HERBICIDES FOR WEED CONTROL IN THE ROOT CROPS *ULLUCUS TUBEROSUS* AND *AMORPHOPHALLUS KONJAC*

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ABSTRACT

Ullucus tuberosus and *Amorphophallus konjac* are new root crops being evaluated for commercial development in New Zealand. Eighteen herbicides were screened in glasshouse experiments for pre- or post-emergence use in these crops. Methabenzthiazuron, chlorpropham, diuron and linuron were well tolerated by *Ullucus* when applied pre-emergence, while dimethanamid, oryzalin and simazine warrant further study. All the post-emergence treatments damaged *Ullucus* although linuron might show acceptable tolerance at a lower rate. Acetochlor, chlorthalopropham, dimethanamid, linuron, methabenzthiazuron, oryzalin, oxadiazon, oxyfluorfen and pendimethalin were all well tolerated by *Amorphophallus* when applied pre-emergence, while asulam, flumetsulam and tribenuron were safely used post-emergence. Bromoxynil was also safe on *Amorphophallus* if applied before leaves emerged from the developing shoot.

Keywords: *Ullucus tuberosus*, *Amorphophallus konjac*, root crops, herbicide, weed control.

INTRODUCTION

Two new root crops currently being evaluated for commercial development in New Zealand are ullucu (*Ullucus tuberosus* Caldas) and konjac (*Amorphophallus konjac* K. Koch). Ullucu, a member of the Basellaceae family, is a perennial herb which produces subterranean fleshy rhizomes that resemble New Zealand yams (*Oxalis tuberosa*) and are high in starch (Sperling and King 1988). It is a native to the Andes from Venezuela to Argentina and forms a staple part of the diet for the locals. The rhizomes are also rich in vitamin C, have a silky texture and a nutty taste and could have potential as a gourmet food (Popenoe 1992). Its agromony is similar to that of potatoes (Sperling and King 1988). Most cultural practices in its homeland are carried out by hand with little or no mechanisation. No references containing herbicide recommendations were found. However, weed control which is achieved by continually cultivating the soil into furrows, is recommended to aid tuber formation (Kay 1973).

Konjac, also known as elephant foot yam, a member of the Araceae family, is also a perennial herb which produces a large subterranean corm. Native to Asia, the konjac corm is traditionally eaten as a vegetable. In Japan it is eaten as a form of vermicelli after prolonged boiling (Kay 1973). More recently the konjac corm has been grown for the starch and glucomannin it produces. Glucomannin, once extracted, is used to add dietary fibre to processed foods and as a food supplement for non insulin-dependent diabetics (Liu *et al.* 1998). In parts of Asia, most notably Japan, konjac is grown as a broad acre crop on flat beds or ridges and takes several seasons to reach maturity (Kay 1973). Modern production in Japan is highly mechanised and some herbicides have been evaluated. Paraquat is recommended provided the konjac leaves are not sprayed (Takabayashi 1975). Paraquat used with trifluralin has provided adequate weed control when applied as a directed spray after transplanting or ridging (Takabayashi 1977, 1978). Linuron, pendimethalin and oxyfluorfen applied pre-emergence and bentazone and bromoxynil applied post-emergence have also been recommended (Nakayama 1974; Bhaumik *et al.* 1988).

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This paper reports on a screening trial conducted in a glasshouse on potted plants where several candidate herbicides were evaluated for pre- or post-emergence use on both crops.

MATERIALS AND METHODS

Three dormant ullucu tubers (1.95 ± 0.66 g) or two dormant konjac corms (9.6 ± 2.9 g) were planted in each 150 mm diameter plastic pot on 24 September 1999. The ullucu tubers were planted in Patumahoe clay soil and the konjac tubers in Horotiu sandy loam soil. The pots were maintained in an unheated glasshouse for the duration of the study. On 1 October 1999 six pots were selected at random for each treatment and identified with a unique label before the treatments were applied. The herbicide treatments (Table 1) were applied using a moving belt pot sprayer fitted with a single TeeJet 8001 even spray nozzle and calibrated to apply 200 litres/ha at 200 kPa. After treatment the pots were laid out at random and top irrigated as required. On two occasions supplementary nutrients were added. Only the untreated control pots were hand weeded. On emergence the plants were inspected regularly for symptoms of herbicide damage. On 30 November 1999 the ullucu plants were harvested and their mean shoot length determined along with total dry weights of the top growth, tubers and roots. The konjac plants were harvested on 26 January 2000 in a similar way.

For the post-emergence experiment the ullucu (2.58 ± 0.65 g) tubers and konjac (5.8 ± 2.3 g) corms were handled the same as for the pre-emergence trial except they were planted on 7 October 1999. On 30 December 1999 six pots of ullucu were selected at random for each treatment and identified with a unique label before the treatments (Table 2) were applied. The konjac plants were treated in a similar manner on 2 February 2000 when the leaves had fully emerged. In addition a further six pots, selected because the konjac shoot had emerged from the soil (2–4 cm) but the leaf had not yet emerged from the shoot, were also treated with bromoxynil.

The ullucu pots were hand weeded on 17 January 2000 and the konjac pots on 23 February to remove weeds not controlled by the herbicides. The post-emergence treatments were applied in the same way as the pre-emergence treatments. After treatment the plants were regularly inspected for herbicide damage symptoms. The ullucu was harvested on 4 February 2000 and the konjac on 13 March 2000 measuring the same parameters as for the plants treated pre-emergence.

RESULTS AND DISCUSSION

Under glasshouse conditions ullucu establishment was irregular with shoots emerging about 3–6 weeks after planting. Konjac was slower to establish taking more than 2 months for the first shoots to emerge. Ullucu has dark red angular stems and green, fleshy, heart-shaped leaves on short stems, while konjac produced a stout, sheathed shoot which grew to 3–5 cm before the bipinnate, oblong leaves on umbrella-like stems emerged.

This study showed that there are several herbicides which can be safely used during the establishment of ullucu and konjac. For ullucu, the methabenzthiazuron, chlorpropham, diuron and linuron treatments all produced top growth equal to or greater than the untreated control (Table 1). These treatments showed no signs of herbicide damage at any stage and, except for diuron, had no significant effect on the tubers. There is no obvious reason why the tubers in the diuron treatment lost weight. Ullucu top growth from the oryzalin treated plants was similar to the untreated but the stems were significantly shorter. The dimethanamid, simazine, pendimethalin and acetochlor treatments all produced less top growth than untreated although the differences were not significant. All these treatments except dimethanamid showed damage symptoms after treatment. Simazine caused some leaf chlorosis while both acetochlor and pendimethalin delayed emergence and produced some stunting and distortion in the plants. Of the remaining treatments, metribuzin and terbacil resulted in severe chlorosis which led to depletion of the tubers before many of the plants died. In the tribenuron, chlorsulfuron, oxyfluorfen and oxadiazon treatments most of the tubers initiated bud formation but failed to emerge and this was reflected in the large tuber weights when the plants were harvested.

TABLE 1: The effect of pre-emergence applied herbicides on the growth of ullucu and konjac, planted 24 September and treated 1 October 1999. Ullucu was harvested 30 November 1999 and Konjac was harvested 26 January 2000.

Herbicide	Rate (kg ai/ha)	Ullucu			Konjac		Corm DM (g)
		Shoot		Tuber	Shoot		
		Length (cm)	DM (g)	DM (g)	Height (cm)	DM (g)	
Untreated	-	13.6	0.57	0.51	10.0	2.08	0.70
methabenzthiazuron	1.40	19.2	1.28	0.48	9.4	2.10	0.77
chlorpropham	4.00	15.4	0.78	0.54	11.3	2.63	1.00
diuron	1.60	19.4	0.73	0.28	11.5	3.81	1.63
linuron	1.00	19.8	0.71	0.51	12.9	3.77	1.53
oryzalin	3.00	9.2	0.57	0.58	10.9	2.70	1.30
dimethanamid	1.35	11.8	0.43	0.55	9.7	2.28	1.00
simazine	2.00	17.3	0.43	0.28	11.8	1.83	0.33
pendimethalin	1.32	10.7	0.39	0.61	10.7	2.60	0.98
acetochlor	2.58	10.4	0.33	0.48	11.4	3.10	1.32
metribuzin	0.75	11.8	0.17	0.12	11.5	3.43	1.37
terbacil	1.60	12.6	0.15	0.09	9.3	1.42	0.35
tribenuron	0.04	6.1	0.09	0.58	9.5	1.83	0.55
oxadiazon	1.52	4.3	0.07	0.53	10.4	2.45	0.98
oxyfluorfen	1.44	1.4	0.03	0.56	11.1	3.60	1.46
chlorsulfuron	0.02	1.6	0.02	0.62	11.2	1.83	0.55
LSD (P<0.05)		3.41	0.266	0.126	2.00	0.790	0.366

The konjac plants were more tolerant to the pre-emergence herbicide treatments with most treatments resulting in production of more top growth than the untreated plants. No treatments gave a significant reduction (Table 1). However, metribuzin, diuron, tribenuron and chlorsulfuron all resulted in some leaf chlorosis while simazine and terbacil gave severe chlorosis and some necrosis. All these symptoms were slow to appear (2-4 weeks after leaf opening) and were still present when the plants were harvested.

None of the post-emergence treatments were tolerated by the ullucu plants, with most causing severe chlorosis, sometimes leading to plant death (Table 2). Linuron had the least effect on ullucu and should be evaluated further at half the rate evaluated here (i.e. 0.5 kg/ha) as this herbicide is used at that rate in crops such as onions, celery, leeks and linseed with good effect. Linuron has also proved to be effective in several herb crops at this rate (James *et al.* 1991).

Konjac was considerably more tolerant than ullucu of the post-emergence treatments evaluated with none of them having a significant adverse effect on crop growth. However linuron caused some leaf chlorosis and bromoxynil applied to open leaves resulted in severe burning and necrosis although the plants did appear to be recovering. Bromoxynil had no effect when applied to the unopened shoot and thus could be used as a knockdown herbicide when the konjac shoots first appear.

The effect of herbicide treatments on the weeds is not reported here as this is well documented elsewhere, particularly in the proprietor's specification sheets. This information should be used in conjunction with the crop tolerance data reported here to design weed management programmes for all the weeds present. None of the specialist grass killing herbicides (fops and dims) were evaluated in this study as it is unlikely that they would damage these crops.

TABLE 2: The effect of post-emergence applied herbicides on the growth of ullucu and konjac.

Herbicide	Rate (kg ai/ha)	Ullucu			Konjac		
		Shoot Length (cm)	Shoot DM (g)	Tuber DM (g)	Shoot Height (cm)	Shoot DM (g)	Corn DM (g)
Untreated	-	26.8	4.15	0.42	7.96	1.55	2.28
asulam	1.6	21.5	2.12	0.47	9.17	1.62	2.42
flumetsulam	0.052	9.5	0.60	0.72	9.54	1.75	2.55
linuron	1.0	23.5	2.57	0.36	9.12	1.32	1.02
tribenuron	0.019	14.6	0.88	0.52	8.69	1.48	2.25
bromoxynil	0.40	18.0	1.98	0.38	7.31	1.40	1.71
bromoxynil ¹	0.40	-	-	-	7.76	1.55	1.93
LSD (P<0.05)		2.49	0.484	0.157	1.28	0.309	0.434

¹This treatment was applied to emerged shoots of konjac before any leaves had emerged from the shoot.

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APPENDIX: Herbicides and their formulations, used in this study.

acetochlor (Roustabout, ec), asulam (Asulox, sc), bromoxynil (Emblem, wp), chlpropham (Chloro-IPC, ec), chlorsulfuron (Glean, wdg), dimethanamid (Frontier, ec), diuron (Karmex, df), flumetsulam (Preside, wdg), linuron (Linuron, df), methabenzthiazuron (Tribunil, wp), metribuzin (Sencor, df), oryzalin (Surflan, wp), oxadiazon (Foresite, sc), oxyfluorfen (Goal XL, ec), pendimethalin (Stomp, ec), simazine (Gesatop, sc), terbacil (Sinbar, wp), tribenuron (Granstar, wdg).
(ec = emulifiable concentrate; sc = soluble concentrate; wp=wettable powder; wdg = water dispersible grain; df = dry flowable).