# FATHEN (*CHENOPODIUM ALBUM*): A BIOTYPE RESISTANT TO DICAMBA

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## ABSTRACT

The broadleaf weed fathen (*Chenopodium album*) is a serious problem in maize crops. In the 1979/80 season a biotype appeared that was resistant to the triazine herbicides and now this biotype is believed to occur in most maize fields. Its control is principally by post-emergence herbicides with dicamba being widely used. Recently there have been reports of inadequate control of fathen by dicamba. To test for resistance, seeds were collected from fathen plants that were found alive in the field after application of dicamba. These seed lines were grown in a glasshouse and treated with several rates of dicamba and other herbicides. The fathen plants from one collection were not resistant to dicamba and were probably from plants that germinated after the field application of dicamba. The fathen plants from the second collection all survived treatment with dicamba applied at 4 times the normal field rate. These plants were killed by nicosulfuron and bromoxynil.

**Keywords**: *Chenopodium album*, fathen, dicamba, herbicide resistance, maize.

## INTRODUCTION

Herbicide resistance, resulting from long-term herbicide use and reduced reliance on non-herbicide tools, is now either a major or an emerging problem in many parts of the world. The latest results of the International Survey of Herbicide Resistant Weeds have recorded 296 resistant biotypes of 178 weed species in 59 countries, with 65 of these biotypes being resistant to triazine herbicides (Heap 2005). The number of herbicide resistant weeds reported in New Zealand has risen slowly since 1982 and to date nine weed species have been confirmed as showing biotype variation in herbicide tolerance.

With the prevalent use of residual herbicides in many crops, it is hardly surprising that the first case of herbicide resistance in New Zealand was discovered in maize fields and, like most countries, the herbicide group involved was the triazine (Rahman 1982). The weed involved in this instance was fathen, which is now one of the worst broadleaf weeds in maize crops. The triazine-resistant biotype has spread steadily and now it is suspected that most, if not all, fathen present in maize fields, is resistant to atrazine.

Experimental work has shown no difference between susceptible and atrazine resistant biotypes of fathen in their tolerance to 2,4-D, dicamba, bentazone and bromofenoxim (Rahman et al. 1983). More recent field studies also showed good efficacy of pyridate, bromoxynil and nicosulfuron on both susceptible and resistant biotypes in maize crops (Rahman et al. 2001). Of these post-emergence herbicide options, dicamba is the most widely used chemical due to its efficacy, the wide spectrum of weeds controlled and relatively low cost.

Fathen has been reported to have developed resistance to several herbicides, mostly to photosystem inhibiting compounds, in 18 countries (Heap 2005). Resistance to dicamba has been found in kochia (*Kochia scoparia*) (Cranston et al. 2001) and charlock (*Sinapis arvensis*) (Meikle et al. 1995; Jasieniuk et al. 1995) The list of weeds resistant to synthetic auxin herbicides (the group to which dicamba belongs) includes 24 species. However, resistance to dicamba in fathen has not yet been reported. Fuerst et al (1983) specifically tested for cross-resistance to several herbicides in triazine-resistant biotypes of four species and found little or no cross-resistance in the case of dicamba. Over the last few growing seasons, some farmers have reported inadequate control of atrazine-resistant fathen by dicamba. Glasshouse investigations on progeny from these sites did not confirm significantly increased tolerance or resistance in any of these cases (T.K. James, unpubl. data). However, this paper describes glasshouse studies to confirm a recent report of a biotype exhibiting resistance to dicamba.

## MATERIALS AND METHODS

Experiment 1 was carried out using seed (Seed-line A) collected at the end of the growing season (April 2003) from fathen plants found in a field that had previously been treated post-emergence with dicamba (Banvel; at 300 g active ingredient/ha, i.e. at full label rate). It had been reported that the dicamba failed to adequately control the fathen plants present at application. For comparison, seed from a susceptible biotype of fathen was collected from a refuse site that had no recent history of dicamba use (Seed-line B). The fathen seed was planted into 100 mm diameter pots containing sterile, commercial potting mix (Daltons). Seeded pots were held at 4°C for 14 days to promote germination and then kept in a glasshouse from 18 September 2003. The fathen plants emerged over the subsequent few weeks and by late October each pot contained at least five plants. The heights of plants with suspected resistance ranged from 60–180 mm while the susceptible plants ranged from 50–160 mm.

On 24 October 2003 six pots of suspected resistant biotype and five pots of the susceptible biotype were each treated with dicamba (Crop Care Dicamba) at 300 and 600 g/ha, bromoxynil (Emblem) at 450 g/ha or remained untreated. All treatments were applied with a moving belt pot sprayer using a single TeeJet 8001E nozzle at 200 kPa, positioned 440 mm above the top of the pot to apply 200 litres/ha. Conditions were sunny and the temperature was 21°C. Fathen plants were visually assessed for damage at 10 and 39 days after treatment (DAT) and for percentage of plants killed at 81 DAT (Table 1). The damage score assessed the relative fitness of the treated plant compared to the untreated controls. Surviving plants were kept to maturity and their seed collected.

Experiment 2 was conducted in 2004 with seed collected from fathen plants that survived the treatments applied in Experiment 1 (Seed-line A) along with some freshly collected seed (Seed-line C) from the same field as the seed used for Experiment 1. Seed-line C was added after another reported failure of dicamba to control fathen plants in the field during the 2003/4 season. This time, fathen plants that survived the dicamba application were identified and marked soon after application and seed collected only from these plants. All these seed lines (Table 2) were planted on 15 November 2004 in 150 mm diameter pots and laid out in a glasshouse. About 5 weeks later, when the plants were 40–100 mm tall, six pots were randomly selected from each seed line for each treatment. The treatments (Table 2) were applied on 22 December 2004 using the same setup as for Experiment 1. At the time it was overcast and 19°C. These plants were visually assessed for damage 35 DAT and for percentage of plants killed 70 DAT (Tables 2 and 3). All data were subjected to analysis of variance to separate the treatment means.

## RESULTS AND DISCUSSION

High levels of damage had occurred in fathen from both dicamba and bromoxynil at 10 days after application in Experiment 1 (Table 1). For dicamba the damage symptoms were extreme deformation of the plants and some wilting of leaves. In the case of bromoxynil the damage consisted of severe leaf burning leading to rapid necrosis. After a further 4 weeks all the smaller plants in the dicamba treatments had died while the larger plants exhibited severe deformation including large warty growths on the stems at ground level and stunted, swollen and grossly deformed growing tips. In the bromoxynil treatment most plants were dead with only a few of the larger plants showing some regrowth from low down on the stem. There were no significant differences between the suspected resistant biotype and the susceptible biotype in terms of herbicide efficacy.

Emergence of the fathen plants used in this experiment was variable leading to plants of different sizes in each pot at the time the treatments were applied. As it was only the larger plants that survived the dicamba treatments, it would appear that in this instance the reason why some plants survived was the poor timing of the spray application rather than herbicide resistance. However, herbicide resistance could not be ruled out as nodding thistle plants resistant to 2,4-D (another synthetic auxin) do not show high levels of resistance until several weeks old (Rahman et al. 1994). Therefore, the surviving plants were grown to maturity and seed collected for further testing.

**TABLE 1: Damage (%) and death (%) of suspected-resistant (Seed-line A) and susceptible (Seed-line B) fathen plants after spraying with dicamba and bromoxynil.**

| Treatment | Rate (g ai/ha) | Seed-line | Percent damage | | Percent plants killed |
|---|---|---|---|---|---|
| | | | 3.11.03 | 2.12.03 | 13.1.04 |
| Untreated | - | B | 0 | 0 | 0 |
| Dicamba | 300 | B | 60 | 85 | 78 |
| Dicamba | 600 | B | 61 | 89 | 84 |
| Bromoxynil | 450 | B | 94 | 99 | 100 |
| Untreated | - | A | 0 | 0 | 0 |
| Dicamba | 300 | A | 60 | 72 | 56 |
| Dicamba | 600 | A | 58 | 83 | 73 |
| Bromoxynil | 450 | A | 85 | 92 | 90 |
| LSD (P<0.05) | | | 9.8 | 14.8 | 54.7 |

Experiment 2 tested the progeny of plants that survived in Experiment 1 (Seed-line A) as well as plants grown from Seed-line C (seed collected from the field site in 2004). The first detail noticed in this experiment was that the plants grown from Seed-line C were morphologically distinct from the other plants in the experiment. The plants from Seed-line C were a lighter shade of green and had considerably less dentate leaves (Fig. 1). Also plants from Seed-line C were faster to mature with flowers appearing after only 7–8 weeks, 4 weeks earlier than the other plants. This early maturity also resulted in the plants only growing to about half the height of the others. As emergence occurred over about a 5-day period, it was difficult to compare the relative fitness of plants from Seed-line A and Seed-line C, but both appeared to grow well. Fathen is a very variable species taxonomically, but both biotypes fit within the description for New Zealand plants (Webb et al. 1988). The seeds of the two biotypes were indistinguishable.

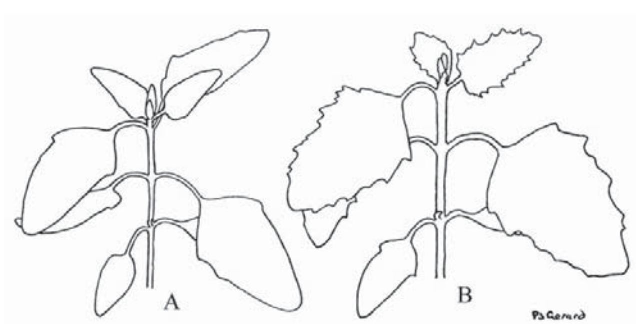


**FIGURE 1: Growth form of dicamba-resistant (A) and susceptible (B) fathen.**

Results for Experiment 2 were similar to those from Experiment 1 for the plants that were progeny of survivors from Seed-line A (Tables 2 & 3). That is, there was a high level of initial damage (mostly deformation) and most plants were killed by the recommended field rate of dicamba. The few survivors were grossly deformed and probably would not have persisted under field conditions. However, for the plants grown from Seed-line C the results were quite different. These plants showed little effect initially. At 35 DAT, damage from the dicamba treatments was about 23% for the standard and 2x field rates (300 and 600 g/ha) and 38% for the 4x field rate (1200 g/ha) compared to 83–99% for the other fathen plants (Table 2). The herbicide damage to the plants grown from Seed-line C was confined to some deformation of leaves and overall plant stunting. There were no signs of the warty stem growths, swollen growing tips or deformation of the stems that were evident in Seed-line A fathen plants. While most of the Seed-line A fathen plants were dead by 10 weeks after treatment, none of the plants from Seed-line C died (Table 3). However, plants from Seed-line C were killed by both bromoxynil and nicosulfuron showing that there is no cross-resistance to these two herbicides and that they could be used to effectively control the dicamba-resistant population of fathen.

**TABLE 2: Plant damage (%) from three herbicides on fathen plants with suspected resistance 35 DAT.**

| | Rate | Previous treatment of Seed-line A fathen[1] | | | | |
|---|---|---|---|---|---|---|
| Treatment | (g ai/ha) | Untreated | Dicamba 300 | Dicamba 600 | Bromoxynil | Seed-line C |
| Untreated | - | 0 | 0 | 0 | 0 | 0 |
| Dicamba | 300 | 83 | 84 | 87 | 87 | 23 |
| Dicamba | 600 | 96 | 97 | 96 | 98 | 22 |
| Dicamba | 1200 | 100 | 100 | 100 | 100 | 38 |
| Bromoxynil | 450 | 100 | 100 | 100 | 100 | 100 |
| Nicosulfuron[2] | 60 | 97 | 98 | 99 | 97 | 96 |
| LSD (P<0.05) | | 4.9 | 4.1 | 5.7 | 4.0 | 4.0 |

[1]Seed collected from plants that survived the 2003 treatments in the glasshouse.
[2]Applied as a tank mix with the adjuvant Amaze Activator at 1 litre/ha.

**TABLE 3: Percent of plants killed by three herbicides on fathen plants with suspected resistance 70 DAT.**

| | Rate | Previous treatment of Seed-line A fathen[1] | | | | |
|---|---|---|---|---|---|---|
| Treatment | (g ai /ha) | Untreated | Dicamba 300 | Dicamba 600 | Bromoxynil | Seed-Line C |
| Untreated | | 0 | 0 | 0 | 0 | 0 |
| Dicamba | 300 | 98 | 98 | 98 | 92 | 0 |
| Dicamba | 600 | 100 | 100 | 100 | 100 | 0 |
| Dicamba | 1200 | 100 | 100 | 100 | 100 | 0 |
| Bromoxynil | 450 | 100 | 100 | 100 | 100 | 100 |
| Nicosulfuron[2] | 60 | 100 | 100 | 100 | 100 | 100 |

[1]Seed collected from plants that survived the 2003 treatments in the glasshouse.
[2]Applied as a tank mix with the adjuvant Amaze Activator at 1 litre/ha.

The results from these two experiments confirm that there is herbicide resistance to dicamba occurring in fathen plants from this site. However, the seed that was used in Experiment 1 obviously did not come from resistant plants. The seed of fathen is a very hard nut (Webb et al. 1988) and is able to survive for long periods in the soil. Fathen seed also has the ability to germinate throughout the growing season. It appears that the seed originally collected from the site in autumn 2003 (Seed-line A) came from non-resistant plants that had germinated after the application of dicamba. In the 2004 growing season, where more care was taken in the collection process, seeds (Seed-line C) obviously came from resistant stock and that resistance was passed on to its progeny. As all the plants of the resistant biotype in Experiment 2 were resistant to dicamba, it would appear that the gene involved in dicamba resistance is dominant and that a reservoir of susceptible seed in the soil is having little effect on the development and spread of resistance at this site. Seed-line A was also tested for atrazine resistance and it was found that atrazine applied at 7.5 kg/ha (5 times normal field rate) had no effect on the fathen plants. Seed-line C was not tested for atrazine resistance but as it came from the same field there is no reason to believe it isn't. Therefore, it is assumed that the biotype identified as Seed-line C is resistant to both dicamba and atrazine.

An interview with the grower's consultant revealed that for regular weed control the field was treated annually with a chloroacetamide and a triazine herbicide pre-emergence while dicamba had been applied at this site specifically to control atrazine-resistant fathen annually for about 20 years. The problem was first noticed about 6 years ago and has become progressively worse. Occasionally pyridate had been used on the fathen but obviously not regularly enough to stop the development of resistance. It is estimated that up to 100 ha in total could be infested with dicamba-resistant fathen.

Further work is required to accurately determine the full extent of the occurrence of dicamba-resistant fathen in New Zealand maize crops. The morphological differences between the resistant and susceptible plants in this study should also be investigated to determine whether dicamba-resistant plants could be easily identified in the field.

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