 et 67% pour, respectivement, les méthodes «Wee-Do» et «FIC», et inférieurs à 50% lorsque la substance chimique utilisée fut le triclopyr. La méthode «Gelcap» n'atteignit jamais un taux de mortalité supérieur à 10%, peu importe la substance chimique employée.

Zusammenfassung. Es wurden drei Methoden zur Injektion von entkapselten Herbiziden - FIC, Wee-Do und Gelcap - verglichen mit einer Standart-Spritzmethode auf zwei gewöhnlichen unerwünschten Sträuchern. Dabei wurde Picloram und Triclopyr benutzt. Beide Chemikalien zeigten ähnliche Auswirkungen bei den vier Anwendungen, obwohl Picloram such im ganzen als etwas effektiver zeigte. Die Mortalität war bei der Standart-Spritzmethode am größten, mit 100% Mortalität unter Benutzung von Picloram und 89% Mortalität bei Triclopyr. Die Picloram-Mortalitätsraten lagen bei 81 und 67% für die Wee-Do und FIC Methode und unter 50% bei der Benutzung von Triclopyr. Gelcap erreichte nie mehr als 10%ige Mortalität, egal in welcher Chemikalie gelöst.