Sweetgum, 0.24 µl

Contact phytotoxicity caused by all formulations to the adaxial leaf surface is nil or negligible at all three concentrations (Figure 9). At 0.32% a.e. contact phytotoxicity to the abaxial leaf surface is also nil or negligible for all formulations. At 1.6% a.e. high to severe contact phytotoxicity is caused to the abaxial surface by all formulations except the two commercial formulations, Garlon 4 (1) and Garlon 3A (2), and the TTEA formulation (3). This is probably due to lower uptake for the formulations not containing organosilicone. At 3.2% a.e. high to severe contact phytotoxicity is caused to the abaxial leaf surface by all formulations except the commercial formulation Garlon 3A (2). An example of contact phytotoxicity caused by 0.24 µl droplets on sweetgum can be seen in Figure 10, a and b.

Sweetgum, 4 µl

Again there is nil or negligible contact phytotoxicity caused to the adaxial surface by all formulations at all three concentrations, except at 3.2% a.e. where TTEA plus Silwet 408 (10) causes high contact phytotoxicity (Figure 11). At 0.32% a.e there is nil to mild contact phytotoxicity caused by all formulations on the abaxial surface, with the TTEA plus n-octyl pyrrolidone plus Silwet 408 formulation (4) and the TTEA plus alcohol ethoxylate plus Silwet 408 (6) formulation causing the greatest amount of contact phytotoxicity. At 1.6% a.e., as with the 0.24 µl droplets, high to severe contact phytotoxicity is caused to the abaxial surface by all formulations except the two commercial formulations, Garlon 4 (1) and Garlon 3A (2). The TTEA formulation (3) caused slightly more contact phytotoxicity than Garlon 3A (2), probably due to the higher concentration per unit leaf area. At 3.2% a.e. extreme contact phytotoxicity is caused to the abaxial leaf surface by all formulations. TTEA plus n-octyl pyrrolidone plus Silwet 408 (4), TTEA plus alkylphenolic glycol ether plus Silwet 408 (8) and TTEA plus alkylphenolic glycol ether plus Silwet L-77 (9) caused severe contact phytotoxicity within 2 hours. Analysis of variance again demonstrates that drop size is highly significant ($P < 0.001$; Figure 9 vs. Figure 11). An example of contact phytotoxicity caused by 4 µl droplets on sweetgum can be seen in Figure 10, c and d.

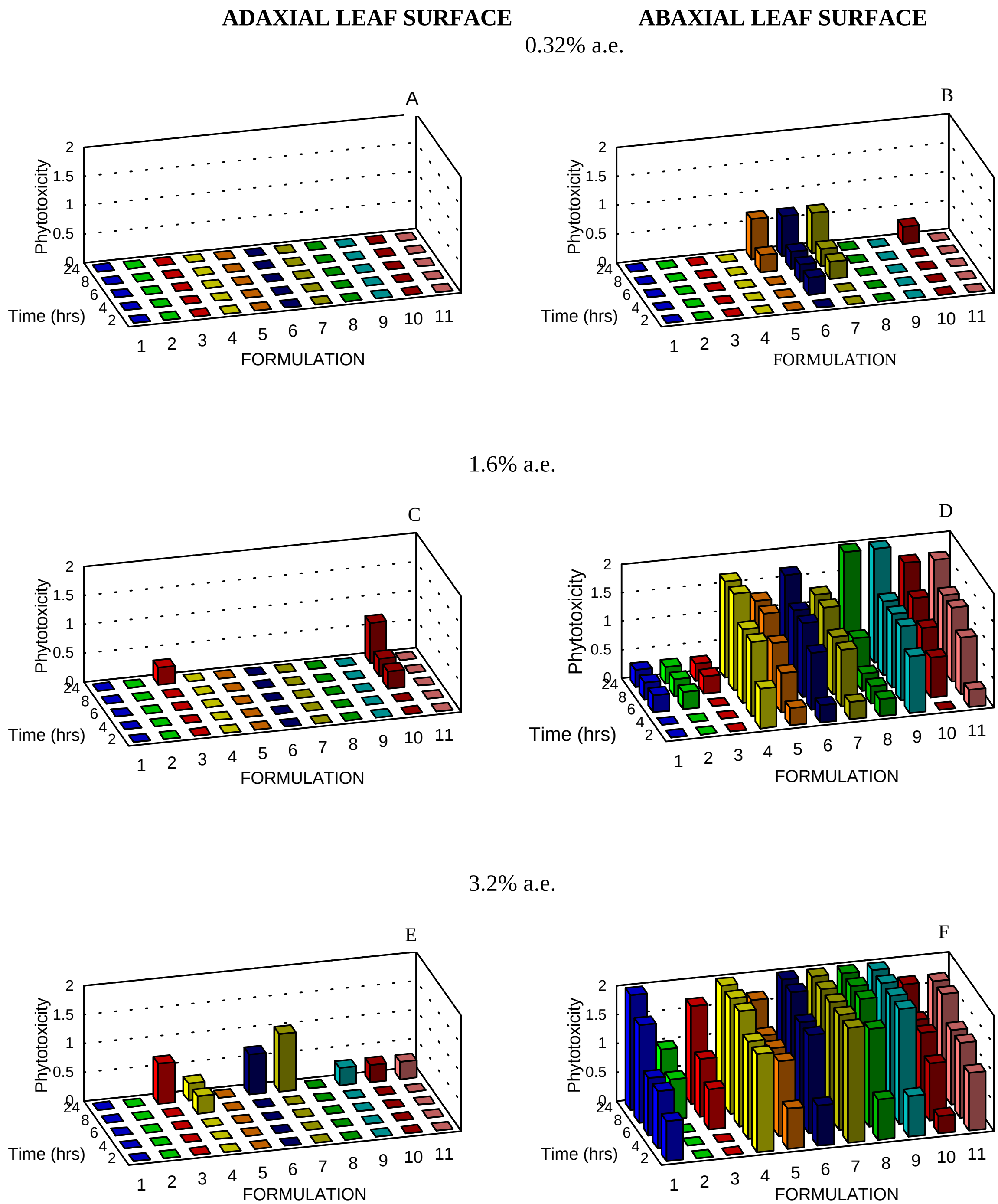
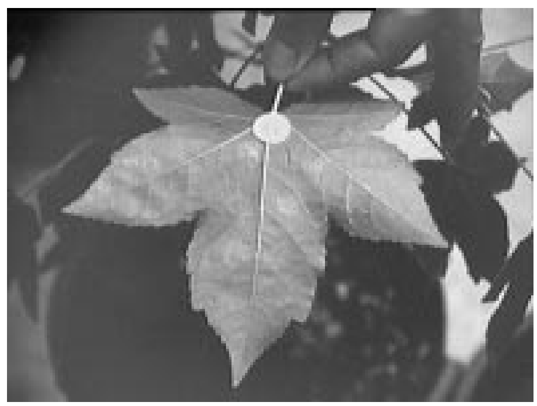


Figure 9: Comparison of contact phytotoxicity caused by 0.24 ul droplets of formulations at 3 concentrations to adaxial and abaxial surfaces of sweetgum. Formulations: 1 = Garlon 4, 2 = Garlon 3A, 3 = triclopyr TEA + sequestrant (TTEA), 4 = TTEA + n-octyl pyrrolidone + Silwet 408, 5 = TTEA + n-octyl pyrrolidone + Silwet L-77, 6 = TTEA + alcohol ethoxylate + Silwet 408, 7 = TTEA + alcohol ethoxylate + Silwet L-77, 8 = TTEA + alkylphenolic glycol ether + Silwet 408, 9 = TTEA + alkylphenolic glycol ether + Silwet L-77, 10 = TTEA + Silwet 408, 11 = TTEA + Silwet L-77

a. *10% triclopyr TEA + sequestrant + n-octyl pyrrolidone + 0.2% L-77 applied as 0.24 ul droplets to the abaxial surface (adaxial view).*

b. *10% triclopyr TEA + sequestrant + n-octyl pyrrolidone + 0.2% L-77 applied as 0.24 ul droplets to the abaxial surface.*

c. *10% triclopyr TEA + sequestrant + n-octyl pyrrolidone + 0.2% L-77 applied as 4 ul droplets to the abaxial surface (adaxial view).*



d. *10% triclopyr TEA + sequestrant + n-octyl pyrrolidone + 0.2% L-77 applied as 4 ul droplets to the abaxial surface.*

Figure 10: Examples of contact phytotoxicity on sweetgum.

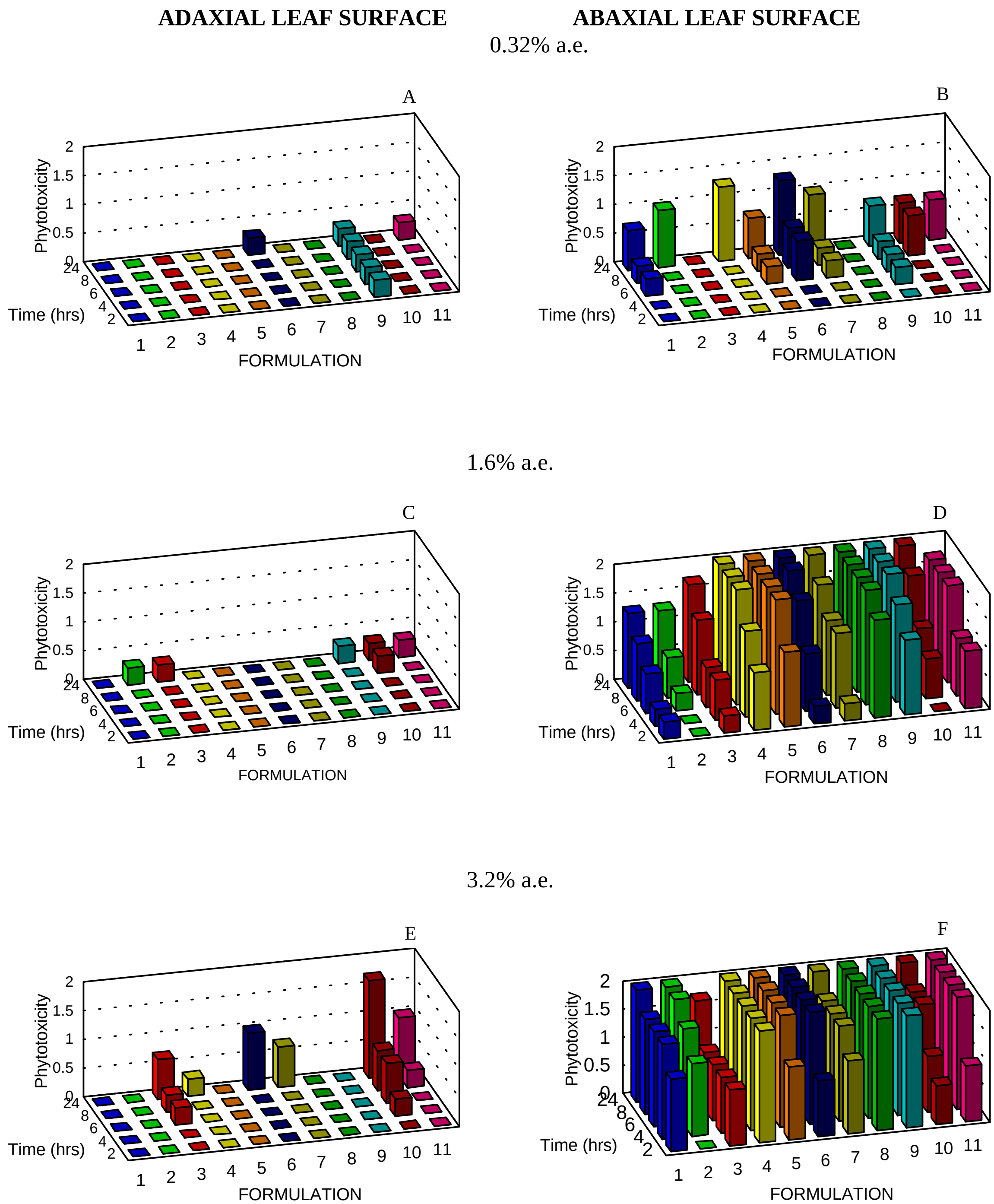


Figure 11: Comparison of contact phytotoxicity caused by 4 ul droplets of 11 formulations at 3 concentrations to adaxial and abaxial surfaces of sweetgum.

Formulations: 1 = Garlon 4, 2 = Garlon 3A, 3 = triclopyr TEA + sequestrant (TTEA), 4 = TTEA + n-octyl pyrrolidone + Silwet 408, 5 = TTEA + n-octyl pyrrolidone + Silwet L-77, 6 = TTEA + alcohol ethoxylate + Silwet 408, 7 = TTEA + alcohol ethoxylate + Silwet L-77, 8 = TTEA + alkylphenolic glycol ether + Silwet 408, 9 = TTEA + alkylphenolic glycol ether + Silwet L-77, 10 = TTEA + Silwet 408, 11 = TTEA + Silwet L-77

Red Oak, 0.24 μl

At 0.32% a.e. there is nil to mild contact phytotoxicity caused to both adaxial and abaxial leaf surface by all formulations (Figure 12). At 1.6% a.e. there is nil to mild contact phytotoxicity caused to the adaxial leaf surface by all formulations except for Garlon 4 (1) and the TTEA formulation (3) which cause high to severe contact phytotoxicity respectively, at 24 hours. On the abaxial surface TTEA plus Silwet 408 (10) is the only formulation to show only mild contact phytotoxicity at 24 hours. At 3.2% a.e. all formulations caused mild to severe contact phytotoxicity to the adaxial surface except for TTEA plus Silwet 408 (10) and TTEA plus Silwet L-77 (11) which both cause nil or negligible contact phytotoxicity over the 24 hour time period. These two formulations also take the longest to develop contact phytotoxicity on the abaxial leaf surface, with TTEA plus alcohol ethoxylate plus (6) Silwet 408 and (7) Silwet L-77 developing severe contact phytotoxicity by 6 hours. An example of contact phytotoxicity caused by 0.24 μl droplets on red oak can be seen in Figure 13, a.

Red Oak, 4 μl

At 0.32% a.e. nil to mild contact phytotoxicity is caused to the adaxial leaf surface by all formulations with the TTEA plus n-octyl pyrrolidone plus Silwet 408 formulation (4) and the TTEA plus alcohol ethoxylate plus Silwet L-77 formulation (7) causing the highest contact phytotoxicity (Figure 14). Both the TTEA plus Silwet 408 formulation (10) and the TTEA plus Silwet L-77 formulation (11) caused nil to negligible contact phytotoxicity over the 24 hour period on both adaxial and abaxial leaf surfaces. At 1.6% a.e. all formulations caused nil or negligible contact phytotoxicity to the adaxial leaf surface over the 24 hour period except for the two commercial formulations and the TTEA formulation which caused mild contact phytotoxicity at 24 hours. Mild to severe contact phytotoxicity is caused to the abaxial surface, with the TTEA plus alcohol ethoxylate plus Silwet L-77 formulation (7) showing the least contact phytotoxicity at 24 hours. At 3.2% a.e. the TTEA plus Silwet 408 (10) and the TTEA plus Silwet L-77 (11) formulations show nil or negligible contact phytotoxicity towards the adaxial leaf surface over the 24 hour period, while the TTEA plus n-octyl pyrrolidone plus Silwet

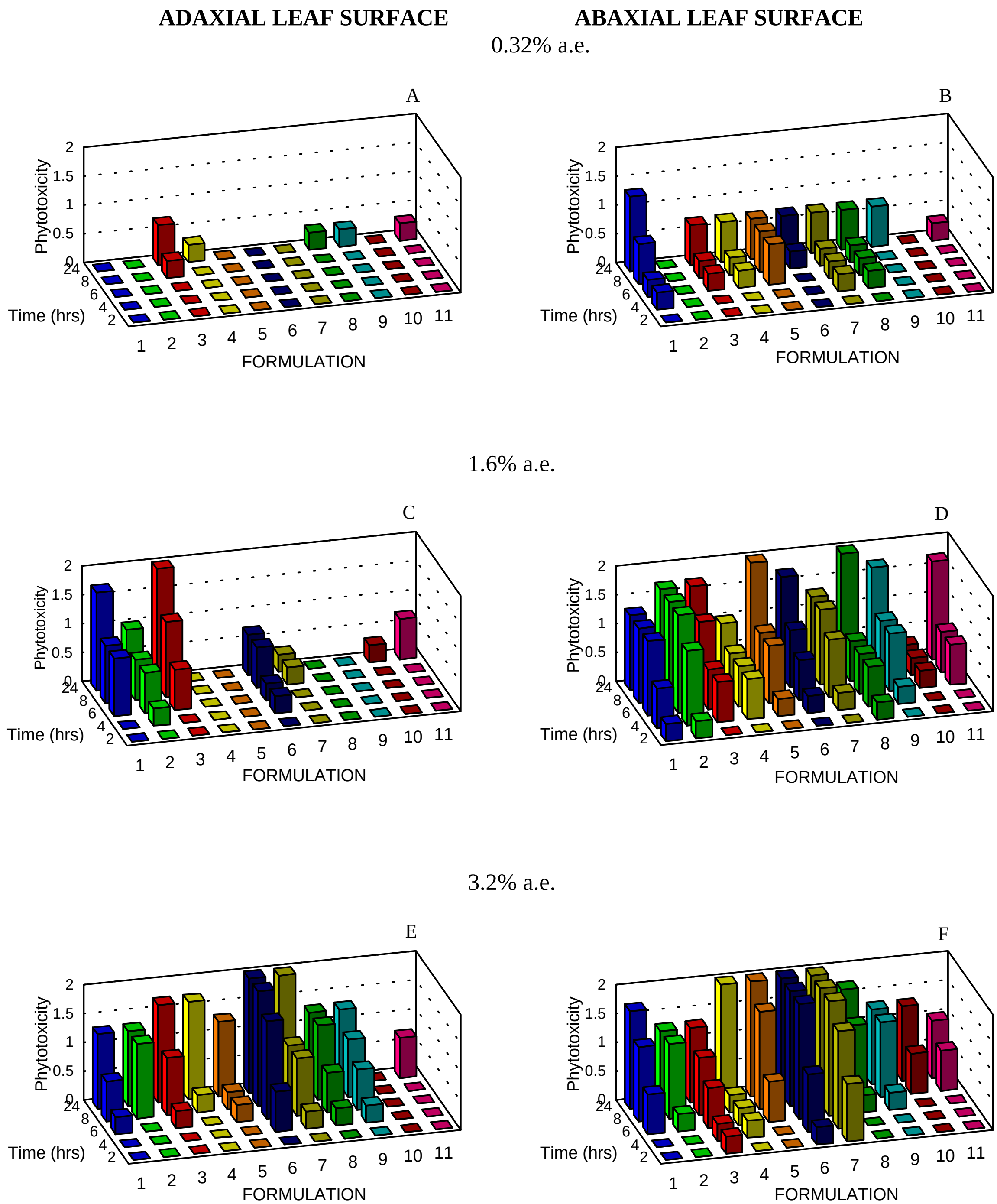


Figure 12: Comparison of contact phytotoxicity caused by 0.24 ul droplets of 11 formulations at 3 concentrations to adaxial and abaxial surfaces of red oak.

Formulations: 1 = Garlon 4, 2 = Garlon 3A, 3 = triclopyr TEA + sequestrant (TTEA), 4 = TTEA + n-octyl pyrrolidone + Silwet 408, 5 = TTEA + n-octyl pyrrolidone + Silwet L-77, 6 = TTEA + alcohol ethoxylate + Silwet 408, 7 = TTEA + alcohol ethoxylate + Silwet L-77, 8 = TTEA + alkylphenolic glycol ether + Silwet 408, 9 = TTEA + alkylphenolic glycol ether + Silwet L-77, 10 = TTEA + Silwet 408, 11 = TTEA + Silwet L-77

L-77 formulation (5) and the TTEA plus alkylphenolic glycol ether plus Silwet 408 formulation (8) cause nil contact phytotoxicity for the first 8 hours and only mild contact phytotoxicity at 24 hours. On the abaxial surface the TTEA formulation (3), TTEA plus Silwet L-77 (11), TTEA plus Silwet 408 (10) and TTEA plus alkylphenolic glycol ether plus Silwet L-77 (9) formulations show mild phytotoxicity at 24 hours while all other formulations show severe contact phytotoxicity at 24 hours. Analysis of variance demonstrated that drop size was not highly significant ($P>0.05$; $P<0.1$) for this species, unlike for sweetgum and red maple, where drop size was highly significant ($P< 0.001$). An example of contact phytotoxicity caused by 4 μl droplets on red oak can be seen in Figure 13, b.

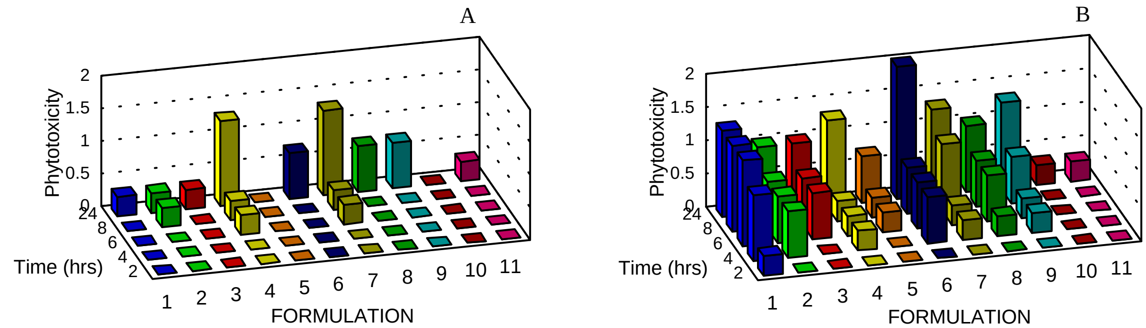
a. *10% triclopyr TEA + sequestrant + 0.2% Silwet L-77 + 0.1% alcohol ethoxylate applied as 0.24 ul droplets to the adaxial surface*

b. *10% triclopyr TEA + sequestrant + 0.2% Silwet 408 + 0.1% alkylphenolic glycol ether applied as 4 ul droplets to the adaxial surface.*

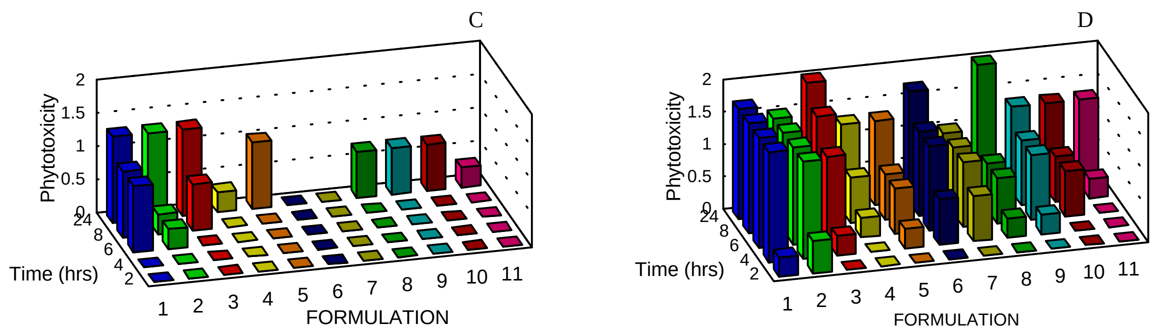
Figure 13: Examples of contact phytotoxicity on red oak.

ADAXIAL LEAF SURFACE **ABAXIAL LEAF SURFACE**

0.32% a.e.



1.6% a.e.



3.2% a.e.

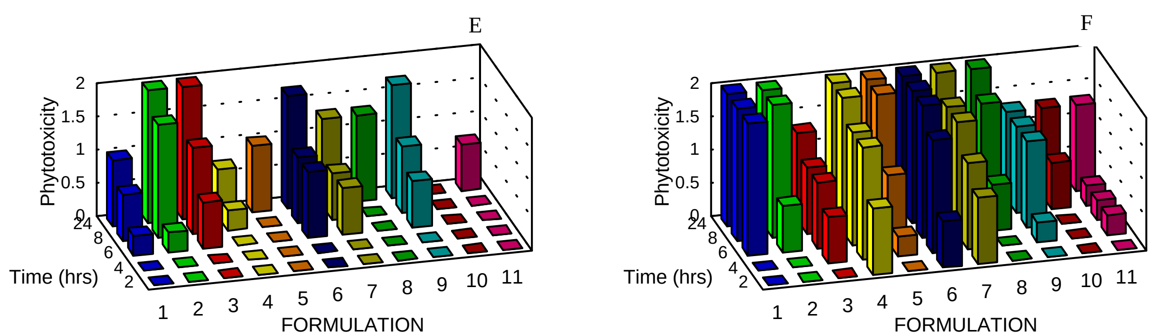


Figure 14: Comparison of contact phytotoxicity caused by 4 ul droplets of 11 formulations at 3 concentrations to adaxial and abaxial surfaces of red oak.

Formulations: 1 = Garlon 4, 2 = Garlon 3A, 3 = triclopyr TEA + sequestrant (TTEA), 4 = TTEA + n-octyl pyrrolidone + Silwet 408, 5 = TTEA + n-octyl pyrrolidone + Silwet L-77, 6 = TTEA + alcohol ethoxylate + Silwet 408, 7 = TTEA + alcohol ethoxylate + Silwet L-77, 8 = TTEA + alkylphenolic glycol ether + Silwet 408, 9 = TTEA + alkylphenolic glycol ether + Silwet L-77, 10 = TTEA + Silwet 408, 11 = TTEA + Silwet L-77

Overall Results

Comparing Figures 6, 8, 9, 11, 12 and 14 it can be seen that, of the three tree species, the adaxial surface of sweetgum is the least susceptible to the herbicide formulations. The adaxial leaf surfaces of red oak and red maple are much more susceptible to the herbicide formulations, and behave similarly. The adaxial leaf surface is less susceptible than the abaxial leaf surface for all three tree species. Looking at the results from the abaxial leaf surfaces it can be seen that for red maple, the commercial formulations can be improved to provide lesser, or a slower development of, contact phytotoxicity below concentrations of 3.2 % a.e.. Commercial formulations can also be improved for red oak. However the two commercial formulations cannot be improved upon with the formulations in this study, in relation to contact phytotoxicity effects on the abaxial leaf surface of sweetgum.

Overall, contact phytotoxicity developed more rapidly and was more severe when 4 μl droplets were applied compared to when 0.24 μl droplets were applied. This is in agreement with the findings of Merritt (1982), who found that “scorch” (contact phytotoxicity) increased with increasing droplet size of difenzoquat applied to *Avena fatua*, and that the activity of difenzoquat was inversely related to the severity of scorch. This also fits with the findings of Ennis and Willianson (1963) that small-droplet applications were more effective than large-droplet ones, and their hypothesis that the small droplets were more effective due to efficient absorption and translocation of the herbicide, whereas “large droplets of high concentration probably become physiologically isolated because of their profound effects on the leaf cells in direct contact with the substances”. McKinlay *et al.* (1972) appeared to confirm this hypothesis when they examined different sized droplets of 2,4-D on sunflower leaves. Leaf cells directly below 400 μm droplets were seen to collapse and eventually die, whereas this did not happen with 200 and 100 μm droplets of the same concentration.

Contact phytotoxicity increased with increasing concentration of active ingredient, which is in agreement with the findings of Merritt (1982). However Merritt detected no difference in the rate of appearance of contact phytotoxicity between the concentrations unlike the findings of the present study.