

DIURNAL INFLUENCES ON 2,4,5-T APPLICATION OVER GORSE AND RADIATA PINE

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ABSTRACT

Trial results show that 2,4,5-T iso-octyl ester applied at a "releasing" rate (1.44 kg/ha a.i.) gave better control of gorse when applied between 0900 and 1500 hours. However, radiata pine seedlings were damaged least by early morning or evening spraying.

INTRODUCTION AND METHOD

Several trials have been conducted to determine the effects of atmospheric conditions on the effectiveness of spraying for gorse (*Ulex europaeus*) control (Davenhill, 1976; Balneaves, 1978, 1980a).

A further trial was conducted to quantify the diurnal influences on the effect of 2,4,5-T iso-octyl ester on gorse and radiata pine (*Pinus radiata*, D. Don), seedlings.

Gorse and radiata pine seed were stratified and sown into 6-litre pots of soil mix and raised in a glasshouse for 5 months. As the seeds germinated and seedlings developed they were thinned out so that each pot contained only one gorse plant and one radiata pine seedling. In addition, pots containing one radiata pine seedling only, served as a non-gorse control.

When the pine seedlings had reached 10 cm in height, the pots were placed outside to "harden-off" for a 6 week period prior to spraying on 9 October 1979. At the time of spraying the pine seedlings were 14-15 cm tall and the gorse plants were 9-10 cm tall. The radiata pine were just beginning to show signs of rapid shoot elongation. The gorse plants were "spiny" to grasp in the lower 6 cm portion of the stem while the upper 3-4 cm was fresh shoot development which was "soft and leafy". Twenty pots were used for each treatment (Table 1) and spraying was carried out using 1.44 kg a.i. 2,4,5-T in 326 litres of water/hectare. No surfactant was used.

Temperature, relative humidity, vapour pressure deficit (VPD), and plant wetness following spraying were recorded for each spraying time (Table 1).

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TABLE 1: TIMING OF 2,4,5-T APPLICATION, WITH CLIMATIC CONDITIONS AND OBSERVATIONS ON PLANT WETNESS FOR EACH SPRAYING

<i>Trt No.</i>	<i>Time of Appln (hr)</i>	<i>Temp. (°C)</i>	<i>R.H. (%)</i>	<i>VPD (mb)</i>	<i>Comments on Spray Droplet Retention (Wetness) on Gorse Plant</i>
1	0600	7.9	68	1.3	Wetness maintained for 20 min
2	0900	16.5	50	9.4	Wetness maintained for 3 min
3	1200	20.6	44	13.6	Wetness maintained for 2 min
4	1500	21.0	44	13.9	Wetness maintained for 2 min
5	1800	12.0	83	2.4	Still wet after 60 min
6	Unsprayed control of gorse and pines				
7	Unsprayed control of pines only				

The first treatment was applied at 0600 hours, five minutes before sunrise. The last treatment was applied after sunset, at 1800 hours. No dew was observed on the plants either before the first, or following the last treatment. During the day of spraying the sky was clear and sunny with no wind. Conditions remained fine and warm for 5 days following spraying.

All potted plants were subjected to a bottom watering treatment the day prior to spraying and on the second day following spraying.

A thermohydrograph was set in position among the potted plants to record temperature and humidity during the day of spraying and from these data the vapour pressure deficit was calculated.

RESULTS

By 1500 hours on the day following spraying the gorse that had been treated at 0900, 1200 and 1500 hours showed effects of the herbicide treatment. Seven days after spraying both the gorse and the radiata pine seedlings were affected. The pines showed some twisting of the terminal needles and chlorosis and this became progressively worse up to a month after treatment.

At one month all gorse plants were desiccated and brown in colour.

At two months many trees in the series sprayed at 0600 and 1800 hours showed signs of recovery but some apical death was present in those treatments sprayed at 0900, 1200 and 1500 hours. One tree sprayed at 1500 hours was dead.

By three months a few gorse plants in all the sprayed treatments had developed fresh shoots from the base of the stem and soon became vigorous. All trees by this stage were showing signs of recovery though they failed to develop a green healthy colour when compared with the unsprayed controls.

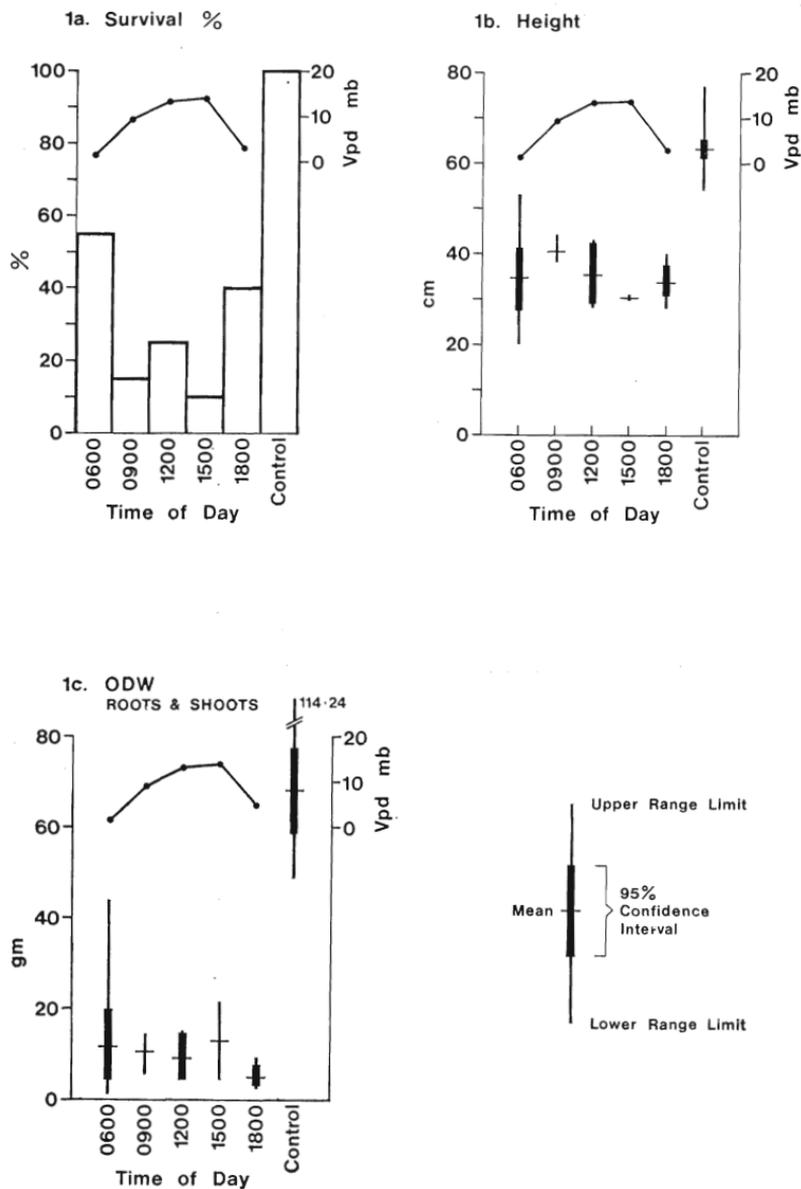


FIG. 1: Survival percentages and growth parameters for gorse in relation to spraying time-of-day. VPD figures for visual comparison only.

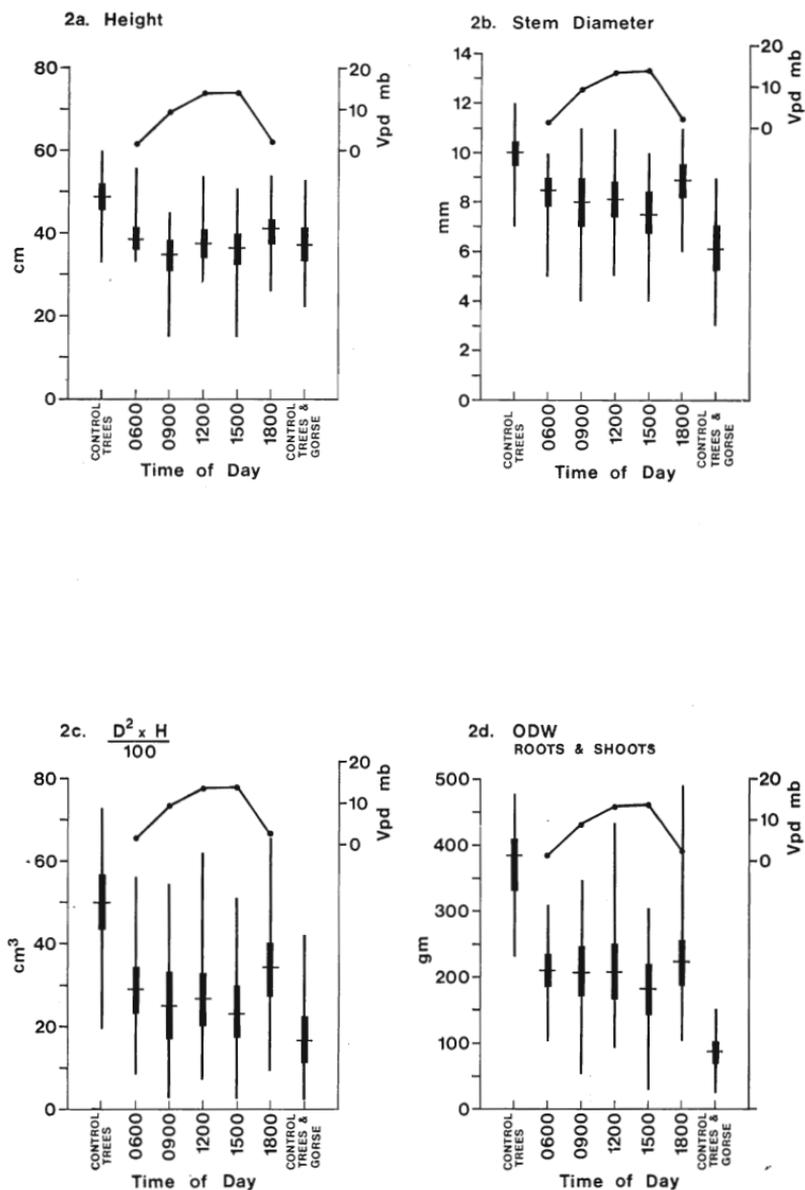


FIG. 2: Growth parameters for trees in relation to spraying time-of-day.

At 8 months from spraying a final assessment was made and results are illustrated in Figs. 1 and 2.

Percentage survival, height (H) and combined oven dry weight of shoots plus roots (ODW) were analysed for gorse. Height, diameter (D), bulk ($D^2 \times H$) and combined oven dry weight were analysed for *P. radiata* trees.

Vapour pressure deficit values for each treatment time are included on the figures (1a-c, 2a-d). No statistical analyses are quoted for VPD. This variable is partially dependent on the treatment variable time. To compare spraying effect for differing VDP levels, there should preferably be common levels of time.

The treatment times may be considered a quantitative factor, so the usual testing between each pair of treatment levels is not reproduced here (*i.e.*, χ^2 test for pairs of levels for survival of gorse plants, Duncan's Multiple Range Test or the various LSD tests for the parametric measurements on the plants and trees). Sufficient previous trial results (Chavasse, 1976) allow the construction of *a priori* hypotheses of lesser treatment effect for "edge of day" spraying times (0600 hr, 1800 hr).

Gorse

Between 45% and 90% of plants were killed with 2,4,5-T applied at the various treatment times; the most effective appeared to be 0900, 1200 and 1500 hour applications. Figure 1a gives survival percentages for clarity. Contingency tests, using chi-square analysis, were carried out for several comparisons decided by the initial hypothesis.

Table 2 shows that spraying during the main part of the day gives a significantly better kill rate of gorse than the edge of day treatments.

TABLE 2: CHI-SQUARE CONTINGENCY TABLE RESULTS OF THE EFFECTS OF SPRAYING TIMES OF DAY ON GORSE (MORTALITY)

	<i>Comparisons</i>	<i>Contingency χ^2</i>
Control (trees + gorse)	All spray trts.	34.78**
Edge of day (0600, 1800 hr)	Middle part of day (0900, 1200, 1500 hr)	11.08**
Morning (0600 hr)	Evening (1800 hr)	0.90
Variation in middle part of day (0900, 1200, 1500 hr)		1.68

**significant ($P \leq 0.01$)

Growth suppression of gorse may be caused by two factors:

- (1) Effect of the herbicide spray — growth retardation or death of gorse plant.
- (2) Vigour of the contiguous radiata pine tree.

The latter can be taken to have negligible effect on gorse growth.

The simple effect of the spray on gorse growth has been measured in previous trials (unpublished data). Here, the remaining growth of the gorse plants can be examined in two ways. The first is by comparing mean growth over all spray treatments with the unsprayed control, the mean being calculated using the number of live plants only — *i.e.*, the retardation effect on the remaining live gorse. The second method is similar, except the total growth is divided by the original number of gorse plants to give a mean of “net” growth. Table 3 shows that there is significantly less growth by the surviving gorse of the treatments than the control plants ($P < 0.01$, one-sided hypothesis) for all analyses.

A one-way analysis of variance was calculated for gorse with linear and quadratic regression components extracted from the time-of-day spraying effect (Snedecor and Cochran, 1967; Chew, 1977). Note: Where a regression component is shown to be significant, then axiomatically all levels of the quantitative factor are significantly different in their effects (Chew, 1977:8).

Table 4 shows no significant difference for spray time treatment effects ($P > 0.05$) and no significant differences for the first two regression components ($P > 0.05$) for both gorse height and ODW. However, some of the samples for the various spraytimes are very small.

Pinus radiata

Growth suppression may be caused by two factors:

- (1) Effect of the herbicide spray.
- (2) Vigour of the contiguous gorse plant.

The simple effect of spray on tree growth was not directly measured in this trial, but has been the topic of previous work (unpublished data). However, an approximate test of this effect may be made by comparing the control without gorse and the mean of the spraytimes treatments for trees, where the contiguous gorse plants were no longer living. Tree growth suppression due to the simple effect of crowding was measured by comparing the two control samples. Table 3 shows significantly less growth with no live gorse present for sprayed trees compared with the unsprayed control trees ($P < 0.01$, one-sided hypothesis). The crowding effect on tree growth was significant also ($P < 0.01$, one-sided hypothesis):

TABLE 3: ONE-SIDED STUDENT'S T-TESTS ON GROWTH SUPPRESSION OF GORSE PLANTS BY HERBICIDE SPRAY. ALSO GROWTH SUPPRESSION OF *P. RADIALATA* TREES BY HERBICIDE SPRAY AND BY CONTIGUOUS GORSE PLANTS.

Effect	Control	Treatment	DF	H	D	$D^2 \times H$	ODW
Spray on gorse:							
(1) Retardation of living gorse	Gorse with adjacent trees	Surviving gorse for all spray trts.	47	15.754**			12.207**
(2) Net growth†	Gorse with adjacent trees	Surviving gorse for all spray trts.	117	29.608**			13.557**
Spray on trees	Trees without gorse	All spray trts. without gorse	88	5.989**	5.033**	6.613**	8.750**
Crowding of trees	Trees without gorse	Control with adjacent gorse	38	4.551**	7.715**	8.095**	15.039**

*Significant ($P \leq 0.05$)

**Highly significant ($P \leq 0.01$)

†Net growth is defined as total growth of living plants ÷ original number of plants

TABLE 4: ONE-WAY ANALYSIS OF VARIANCE ON SPRAYING TIMES-OF-DAY WITH REGRESSION COMPONENTS EXTRACTED FOR HEIGHT AND ODW MEASUREMENTS OF GORSE

Source of Variation	DF	MS	
		Height	ODW
Treatment (spray times)	4	37.680	71.871
Linear component	1	15.203	214.889
Quadratic component	1	21.418	17.520
Deviations	2	57.050	27.537
Error	24	52.749	70.632
Total	28	50.596	70.809

No significant differences ($P > 0.05$) in table.

Time-of-day spraying effects were analysed by carrying out the following statistical tests. A two-way analysis of variance, presence/absence of adjacent gorse plant (random factor) and times of herbicide spraying (fixed factor) showed no significant differences for main effects or for interaction (Table 5). The *t*-tests on each

TABLE 5: TWO-WAY ANALYSIS OF VARIANCE ON SPRAYING TIMES-OF-DAY AND PRESENCE/ABSENCE OF ADJACENT GORSE PLANT FOR VARIOUS *P. RADIATA* MEASUREMENTS

Source of Variation	DF	MS			
		Height	Diam.	$D^2 \times H/100$	ODW
Adjacent gorse (live/dead)	1	42.50	7.572	376.6	37.71
Time of spraying	4	88.08	5.034	315.8	77.15
Interaction	4	16.34	1.885	120.2	20.07
Error	89	54.13	2.655	198.8	70.38
Total	98	55.50	2.792	206.6	67.34

No significant differences ($P > 0.05$) in table

spraytime live/dead gorse sample pair gave no significant differences. Thus a contiguous gorse plant did not significantly depress growth compared with no adjacent gorse plant for each spraytime treatment. Results available on request for the *t*-test.

Linear and quadratic regression components were extracted from the spraytime treatment effects (Table 6). The quadratic component, with a minimum near the middle of day, generally showed significance (except ODW). Without the linear component being significant, the shape of the regression curve is an upright U. Thus the herbicide applied at 600 and 1800 hr generally gave

TABLE 6: ONE-WAY ANALYSIS OF VARIANCE ON SPRAYING TIMES-OF-DAY WITH REGRESSION COMPONENTS EXTRACTED FOR VARIOUS *P. RADIATA* MEASUREMENTS

Source of Variation	DF	MS			
		Height	Diam.	$D^2 \times H/100$	ODW
Treatment (spray times)	4	125.234	5.569	404.38	61.190
Linear component	1	99.466	1.018	235.71	9.356
Quadratic component	1	278.214*	13.644*	954.33*	86.688
Deviations	2	61.629	3.807	213.74	74.358
Error	94	52.536	2.674	198.21	67.605
Total	98	55.503	2.792	206.63	67.343

*Significant ($P \leq 0.05$)

a significantly decreased effect in the suppression of *P. radiata* growth compared with the application times closer to noon.

CONCLUSIONS

The conclusions are general and, if more data were available on a similar trial, regression equations for the quadratic component could be quoted and therefore quantitative estimates given for effect of times of spraying.

However, this initial work has indicated that, while a better kill rate and stronger suppression of gorse could be achieved by spraying between 0900 hours and 1500 hours, radiata pine tree damage was more severe at this time.

Spraying at 0600 and 1800 hours gave less tree growth suppression than spraying at 0900-1500 hours. It is clearly noted that growth of radiata pine seedlings in the total absence of gorse and spray effect was substantially greater than when growing with gorse competition and being subjected to a release spray of 2,4,5-T. This further supports the case for a pre-plant spray programme (Balneaves 1980b) to eliminate as much as possible the competition of gorse and spray effects of releasing with 2,4,5-T herbicide following planting.

A trial with a range of levels of VPD for common times-of-day levels would be required to obtain a better understanding of correlations between VPD and effects of spray on *P. radiata* and gorse.

REFERENCES

- Balneaves, J. M., 1978. Seasonal growth of gorse and its susceptibility to 2,4,5-T and 2,4,5-T/picloram. *N.Z. J For.*, 23(1): 137-42.
- 1980. Rain after 2,4,5-T application—Effect on gorse control. *N.Z J For.*, 25 (1): 75-8.

- 1980b. A programme for gorse control in forestry using the double spray regime. *Proc. 33rd N.Z. Weed & Pest Control Conf.*
- Chavasse, C.G.R., 1976. The use of herbicides in forestry in New Zealand. *N.Z. For. Serv., For. Res. Inst, Symp. No. 18.*
- Chew, V., 1977. *Comparisons among Treatment Means in an Analysis of Variance.* Agricultural Research Service of U.S. Dept. of Agriculture. Washington, DC, pp. 7-14.
- Davenhill, N. A., 1976. Current gorse control research using herbicides. In C. G. R. Chavasse (comp.), The use of herbicides in forestry in New Zealand, *FRI Symp. No. 18: 73-7.*
- Snedecor, G. W.; Cochran, W. G., 1967. *Statistical Methods*, 6th ed. Iowa State University Press. Ames, Iowa, pp. 313-6, 349-58.