CHAPTER 6: CONCLUSIONS

Contact Phytotoxicity Study

Abaxial leaf surfaces are more sensitive than adaxial leaf surfaces for all three tree species, suggesting that the herbicide formulations require further optimization. The adaxial leaf surface of sweetgum was the least sensitive to any herbicide formulation. The abaxial surface of red oak shows the highest overall contact phytotoxicity to all formulations. Hence there are significant species differences in formulation sensitivity and therefore potential differences in herbicide efficacy. When 24h data is considered, overall the addition of the organosilicone surfactants Silwet L-77 and Silwet 408 to the triclopyr amine formulation does not reduce the individual species' contact phytotoxicity responses. However, it is more appropriate to consider the rate at which contact phytotoxicity can develop over the 24 h period. In that comparison, the addition of the organosilicone surfactants Silwet L-77 and Silwet 408 delayed and reduced phytotoxicity in red oak (the most susceptible species to contact phytotoxicity), and to a lesser extent in red maple, but increased the rate in sweetgum.

Contact phytotoxicity of Garlon 4, Garlon 3A and triclopyr triethylamine salt (all at 1.6% ae) plus 0.2% Silwet L-77 on the three plant species in relation to their uptake and translocation have been studied subsequently by the author (Forster *et al.,* 1997). The formulations were applied as 0.24 µl droplets. The relative amounts of herbicide translocated out of the treated leaf was related to the rate at which contact phytotoxicity developed. Considering both the adaxial and abaxial leaf treatment results, within each species and formulation combination, there was in every case, lower translocation (of absorbed herbicide) where there was greater or earlier contact phytotoxicity. There were also clear differences in translocation trends between the form of the herbicide ($P < 0.001$). The ester formulation showed lower translocation overall for all three species, possibly caused by the need for hydrolysis to the free acid first. There were also clear species differences ($P < 0.001$). Overall, red oak was the most susceptible species with respect to contact phytotoxicity and translocated all three formulations least. If similar formulation forms are compared, then formulations translocate most in sweetgum, with much lesser contact phytotoxicity symptoms. This species exhibits very low translocation only with the triclopyr +

Silwet L-77 treatment to the abaxial surface, where it also shows earlier and greatest contact phytotoxicity. Similar effects are observed with red maple. The addition of Silwet L-77 to triclopyr triethylamine salt was found to improve uptake of the active ingredient into the three plant species, to equal or exceed that demonstrated by the ester formulation.

This adds weight to the conclusions made in the contact phytotoxicity study: if the droplet size becomes too big, then efficacy will be reduced; increasing the concentration of active ingredient above a certain limit will not increase efficacy, and may in fact reduce it; the addition of the organosilicone surfactants Silwet L-77 and Silwet 408 delayed and reduced phytotoxicity in red oak (the most susceptible species to contact phytotoxicity), and to a lesser extent in red maple, but increased the rate in sweetgum. It is advantageous that the greatest potential is to improve efficacy towards red oak, as red oak is the most resistant of the three tree species to triclopyr (pers. Com. S.M. Zedaker).

Adhesion and Retention Study

Since the principal purpose of the adhesion and retention screening was to identify the "best" formulations for further evaluation and testing, it is appropriate to consider which method is more suitable or more discriminatory between the different formulations. The adhesion data is fully quantitative; the retention data is semi-quantitative. In addition, most results tended to be 100% or close to it with the retention method; in contrast, there was a greater spread or range of results with the adhesion data.

All new formulations gave greater adhesion than the commercial formulations, with Triclopyr TEA plus sequestrant plus n-octyl pyrrolidone plus Silwet 408 giving, overall, the greatest adhesion ($p=0.05$). Increasing product concentration gave greater adhesion. Increasing droplet size and angle of impact reduced adhesion. The adaxial leaf surface showed higher adhesion than the abaxial leaf surface. Adhesion was higher on sweetgum, followed by red oak, with red maple being the most difficult species to get formulations to adhere to.

Whereas increasing product concentration improves adhesion, the best contact phytotoxicity result would be from lowering product concentration. Looking at both sets of results, the best product concentration of those studied would then be 1.6% ae as this can provide high adhesion, while still enabling us to choose a formulation which gives minimal contact phytotoxicity.

In the laboratory formulation had no significant effect on retention. However, there are other considerations which affect retention that need to be kept in mind. It was observed that droplets containing organosilicone could impact an already wetted surface and still be adhered / retained, whereas those droplets not containing any organosilicone surfactant would bounce quite a distance on impact with a pre-wetted surface. Impaction with an already wetted surface was not part of this study, and therefore was not studied quantitatively. If, in practice, droplets were to impact an already wetted surface (due to high volume spraying), then retention would be much lower by formulations containing no organosilicone surfactant, than those containing organosilicone surfactants. Also, formulations provide greater “wrap-around” to the lower surface (Forster and Zabkiewicz, 1998), which is of great benefit when stomata are only on the abaxial surface, as is the case with these species. 100% retention was defined as a droplet which impacted and did not bounce further than a 1 cm radius. If the droplet were to impact the edge of the leaf, it may well bounce off.

Concentration and leaf angle also had no significant effect on retention. Droplet size was significant, with retention decreasing with increasing droplet size. Retention to the adaxial surface was significantly higher than retention to the abaxial surface. There was no significant difference overall between sweetgum and red oak, but retention to red maple was significantly lower.

It is concluded that adhesion data ratings are the better choice than retention data ratings. Understanding primary adhesion and the interactions between a droplet and a leaf surface should lead to a better definition of desired formulation and adjuvant properties.

We have achieved what we set out to do, ie. improve the amine formulation so that it gave equal to or greater adhesion than Garlon 4.

Spray Retention under Field and Track-Sprayer Conditions

The addition of the organosilicone surfactant Silwet 408 to the amine formulation gives the same total deposition as the commercial ester formulation, Garlon 4, while enhancing the abaxial retention as a percentage of total deposition. This means that the addition of organosilicone surfactant may have the ability to enhance herbicide uptake via the abaxial leaf surface, and therefore enhance efficacy. Field trial results showed that the alcohol ethoxylate, DA6, is not an essential component of the triclopyr amine / Silwet 408 formulation, in terms of retention.

The track sprayer did not replicate field results, a possible explanation being that the plants were too close to the spray nozzle when going under the track sprayer, and therefore the drops had a much higher velocity than those hitting the plants in the field, causing increased reflection of the spray droplets. It must be noted, however, that the abaxial retention as a percentage of total deposition was the same for both the field trial and the track-sprayer study.

The percentage of total theoretical spray deposition in both trials was quite low. This was possibly due to poor application technique, and this is an area in which potential gains may be realized. Smaller droplets may have provided higher retention.

Leaf Characteristics (Wax Character and Leaf Angle)

In agreement with published literature, the micro-roughness of the leaf surface can be used as a guide to explain adhesion results. The difference among trees in terms of leaf angles appeared to be much less important in explaining retention. From the droplet generator study, we would have expected there to be close to 100% retention in the field study, which was far from the case.

An important point made in the introduction and justification is worth reiterating here. This project was split between the physico-chemical processes and the biological processes and the author focused on the former, with a foray into the biological side with regard to contact phytotoxicity. The results of these two studies need to be compiled to enable the best surfactant

formulation to be determined, as the studies in isolation may point to formulations which in fact do not give good efficacy.