# PESTICIDE APPLICATION TECHNIQUES FOR OPTIMIZING EFFICIENCY[1]

**by Franklin R. Hall**

**Abstract.** Optimization of pesticide usage requires proper attention to 4 basic principles: 1) correct identification of the problem, 2) selection of proper material, 3) optimum use of application equipment, and 4) proper timing of the control method. Present data indicate that there is much inefficiency in the application technique. The targeting dose technique, which requires the correct alignment of sprayer capacity and utilization to tree size, is presented and discussed. Inadequate concern for proper sprayer calibration can result in a waste of dollars, inadequate pest control and an excess of material placed on non-target areas. Greater attention to the basic principles of spray application technology can maximize spray delivery efficiency and, hence, your profit margin.

Chemicals for the control of insect and disease pests of trees and shrubs continue to play an important role in the protection of our valuable ornamentals. In fact, the prognosis is that even more effective chemicals will be developed for this important aspect of our industry. The question then arises, how well are we currently utilizing the equipment required to apply these valuable chemical tools. The sprayer of today is essentially the same as it was 30-40 years ago: liquid container, pump and nozzles. However, the chemicals have changed dramatically, with increases in efficacy of up to 20-fold over the standard pesticides of just 10 years ago. It is time that we paid extra attention to this valuable aspect of the plant protection process. In order for these chemicals to be utilized to their optimum potential, we should review the principles of the application process to insure that we are taking full advantage of this greater efficacy.

**The basic requirements.** Optimization of pesticides requires proper attention to basic principles: 1) *correct identification* of the problem, be it insect, disease, or physiological; 2) selection of the *correct material* for the job at hand; 3) *optimum use* of the chemical in correctly aligned equipment for the target; and 4) *proper timing* of the application. There is concern expressed by the public regarding potential hazards of chemicals that are being placed in the environment. There are increased regulatory constraints in the use of pest control chemicals. Pest resistance has not diminished in importance. These factors warn us that we must address this issue of improving the pesticide application process. The application process (Fig. 1) consists of an interaction of many complex levels of activity, all of which have significant effects on the success or failure of the operation. These are every day factors which can be improved (with some effort on your part). The most frequent problems encountered in pesticide application include the failure to calibrate properly for a successful match to the target and/or a lack of adequate equipment maintenance (nozzles, discs, pumps and pressure gauges). These basic factors along with improved training of your operators and the emphasis on continual adjustments are all subjects that need to be reinforced.

**Targeting.** The correct application method can be defined as getting the material to the target in sufficient amounts to do the job. Various spray application analyses have demonstrated how inefficient this process is, especially when trying to spray a tree 50 to 100 feet tall. As you can see from the following illustration (Fig. 2), significant amounts (ca. 55%) of pesticide are placed in the non-target environment during the application process. The improper match of the equipment to the target configuration exaggerates this already poor situation. Thus, control or minimization of the drift factor, excess run-off and poor target impaction efficiency are also included in this discussion of the application process.

1. Presented at the annual conference of the International Society of Arboriculture in Indianapolis, Indiana in August 1983.

The principles of targeting require that you have knowledge of the aforementioned 4 basic factors. Assuming that we have correctly identified the needs, chosen the proper chemical, we now need to match the target and the equipment. It is in this phase of the operation that we frequently find the most problems. Apparently we take it for granted. Targeting also requires that you adjust your equipment alignment as you change targets even within a customer's property, as well as between accounts. This will place extra demands on your operators to insure that they know the variables which can be manipulated for optimum application efficiency. This also means an increase in attention to a weak point common in arboricultural operations, which is *record keeping,* for each client's situation requires adjustments.

The change in pump pressure and nozzle sizes, as well as the spray gun operation, play a major role in the height of sprays. How high you can spray depends on the following factors which are under your control:

1. Pump pressure
2. Hose length
3. Hose diameter
4. Spray nozzles
5. Disc size
6. Pump capacity

**What about coverage and drift?** The spray ap-

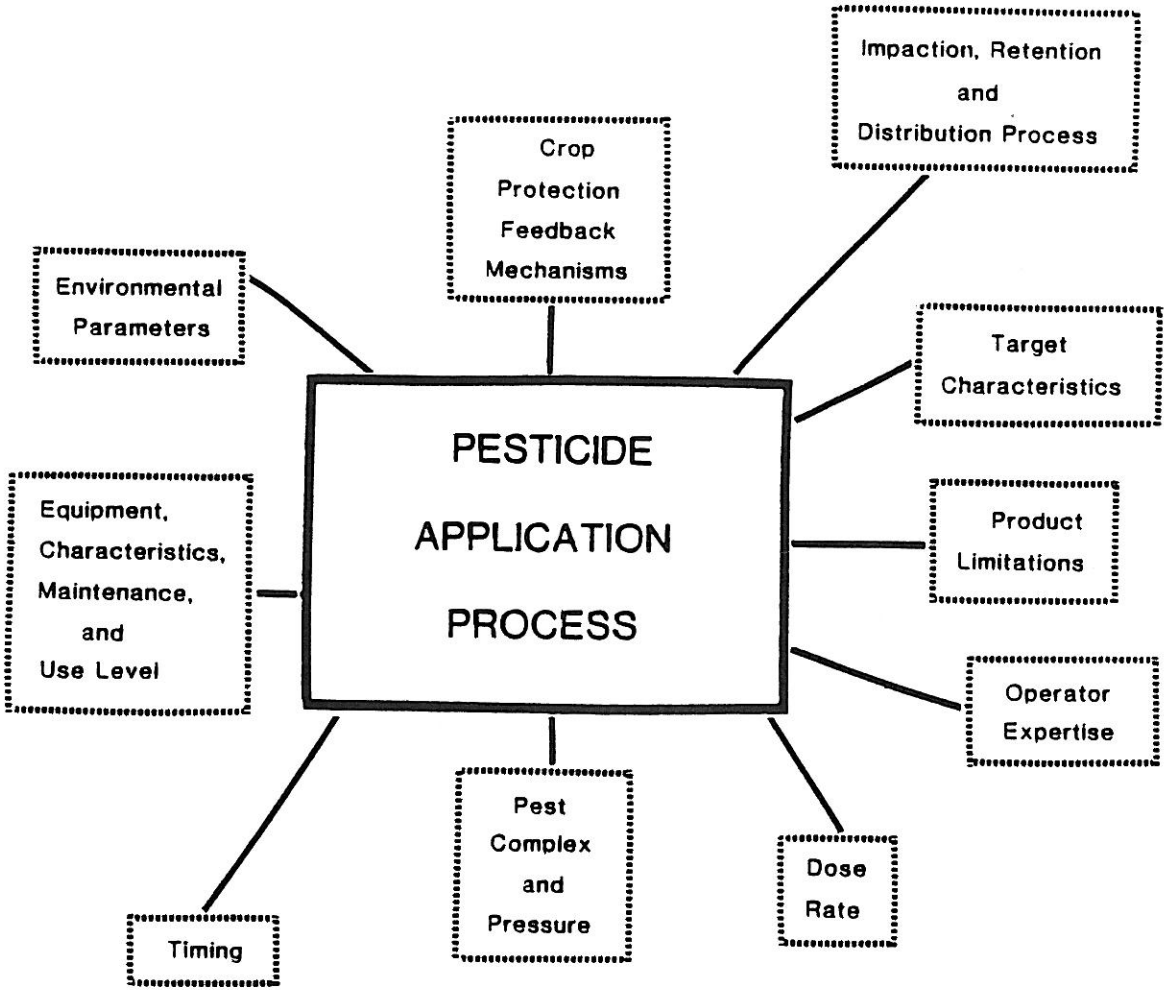


**Fig. 1. Interaction of many complex levels of activity are incorporated in the success or failure of the application process.**

plication process has been estimated to account for approximately 70% of pest control efficiency. But is good coverage obtained at the expense of drift or excessive use of chemicals? It can be if the equipment calibration and the operator are not correctly matched for the target. Hydraulic sprayers produce a wide range of droplet sizes, a portion of which can be a major contribution to off-target contamination. Conditions which control drift are the system pressure, flow of spray solution, and especially the size and configuration of the spray nozzle/surface. Droplet sizes in these sprayers can range from a low of 5 to 10 microns (μm) to a high of 1000 um. This wide pattern in droplet size can account for both the variation in coverage and drift and hence performance.

In general, the smaller the droplets, the more efficient the coverage if we can impinge these smaller droplets on the foliar surface. There are different energy requirements needed for impingement of droplets; smaller droplets are more responsive to even slight environmental turbulence, and hence become part of the drift portion of the spray. Under low prevailing winds, the proper spraying techniques can minimize drift to non-target trees and areas. Table 1 shows the *theoretical* coverage obtained with different sizes of droplets. This assumes that the droplets can be spread evenly over a plant surfact. When spraying tall trees (50 feet and above), however, small droplets can be a major problem. You should schedule these situations for early morning applications.

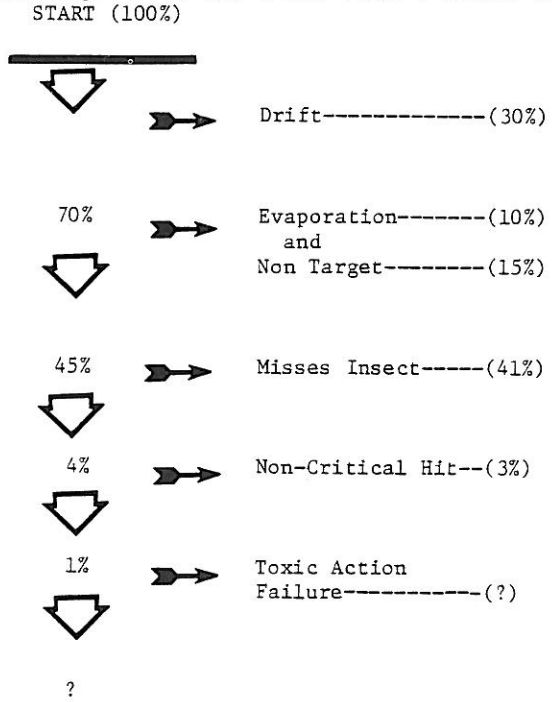


**Fig. 2. A typical spray deposition efficiency analysis.**

**Table 1. Theoretical plant surface coverage obtained by sprayed 1 liter of spray evenly over 1 hectare with various sizes of droplets.**

| *Droplet diameter* | *Number of droplets/cm²* |
|---|---|
| 10 | 19099 |
| 20 | 2387 |
| 50 | 153 |
| 100 | 19 |
| 200 | 2.4 |
| 400 | 0.298 |
| 1000 | 0.019 |

The potential for drift is influenced by the 6 factors listed in Table 2. The first 3 are under your direct control, the last 3 can be major contributors to excessive drift and poor coverage if you continue the application process during poor weather conditions. A delay in application undoubtedly complicates scheduling and labor usage, but, at the same time, repeat applications may not be needed if it is done properly. In addition, the excessive hazards of drift problems (and hence legal problems) caused by poor application conditions, can often be avoided by better planning and more efficient use of equipment and personnel.

**Table 2. Variables affecting the amount of pesticide drift from hydraulic nozzles.**

| | |
|---|---|
| 1. Droplet size | 4. Evaporation rate |
| 2. Droplet weight | 5. Air movement |
| 3. Spray pressure | 6. Temperature and RH |

There will always be some drift. The GPM pump capacity can be insufficient in many situations. Increasing pump pressure will add to the drift potential. Continued adjustments in discs, pump pressure and the spraying protocol will enable you to effectively spray various targets. Good judgment and planning plus communication with ad-

joining property owners can eliminate potential application lawsuits. In addition, spray away from houses (not towards windows) and spray inward from the adjoining property.

**Calibration.** Hydraulic sprayer calibrations for various tree sizes are dependent upon using 400 psi at the nozzle and adjusting the pressure for a combination of factors. Changes in pressure are influenced by rate of flow, viscosity of liquid, hose diameter and smoothness, number of fittings and hose length. A 10% loss in pressure can be created by a hose reel or meter. The National Arborist Association has an excellent pesticide calibration worksheet, which I highly recommend. You should review it at your earliest opportunity. Table 3 shows the disc sizes needed to yield various spray heights and Table 4 shows the disc capacity in GPM. The NAA worksheet enables you to calculate the pressure settings at the pump. These values are dependent upon the hose length and size, disc size, plus the adjustments for couplings, hose reels and meters.

**Table 3. Tree heights and disc sizes[1].**

| *Approx. height* | *Disc* | *Nozzle psi* | *Min. Pump GPM* |
|---|---|---|---|
| Up to 40-65' | #14 or smaller | 350 to 400 | 25 |
| 50' to 70' | #16 | 375 to 450 | 35 |
| 65' to 110' | #22 | 375 to 450 | 50 |

1. All at a minimum of ¾" hose diameter.

**Table 4. Disc capacity in GPM.**

| *Disc size* | *400 psi* | *500 psi* |
|---|---|---|
| 14 | 21.1 | 23.5 |
| 16 | 26.5 | 29.6 |
| 18 | 34.0 | 38.0 |
| 22 | 52.5 | 57.8 |

## The Future Outlook

The future of spraying by arborists will, in part, depend upon how well we maximize our efforts to optimize our spraying techniques. If we do our job well, we will be able to continue to use chemical tools. If not, we can blame ourselves for not having done the job right. It's a case of *"back to basics."*

The concept of pest management in agriculture is also related to the philosophy of a tree health care program for you as arborists. Monitoring for tree problems is more difficult than spraying. It takes more technically trained personnel, but the potential gains are many. They include the use of chemicals only when needed, thus reducing the chemical load in the urban environment. Some species of trees are not susceptible to diseases or insect pests, consequently, we do not need to spray all trees. The costs of chemicals continue to escalate and pest resistance and secondary problems continue to flare up. The hazards and the amount of spraying in the urban environment continue to be debated (and perhaps they will be even more regulated in the future). I believe that the time is right to engage in a program of upgrading our expertise in pesticide applications. You, your operators, and the environment (from the resulting increases in efficiency and reduced costs) will all benefit from this improved application efficiency. Your understanding of basic principles of application technology as well as your willingness to actively utilize calibration routines may well determine our future usage of these chemical tools for arboriculture.

**References**

1. Hall, F. and D. Reichard. 1978. Keeping pesticide application on target. Amer. Fruit Grower, June 1978. p. 21-22.
2. Hall, F. 1978. Pitfalls in the application of pesticides to tree fruits. Wisconsin-Minn. Hort. Meeting. Jan. 1982.
3. Hall, F. 1982. An assessment of crop protection opportunities in real world agroecosystems. Purdue University Symposium, October 1982.
4. Matthews, G. 1979. Pesticide application methods. Longman, London and New York. 334 p.
5. National Arborist Association. 1983. Targeted Pesticide Applications (slide program and study worksheets). New York.

*Professor*
*Department of Entomology and*
*Head, Laboratory for Pest Control*
*Application Technology*
*Ohio Agricultural Research and*
*Development Center*
*The Ohio State University*
*Wooster, Ohio 44691*