Selective herbicides for dahlia production

R.C. Southward, K.C. Harrington, J.G. Hampton[1] and H. Han

Institute of Natural Resources, Massey University, Palmerston North, New Zealand
[1] New Zealand Seed Technology Institute, Lincoln University, Canterbury, New Zealand

Abstract

Herbicide efficacy and tolerance were investigated in 'Figaro' series Hammett dahlias. In the first experiment inter-row applications of oxyfluorfen, oxyfluorfen plus oryzalin, oxadiazon, and oxadiazon plus simazine herbicide treatments to two month old plants did not affect field grown tuber yields, or subsequent forced re-sprouting under glasshouse conditions. Trifluralin and oryzalin treatments reduced tuber yields as much as leaving weeds uncontrolled. This was probably due to competition from inadequately controlled weeds, as no obvious toxic effects were observed from these two herbicides. The second experiment evaluated thirteen herbicides applied either pre- or post-emergence to dahlias grown in pots both from seeds and transplanted seedlings. Of the pre-emergence treatments, alachlor, chlorpropham, chlorthal-dimethyl, pendimethalin and trifluralin did not injure either direct-sown or transplanted plants. Methabenzthiazuron did inhibit the early growth of direct sown dahlia, but plants recovered very quickly. Terbacil damaged direct sown dahlia, but not transplanted seedlings. EPTC, oxyfluorfen, oryzalin, and simazine all caused some injury to direct sown and transplanted dahlias. Of the post-emergence treatments, chlorpropham did not injure either direct sown or transplanted dahlia. Chlorthal-dimethyl, haloxyfop, and methabenzthiazuron caused some plant injury to early growth of direct-sown seedlings, but injured plants recovered quickly.

Additional key words: *Dahlia, herbicide tolerance, seed production, tuber production*

Introduction

Although a number of overseas studies report tolerance of dahlias to herbicides, most have not measured effects of the chemicals on tuber or seed production, and some of the herbicides are unavailable in New Zealand (Brosh *et al.*, 1976; Fretz, 1976; Fryer and Makepeace, 1978; Bodman and Hughes, 1985; Talbert *et al.*, 1992; Staats and Klett, 1993; Kulns, 1994). In addition variation in tolerance to herbicides has been reported among dahlia cultivars (Clay and Ivens, 1964). The research reported in this paper was conducted to improve information on weed control in dahlia breeding and multiplication programmes. The subsequent re-sprouting ability of tubers produced following the use of residual herbicides was of particular interest. The use of six herbicide treatments considered safe for pot grown dahlia by Staats and Klett (1993) was investigated in a field trial. Subsequently, in a pot experiment, toxicity to dahlia of a wider range of herbicides under both a transplanted seedling-to-seed, and a seed-to-seed system was determined.

Materials and Methods

All investigations were conducted at Massey University, Palmerston North using Hammett 'Figaro' series dahlia seed.

Trial 1

Seeds were sown in 50 ml cell trays on 14 October 1994 in a glasshouse (16-22°C). They were potted into 600 ml polythene planter bags using a mix of bark:pumice (4:1 v/v) with 1 kg/m^3 lime, 3 kg/m^3 dolomite and 1.5 kg/m^3 of 3-4 month Osmocote (N:P:K 14:16.1:11.6) in late November. Seedlings were moved under shade one week after potting, transplanted by hand into a rotary-hoed field (Karapoti brown sandy loam) on 20 December 1994 and irrigated immediately (approximately 25 mm). Nitrophoska fertilizer (N:P:K:S; 12:10:10:2) was applied at 100 kg/ha on 11 January 1995. Plant protection included an electric rabbit fence, snail and slug bait and a regular insecticide/ fungicide/miticide spray programme (approximately 14 day intervals).

Each plot was 8.4 m^2 arranged in 4 rows of 8 continuous plots. The plant spacing was 0.75 x 0.75 m. Treatments were allocated using a completely randomized design with four replications of ten plants each. An analysis of variance was performed on the results.

Most herbicides were applied on 21 December 1994 using a knap-sack sprayer. Trifluralin was applied on 19 December, the day before transplanting and immediately rotary hoed to a depth of 20 cm. Ronstar SG pellets (oxadiazon + simazine) were applied by hand on 23 December 1994. Irrigation (approx. 25 mm) occurred after application. All sprays were directed to the inter-row soil surface in calm conditions. Push hoeing on the hand weeded treatment occurred on 5 and 25 February, 15 March, and 13 April 1995.

Two quadrats (0.2 x 0.6 m) in each plot were cut at ground level on 4 July 1995, separated into species, dried and weighed. In late July tuber clumps were dug up, washed and stems were trimmed. Clumps were weighed and individual tubers counted. After potting up, using the previously described potting mix, they were placed in a glasshouse (heating 21°C). Sprouting was recorded every two or three days for 35 days. By this stage most sprouted plants had visible flower buds (Southward, 1997).

Trial 2

Dahlia plants were established in pots both from seed and from transplanted seedlings. Direct sown seeds were established in 5.5 l polythene planter bags filled with Karapoti brown sandy loam on 13 December 1995. Pre-emergence herbicide treatments were applied to the pots using a pendulum laboratory sprayer operating at 200 kPa and delivering 308 l/ha before or after seed sowing, depending on the treatment. Post-emergence herbicides were sprayed over the top of plants using the same sprayer, after thinning to one plant per pot, at the four leaf stage on 8 January 1996.

Transplanted dahlias were established in 50 ml cell trays on 8 December 1995 in a glasshouse (16-25°C). Pre-emergence herbicides were applied to the planter bags directly before or after transplanting (four leaf seedling stage) on 8 January 1996. Post-emergence herbicides were applied 18 days after transplanting.

All pots were then placed on weed mats outdoors and were irrigated every two days after sowing or transplanting by overhead automatic sprinkler. All pots were weeded by hand pulling when required. A fungicide, miticide and insecticide were used on 27 February and 7 March. In addition to regular scoring of visual damage symptoms after application, final seed number and fresh weight of tubers were recorded.

A completely randomized design with four replications was employed for both trials. Each treatment replicate consisted either of one plant (transplanted trial), or ten seeds (direct seeded trial). Analysis of variance was performed and Duncan's multiple range test used for means' separation (Han, 1996).

Table 1. Effect of herbicide treatments on weed growth, dahlia tuber production and tuber regrowth.

Treatment	Rate (kg a.i./ha)	Weed dry weight[1] (g/m^2) Total	Night-shade	Grass	Clover	Tuber FW (g/plant)	Tubers per plant	Shoots per clump	Shoots sprouted per tuber (%)
oxyfluorfen + oryzalin	1.44 +3.5	129a[2]	36a	41ab	18b	1172a	13.9a	8.13a	69a
oxyfluorfen	1.44	158a	38a	29ab	24b	905b	12.2a	6.80ab	66a
oxadiazon +simazine	4.0 +1.0	290ab	152ab	110c	12b	698bc	11.8ab	6.70ab	67a
oxadiazon	1.5	198ab	31a	27ab	30b	713bc	11.5abc	6.20ab	63ab
trifluralin	1.2	397b	297b	16ab	65c	357d	9.7cd	5.15bc	63ab
oryzalin	3.5	689c	674c	3a	3b	335d	7.6de	4.83bc	62ab
hand weeded	-	137a	7a	30ab	<1a	652c	9.4cd	5.78b	70a
unweeded control	-	647 c	525c	41bc	13b	219d	6.6e	3.15c	47b

[1] nightshade, *Solanum nigrum*; grasses: *Echinochloa crus-galli*, *Setaria* spp., *Digitaria sanguinalis* and *Poa annua*; clovers: *Trifolium repens, T. dubium.*

[2] Means with the same letter in the same column do not differ significantly at $P \leq 0.05$.

Results and Discussion

Trial 1

The herbicides assessed in the field trial varied significantly in their ability to keep plots free of weeds, and the oxyfluorfen/oryzalin mixture gave the best control (Table 1). Good weed control allowed significantly improved tuber development. Plants from plots treated with trifluralin and oryzalin had poor tuber yields, which did not differ significantly from the unweeded control (Table 1). This was probably due to weed competition as no phytotoxic effects caused by the herbicide were observed. Four treatments (oxyfluorfen plus oryzalin, oxyfluorfen, oxadiazon plus simazine, and oxadiazon) had tuber production equivalent to, or better than, the hand-weeded treatment. Two of these treatments (oxyfluorfen plus oryzalin and oxyfluorfen) had particularly high tuber clump fresh weights due mainly to clumps bearing more tubers (Table 1).

All herbicide treatments which controlled weeds well produced more shoots per clump than the unweeded treatment (Table 1). In addition the oxyfluorfen/oryzalin

Table 2. Crop damage score (0 = healthy, 10 = dead), and tuber and seed production following treatment with pre-emergence herbicides for direct seeded and transplanted dahlias.

a) direct seeded

Herbicides	Timing[1] and Rate (a.i. kg/ha)		Visual score 4 WAT[2]	7 WAT	12 WAT	Tuber FW (g per plant)	Seeds per plant
alachlor	AS	1.92	3.3 cd[3]	0.5 d	1.3 cd	63.5 b	0.5 b
chlorpropham	AS	3.20	3.5 cd	1.8 cd	2.5 cd	83.4 ab	16.5 ab
chlorthal-dimethyl	BS	7.50	2.8 cd	0.5 d	1.0 cd	63.7 b	6.3 ab
EPTC	BS	4.32	7.3 b	4.3 bc	3.0 c	80.4 ab	0.0 b
methabenzthiazuron	AS	1.05	4.3 c	2.5 bcd	2.5 cd	82.8 ab	9.8 ab
oryzalin	BS	4.50	8.0 ab	3.8 bc	3.5 c	53.8 b	19.3 ab
oxadiazon	AS	1.52	8.3 ab	5.3 b	6.5 b	-	-
oxyfluorfen	AS	0.72	8.0 ab	5.3 b	3.3 c	59.7 b	25.5 a
pendimethalin	AS	1.32	3.3 cd	0.3 d	1.0 cd	104.8 a	3.5 ab
simazine	AS	1.00	10.0 a	10.0 a	10.0 a	-	-
terbacil	BS	0.96	9.8 a	9.5 a	8.5 ab	-	-
trifluralin	BS	1.20	1.8 d	0.0 d	0.0 d	101.7 a	7.0 ab
untreated	-	-	2.3 cd	0.8 d	1.0 cd	74.9 ab	2.3 b

b) transplanted

			1 WAT	6 WAT	13 WAT		
alachlor	AT[1]	1.92	1.0 d	1.8 bcd	0.5 bc	75.3 bcd	15.8 b
chlorpropham	BT	3.20	1.5 cd	1.3 bcd	0.5 bc	85.8 abcd	27.3 b
chlorthal-dimethyl	BT	7.50	0.8 d	0.5 d	0.5 bc	89.8 abc	29.0 b
EPTC	BT	4.32	1.5 cd	3.5 abc	3.0 ab	64.6 cd	12.3 b
methabenzthiazuron	AT	1.05	1.3 cd	0.5 d	1.0 bc	78.0 bcd	32.2 ab
oryzalin	BT	4.50	1.3 cd	2.3 abcd	0.3 bc	102.0 ab	20.0 b
oxadiazon	AT	1.52	5.0 b	0.5 d	1.3 bc	-	-
oxyfluorfen	AT	0.72	7.3 a	1.8 bcd	0.5 bc	76.3 bcd	62.8 a
pendimethalin	AT	1.32	1.3 cd	1.0 cd	0.8 bc	111.8 a	15.3 b
simazine	BT	1.00	2.0 cd	4.8 a	4.0 a	-	-
terbacil	BT	0.96	1.8 cd	1.0 cd	0.0 c	114.2 a	21.3 b
trifluralin	BT	1.20	1.3 cd	0.3 d	0.5 bc	94.4 abc	6.0 b
untreated		-	2.5 c	0.3 d	0.5 bc	57.7 d	19.8 b

1 Herbicides applied: AT = after transplanting, AS = after sowing, BT = before transplanting, BS = before sowing.
[2] WAT = weeks after treatment.
[3] Means with the same letter in the same column do not differ significantly at $P \leq 0.05$.

treatment produced more shoots than the oryzalin or trifluralin treatments, which had not controlled weeds as well (Table 1). Thus weed competition appears to have reduced re-sprouting by a combination of lower tuber numbers and tuber weight (Table 1). The percentage of tubers that sprouted from each clump was similar (62-70 %) for seven of the eight treatments. This may suggest some dormancy mechanism in the tuber or lower stem that allows only this percentage of shoots to sprout. Dividing the clumps may influence this result.

Trial 2

Of the twelve pre-emergence herbicides used in this second trial, alachlor, chlorpropham, chlorthal-dimethyl, pendimethalin, and trifluralin could all be used safely for both direct-sown and transplanted dahlias (Table 2). Although the pre-emergent methabenzthiazuron treatment affected the early growth of direct sown dahlia (transplants were unaffected), plants recovered very quickly. Terbacil applications caused plant death in direct sown dahlias, but caused no damage in transplanted dahlias (Table 2). EPTC, oryzalin, and oxyfluorfen caused significant initial injury but plants recovered. Oxadiazon and simazine also caused significant initial injury to both direct-sown and transplanted dahlias, and plants failed to recover as well.

In Trial 2, oryzalin, oxyfluorfen, oxadiazon, and simazine all caused damage to dahlia. In Trial 1, however, these herbicides were used safely because the application method avoided direct foliar contact. In addition, final tuber weights in Trial 2 were no different to the untreated control. Seed number was actually higher in the oxyfluorfen treatment compared with the control for both plant establishment methods. However, large variations in data occurred. Very large differences (0.03-6.66 g/plant) amongst 'Figaro' series clones in a separate seed production trial (Southward, 1997) indicate that this herbicide trial yield data may not be reliable, especially as only four replicates of one plant each were used.

Chlorpropham did not show any plant injury as a post-emergence herbicide for both direct-sown and transplanted dahlias (Table 3). Haloxyfop, chlorthal-dimethyl and methabenzthiazuron caused some plant injury to early growth of seedlings when applied after emergence. However, injured plants recovered quickly

Table 3. Crop damage score (0 = healthy, 10 = dead), and tuber and seed production following treatment of direct seeded dahlias with post-emergence herbicides and treatment of transplanted dahlias with post-emergence herbicides 18 days after transplanting.

a) direct seeded

Herbicides	Rate (a.i. kg/ha)	Visual score 1 WAT[1]	5 WAT	13 WAT	Tuber FW (g per plant)	Seeds per plant
chlorpropham	3.20	2.5 bc[2]	0.8 c	0.5 c	66.8 a	4.8 ab
chlorthal-dimethyl	7.50	5.0 b	1.5 c	1.0 c	79.5 a	17.8 ab
haloxyfop	0.30	4.5 bc	2.3 c	0.5 c	83.9 a	14.0 ab
methabenzthiazuron	1.05	3.5 bc	1.5 c	1.3 c	79.9 a	29.8 a
oxyfluorfen	0.72	8.8 a	5.75 b	5.3 b	-	-
terbacil	0.96	8.8 a	10.0 a	10.0 a	-	-
untreated	-	2.0 c	1.5 c	0.5 c	74.8 a	2.3 b

b) transplanted

		1 WAT	4 WAT	12 WAT		
chlorpropham	3.20	0.5 c	0.3 c	0.0 c	112.4 a	18.5 a
chlorthal-dimethyl	7.50	1.8 c	0.8 c	0.0 c	89.8 a	15.0 a
haloxyfop	0.30	0.0 c	0.8 c	0.8 bc	44.5 c	0.8 a
methabenzthiazuron	1.05	0.5 c	1.3 bc	0.5 bc	88.4 ab	8.0 a
oxyfluorfen	0.72	8.5 a	3.8 b	1.3 b	96.2 a	4.0 a
terbacil	0.96	5.3 b	8.8 a	8.5 a	-	-
untreated	-	0.0 c	0.3 c	0.5 bc	57.7 bc	19.8 a

[1] WAT = weeks after treatment.
[2] Means with the same letter in the same column do not differ significantly at $P < 0.05$

(Table 3). These herbicides did not injure transplanted dahlias when applied post-emergence (Table 3). Oxyfluorfen caused significant initial injury but transplants recovered eventually with apparently no effect on final tuber weight or seed number. Direct-sown plants did not recover as well, with some plant mortality. Terbacil caused severe injury and plant death as a post-emergence treatment in both direct sown and transplanted dahlia.

Recommendations

Results from these two studies indicate that there are a number of herbicides which can be used safely in dahlia production. However, crop safety in dahlia is influenced by a number of factors including plant establishment method, herbicide application timing (pre-emergence and post-emergence), and whether applications are directed or overall.

The safest herbicides were alachlor, chlorpropham, chlorthal-dimethyl, pendimethalin, trifluralin, methabenzthiazuron, and haloxyfop. Terbacil was safe as a pre-emergence herbicide on transplants. EPTC, oryzalin, and oxyfluorfen tended to cause significant initial injury when applied overall but plant recovery was generally good. When directed (Trial 1), the latter two were quite safe. Both oxadiazon and simazine caused significant injury, and some plant mortality, to both direct-sown and transplanted dahlias. However, when applied to well established plants without foliar contact, they were safe. There appears to be no detrimental residual effect on re-sprouting ability in tubers after production using pre-emergence herbicides for those tested in the first trial.

Specific recommendations will depend on the weed species that establish within dahlia crops, past land and herbicide use, and future crop rotation considerations. Small scale trials for any given situation are recommended before any large-scale application occurs, as variables such as soil type and temperature may influence results obtained.

References

Bodman, K. and Hughes, I.K. 1985. Growing dahlias. *Queensland Agricultural Journal* ***111(3)***, 141-150.

Brosh, S., Finkelstein, Y., Sando, Z. and Diskin, I. 1976. Weed control in flower crops of the sunflower family (Compositae). *Phytoparasitica 4 (2)*, 160.

Clay, D.V. and Ivens, G.W. 1964. Herbicide trials on dahlias. *Proceedings of the 7th British Weed Control Conference*, 241-247.

Fretz, T.A. 1976. Herbicide performance on transplanted annual bedding plants. *HortScience* ***11(2)***, 110-111.

Fryer, J.D. and Makepeace, R.J. (eds.) 1978. Weed Control Handbook Volume II. Recommendations including plant growth regulators, 8th edition. Blackwell Scientific Publications, Oxford, UK. 532 pp.

Han, H. 1996. Hybrid Dahlia *(Dahlia hybrida L.)* Seed Production. Unpublished M.Appl.Sc Thesis, Seed Technology Centre, Massey University, Palmerston North.

Kulns, L.J. 1994. Weeds. *In* Bedding Plants I, (ed. E.J. Holcomb), pp. 273-284. Ball Publishing, Batavia, Illinois.

Southward, R.C. 1997. Some Aspects of Seed Production and the Evaluation of Herbicides for Tuber Production of the Hammett 'Figaro' Series Semi-dwarf Dahlia. Unpublished M.Hort.Sc Thesis, Seed Technology Centre, Massey University, Palmerston North.

Staats, D. and Klett, E. 1993. Evaluation of weed control and phytotoxicity of pre-emergence herbicides applied to container-grown herbaceous and woody plants. *Journal of Environmental Horticulture* ***11(2)***, 78-80.

Talbert, R.E., Wichert, R.A., Carey, V.F. III, Johnson, D.H., Ruff, D.F., and Kendig, J.A., 1992. The 1991 field evaluation of herbicides on small fruit, vegetable and ornamental crops. *Research Series Arkansas Agricultural Experiment Station* No. 417. 58 pp.