SPRAY RETENTION UNDER FIELD AND TRACK-SPRAYER CONDITIONS

Spray Retention under Field Conditions

The spray formulations and droplet size used in this study were decided upon at a meeting with the sponsors of this research (DowElanco & OSi Specialties) after reviewing the results from all earlier work in this study. Garlon 4 was included as the commercial formulation that the experimental amine formulations needed to match or improve upon, in relation to retention, wrap-around to the under surface of the leaves, and of course efficacy (efficacy was not an objective for study in this thesis). Silwet 408 was comparable, if not slightly better than Silwet L-77 with respect to adhesion and contact phytotoxicity results, and was chosen by OSi Specialties as the organosilicone of choice to work with. Although, overall, n-octyl pyrrolidone would appear to be the best co-surfactant to use, it is also much more expensive to manufacture than the alcohol ethoxylate (DA6), and the difference in performance between the two did not warrant the increased cost, therefore DowElanco chose to use DA6 as the co-surfactant along with Silwet 408. Adhesion and contact phytotoxicity results indicated that the inclusion of the co-surfactant may not be of practical benefit, so the triclopyr amine formulation with Silwet 408 without a co-surfactant was also studied in the field trial. The highest concentration of triclopyr (3.2% a.e.) was shown to cause severe contact phytotoxicity and was therefore not studied in the field trial. The 2000 μm droplets gave the lowest adhesion and the highest contact phytotoxicity and therefore this droplet size was not used in the field study. It was not viable to study two droplet sizes in the field trial. Large diameter droplets are preferred so as to minimize drift, and Radiarc sprayers producing droplets much greater than 1000 μm are used in forest site preparation and forest release in the Southern USA. It was decided that 1000 μm droplets would be more acceptable from a drift management point of view.

The results of spray retention by the adaxial and abaxial leaf surfaces of sweetgum, red maple and red oak are shown in Table 18. There is a significant difference between retention by the adaxial surface, and retention by the abaxial surface. This is a reflection of the difference in surface

roughness between the adaxial and abaxial leaf surfaces, and is in agreement with the published literature (Wirth *et al.*, 1991; Anderson *et al.*, 1987).

Spray retention by the adaxial leaf surface

In the analysis of retention by the adaxial surface, treatment was significant (p=0.039) as was species (p=0.0159). Garlon 4 is significantly different to triclopyr TEA + sequestrant (TTEA) + Silwet 408 (p=0.0163) and significantly different to TTEA + Silwet 408 + alcohol ethoxylate (DA6) (p=0.0513). The addition of DA6 to the TTEA + Silwet 408 formulation makes no significant difference (p=0.5123), and concentration of active ingredient makes no significant difference (p=0.898). Retention by sweetgum is significantly different to both red maple (p=.0058) and red oak (p=0.0344), whereas red maple is not significantly different to red oak (p=0.4313).

Table 18: Retention (µl/100 cm^2) and mean retentions of triclopyr formulations by adaxial and abaxial surfaces of sweetgum, red maple and red oak.

	%	Sweetgum		Red Maple		Red Oak		$\bar{x}$		
Formulation	**Conc**	**Ad**	**Ab**	**Ad**	**Ab**	**Ad**	**Ab**	**Ad**	**Ab**	**Ad+ Ab**
Garlon 4	0.72	69.6 ab	13.6 cd	65.4 ab	10.0 d	58.0 abcd	17.9 cd	64.3	13.8	39.1
Garlon 4	3.59	87.6 a	15.0 cd	45.8 abcd	16.2 cd	46.6 bcd	17.5 cd	60	16.2	38.1
TTEA + Silwet 408	1 0.1	48.2 abcd	24.9 abcd	35.7 bcd	32.2 ab	28.2 cd	11.5 cd	37.4	22.9	30.1
TTEA+ Silwet 408	5 0.1	54.2 abcd	16.0 cd	28.8 cd	35.0 abc	46.4 abcd	28.9 abc	43.1	26.6	34.9
TTEA + Silwet 408 + DA6	1 0.1 0.01	57.1 abcd	18.8 abcd	24.6 d	20.5 abcd	50.7 abcd	25.2 abcd	44.1	21.5	32.8
TTEA + Silwet 408 + DA6	5 0.1 0.05	58.7 abc	21.1 abcd	38.4 bcd	38.3 a	44.0 bcd	22.8 bcd	47	27.4	37.2
$\bar{x}$		62.6	18.2	39.8	25.4	45.7	24.8			
$\bar{x}$ **(Ad + Ab)**		40.4		32.6		35.3				

Within columns and leaf surfaces, treatments with no letter in common are significantly different.

Spray retention by the abaxial leaf surface

In the analysis of retention by the abaxial leaf surface, none of the main effects (treatment, concentration and species) were significant.

Abaxial retention as a percentage of total deposition

Abaxial retention as a percentage of total deposition is shown in Table 19. Deposition is defined here as the total amount of spray retained by the leaf in µl / 100 cm^2 , considering just one side of the leaf surface to be exposed directly to the spray, i.e. plan area of the leaf. Analysis of retention as a percentage of total deposition showed both treatment and species to be significant ($p=0.0001$). Garlon 4 is significantly different (lower) to both the TTEA plus Silwet 408 formulation ($p=0.0001$) and the TTEA plus Silwet 408 plus DA6 formulation ($p=0.0001$). The addition of Silwet 408 greatly enhances the percentage abaxial retention compared to Garlon 4 ($p=0.0001$). The addition of DA6 to the TTEA plus Silwet 408 formulation makes no significant difference ($p=0.7348$). Concentration of active ingredient makes no significant difference ($p=0.5835$). Sweetgum is significantly different from both red maple ($p=0.0001$) and red oak ($p=0.0067$). Red maple is significantly different to red oak ($p=0.0309$).

Table 19: Abaxial retention as a percentage of total deposition (µl/100 cm^2) of triclopyr formulations by sweetgum, red maple and red oak.

Formulation	% Conc	Sweetgum % Ab retention	Red Maple % Ab retention	Red Oak % Ab retention	$\bar{x}$ of treatment
Garlon 4	0.72	16 ef	13 f	24 def	17.7
Garlon 4	3.59	15 f	26 bcd	27 cde	22.7
TTEA **+ Silwet 408**	1 0.1	34 abc	47 ab	18 abc	36.7
TTEA **+ Silwet 408**	5 0.1	23 cde	55 ab	38 abc	38.7
TTEA **+ Silwet 408** **+ DA6**	1 0.1 0.01	25 cde	45 ab	33 bcd	34.3
TTEA **+ Silwet 408** **+ DA6**	5 0.1 0.05	26 cd	50 a	34 abcd	36.7
$\bar{x}$ **of species**		23.2	39.3	30.8	

Treatments with no letter in common are significantly different.

Total and theoretical spray deposition

Hess (1987) stated that "the leaf shape of individual leaves and their orientation with respect to the spray determine the amount of spray that comes into contact with the shoot (stem, together with its leaves) tissue. Only plant surfaces in the direct path of the spray will intercept herbicide, unless through secondary interception. Other parameters being equal, the greater the surface area of shoots oriented perpendicular to the spray, the greater will be the interception of the herbicide".

If the leaves were fully exposed to the spray, then the theoretical total spray available to be deposited on the leaf surface is 140 µl / 100 cm^2. Table 20 shows the total spray and percentage theoretical deposited on the leaf surfaces (µl / 100 cm^2) if we consider just one side of the leaf surface to be exposed directly to the spray. In the analysis of total spray deposition, none of the main effects (treatment, concentration and species) were significant. The effect of the addition of

Silwet 408 to the amine formulation has been to achieve the same total deposition as the commercial ester formulation (Garlon 4), while increasing the deposition / retention ratio to the abaxial leaf surface.

The average percentage of theoretical deposition for sweetgum was 57.5%, for red maple was 47% and for red oak was 50%. There could be several reasons for such low (in comparison to the laboratory based, single droplet, adhesion and retention study) depositions. It is quite likely that the leaves were not all perpendicular to the spray. However the plan area of the leaves to the spray for all three tree species was still high, so this explanation can only account for a proportion of the loss, unless the trajectory of the spray was not close to being vertical. As only fully exposed leaves were studied, shielding from other leaves or plants should not have been a factor. The application volume rate was low, but run-off could have been a factor with the formulations containing Silwet 408. Other possible explanations for the low deposition could have been reflection of the droplets due to their large size, or reflection from pre-wetted surfaces.

Table 20: Total deposition (µl / 100 cm^2, taking the leaf area to be that of one side of the leaf surface only) and % of total theoretical spray deposit available, of triclopyr formulations to three plant species.

Formulation	% Conc	Sweetgum		Red Maple		Red Oak	
		Total	% Theor.	Total	% Theor.	Total	% Theor.
Garlon 4	0.72	83.2	59	75.4	54	75.9	54
Garlon 4	3.59	102.6	73	62	44	64.1	46
TTEA + Silwet 408	1 0.1	73.1	52	67.9	49	43	31
TTEA + Silwet 408	5 0.1	70.2	50	63.8	46	75.3	54
TTEA + Silwet 408 + DA6	1 0.1 0.01	75.9	54	45.1	32	75.9	54
TTEA + Silwet 408 + DA6	5 0.1 0.05	79.8	57	76.7	55	66.8	48

From tests of fixed effects, treatment is not significant for total.

Spray retention under Track-Sprayer Conditions

Spray retention by the adaxial and the abaxial leaf surface

The results of spray retention by the adaxial and abaxial leaf surfaces of sweetgum, using droplet sizes of approximately 650 μm and 1000 μm, are shown in Table 21.

In the analysis of deposition to the adaxial leaf surface of sweetgum, none of the main effects (treatment, concentration and drop size) were shown to be significant.

In the analysis of spray retention by the abaxial leaf surface, treatment was highly significant (p=0.0001) as was drop size (p=0.0001) and concentration (p=0.0002). Garlon 4 gives significantly different (p=0.0001) retention to the TTEA + Silwet 408 + DA6 formulation. The addition of Silwet 408 to the amine formulation can increase retention by the abaxial surface compared to Garlon 4. 650 μm spray droplets can give significantly (p=0.0001) higher retention to the abaxial leaf surface compared to 1000 μm spray droplets.
Retention by the adaxial surface is significantly higher (p=0.0001) than retention by the abaxial surface.

Abaxial retention as a percentage of total deposition and total deposition

Analysis of abaxial retention as a percentage of total deposition showed both treatment and drop size to be highly significant (p=0.0001)(Table 22). Concentration was also significant (p=0.0154). The addition of Silwet 408 to the amine active ingredient significantly increased (p=0.0001) the percentage abaxial retention, ie. it increased the amount retained by the abaxial surface compared to the overall leaf deposition. 650 μm spray droplets enabled a higher percentage abaxial retention to overall deposition, than did 1000 μm spray droplets.

For total deposition drop size is significant (p=0.01), treatment is only significant at p=0.054, while concentration is not significant (p=0.5)(Table 22).

Table 21: Retention (µl/100 cm^2) of triclopyr formulations by the adaxial and abaxial surfaces of sweetgum using 650 µm and 1000 µm droplets

Formulation	% Conc	Sweetgum			
		650 µm	1000 µm	650 µm	1000 µm
		Ad	Ad	Ab	Ab
Garlon 4	0.72	37.6 ^{abc}	43.7 ^{a}	10.1 ^{bcd}	3.0 ^{f}
Garlon 4	3.59	36.5 ^{abc}	37.1 ^{abc}	7.2 ^{cde}	6.2 ^{e}
Garlon 4	7.2%	22.9 ^{d}	31.0 ^{bcd}	12.2 ^{b}	6.7 ^{de}
TTEA + Silwet 408 + DA6	1 0.1 0.01	34.5 ^{abc}	26.7 ^{cd}	9.6 ^{bcd}	8.4 ^{cde}
TTEA + Silwet 408 + DA6	5 0.1 0.05	28.3 ^{cd}	29.1 ^{cd}	23.0 ^{a}	8.8 ^{bcde}
TTEA + Silwet 408 + DA6	10 0.1 0.1	45.5 ^{a}	40.9 ^{ab}	18.8 ^{a}	10.0 ^{bc}

Within adaxial columns and abaxial columns, treatments with no letter in common are significantly different.

Table 22: Abaxial retention as a percentage of total deposition, together with total deposition (μl / 100 cm^2) of triclopyr formulations by sweetgum.

Formulation	% Conc	Sweetgum			
		650 μm	1000 μm	650 μm	1000 μm
		% Ab retention	% Ab retention	Total	Total
Garlon 4	0.72	21 ^{cde}	6 ^{f}	47.6 ^{bc}	46.4 ^{bc}
Garlon 4	3.59	16 ^{de}	14 ^{e}	43.8 ^{bcd}	43.4 ^{bcd}
Garlon 4	7.2%	35 ^{ab}	18 ^{de}	35.2 ^{d}	37.6 ^{cd}
TTEA + Silwet 408 + DA6	1 0.1 0.01	22 ^{cde}	24 ^{bcd}	44 ^{bcd}	35 ^{d}
TTEA + Silwet 408 + DA6	5 0.1 0.05	45 ^{a}	23 ^{bcd}	51.4 ^{ab}	37.8 ^{cd}
TTEA + Silwet 408 + DA6	10 0.1 0.1	29 ^{bc}	20 ^{cde}	64.4 ^{a}	50.8 ^{b}

Within abaxial ratio columns, treatments with no letter in common are significantly different.
Within Total columns, treatments with no letter in common are significantly different.

The field results are very different from the track-sprayer results for adaxial, abaxial and total deposition (Tables 23 and 24). However, it is interesting to see that the percentage abaxial retention is generally the same for the field study and the track-sprayer study (Table 24). Total deposition, and retention by both the adaxial and abaxial leaf surfaces of sweetgum was much lower for plants put through the track-sprayer, compared to plants sprayed in the field, which was quite unexpected. One would have expected the reverse to be true due to the fact that within the track-sprayer: the target is well exposed to the spray; there is a still air environment so that there is, in effect, no drift; there is no interference from non-target foliage. One possible explanation is that the plants were much closer 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 is also possible that the spray from the radiarc sprayer had a higher percentage of smaller droplets than was the case using the track sprayer nozzles, resulting in higher deposition. Another very real possibility is that the leaf

morphology and orientation of the leaves were quite different in the field trial carried out in Virginia, to those grown in New Zealand.

Table 23: Field and track sprayer spray retention by adaxial and abaxial sweetgum leaf surfaces using 1000 μm spray droplets

Formulation	% Conc	Sweetgum			
		Field	Track-sprayer	Field	Track-sprayer
		Ad	Ad	Ab	Ab
Garlon 4	0.72	70	44	14	2.7
Garlon 4	3.59	88	37	15	6.2
TTEA + Silwet 408 + DA6	1 0.1 0.01	57	27	19	8.4
TTEA + Silwet 408 + DA6	5 0.1 0.05	59	29	21	8.8

Table 24: Percentage abaxial retention as a percentage of total deposition, along with total deposition (μl/100 cm^2) for both field and track-sprayer results using 1000 μm spray droplets

Formulation	% Conc	Sweetgum			
		Field	Track-sprayer	Field	Track-sprayer
		% Ab retention	% Ab retention	Total	Total
Garlon 4	0.72	16	7	83	46
Garlon 4	3.59	15	15	100	43
TTEA + Silwet 408 + DA6	1 0.1 0.01	25	26	76	35
TTEA + Silwet 408 + DA6	5 0.1 0.05	26	27	78	38