Potential herbicides for sunflower crops in southern Australia

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Summary

Sunflower in its early growth stages is a poor competitor with weeds, however, once established, it competes well. Weeds including fat hen (*Chenopodium album* L.), black-berry nightshade (*Solanum nigrum* L.) and dock (*Rumex* spp.) are not controlled adequately by herbicides registered currently for use in sunflower crops in southern Australia. Other herbicides may be suitable for pre-emergent and post-emergent use in sunflowers to increase the range of weeds which can be controlled. These herbicides are listed and discussed.

Introduction

Sunflowers (*Helianthus annuus* L.) are a minor crop in southern Australia, grown either in an irrigated cropping rotation or as an occasional dryland crop. Much of the technology developed in Europe and North America cannot be applied to sunflower production in the Australian environment (Lovett *et al.*, 1979).

Sunflowers are poor competitors with weeds in the early growth stages but, if they emerge in a well-prepared weed-free seedbed, their subsequent rapid growth allows them to compete successfully (McAllister and Swann, 1970; Potter and Smith, 1977).

Despite the yield losses which result from weed competition, less than 25% of sunflower growers in Australia employ weed control measures (Lovett *et al.*, 1979). Weed control by cultivation and the use of the limited range of herbicides available is frequently unsatisfactory. There is a need for further suitable herbicides for use in sunflowers.

A range of herbicides has been tested in trials in sunflowers, both in Australia and overseas. This review summarizes, from the recently published literature, pre-emergent and selective post-emergent herbicides suitable for evaluation in sunflowers.

Sunflower growth and competition

Sunflowers are susceptible to weed competition because the low plant density and single stemmed habit leads to an absence of ground cover for a considerable proportion of the life cycle (Robinson *et al.*, 1967; Lovett *et al.*, 1979). During the first 4 to 6 weeks after sowing, sunflowers are not able to suppress the emergence and growth of weeds. Weeds which emerge after this period are suppressed adequately (Johnson, 1971).

Weeds of sunflowers

The problem weeds of sunflower crops in southern Australia are mainly summer growing weeds such as fat hen (*Chenopodium album* L.), pigeon grass (*Setaria* spp.) and barnyard grass (*Echinochloa crus-galli* (L.) Beauv.) (Potter and Smith, 1977). Other weeds which may cause problems in sunflower crops include Bathurst burr (*Xanthium spinosum* L.), and dock (*Rumex* spp.), black-berry nightshade (*Solanum nigrum* L.), *Amaranthus* spp., wireweed (*Polygonum* spp.) and pigweed (*Portulaca oleracea* L.) (Potter and Smith, 1977; Kloot, 1980).

Current chemical weed control

In southern Australia, the main method of weed control is early preparation of the seedbed with 3 to 4 months clean fallow. However, chemical weed control is becoming increasingly important in sunflowers, especially where the weather prevents adequate workings of the seedbed or where reduced tillage is practised.

The knockdown herbicides diquat (as Reglone), paraquat, and paraquat

Table 1 Herbicides registered for weed control in sunflowers in Australia

Common name	Trade name (Manufacturer)	Application rate (kg a.i. ha^{-1})	Comments
trifluralin	many	0.56–0.84 PPI All States	Control of grasses and broad-leaf weeds. No control of black-berry nightshade. Has been used up to 1.2 kg a.i. ha^{-1} for fat hen control. Controls pigeon grass, barnyard grass, pigweed, wireweed and *Amaranthus* spp.
pendimethalin	Stomp 330 E (Cyanamid)	1.0–1.5 PPI or PE Qld, N.S.W., S.A. only	Controls many grass and broad-leaf weeds. Some control of black-berry nightshade if incorporated at low rate. Variable results with fat hen. Controls pigeon grass, barnyard grass, pigweed, wireweed and *Amaranthus* spp.
EPTC	Eptam (Stauffer)	2.9 PPI N.S.W., Vic. only	Only registered in southern NSW and Victoria for furrow irrigated sunflowers. Control of grass and broad-leaf weeds including barnyard grass, *Amaranthus* spp., fat hen and black-berry nightshade. Does not control wireweed. Suppresses pigweed.
2,2–DPA	many	1.6–4.1 Post (directed spray) All States	Requires a row crop. Controls most grass species.
diquat	Reglone (ICI)	0.28–0.42 PP or Post (directed) All States	Kills broad-leaf weeds and some grass weeds.
paraquat	several	0.28–0.42 PP or Post (directed) All States	Kills annual grasses and some broad-leaf weeds.
paraquat + diquat	Sprayseed (ICI)	0.25 + 0.15 to 0.375 + 0.225 PP All States	Use to kill existing weeds prior to sowing.

PP = presowing
PPI = preplanting, incorporated
PE = pre-emergent
Post = post-emergent

plus diquat (as Sprayseed) can be used to kill pasture and weed growth, and consequently reduce the need for cultivation prior to sowing sunflowers.

Trifluralin is registered for weed control in sunflowers; it can be applied up to 4 weeks prior to sowing, but must be incorporated immediately to 8 cm (Table 1). Problem weeds such as black-berry nightshade and dock are not controlled by trifluralin (Potter and Smith, 1977; Kloot, 1980).

Pendimethalin (as Stomp 330E) is registered for pre-emergent use in sunflowers (Table 1); it is best applied just prior to seeding, and incorporated within 24 hours to 5 cm. As a non-incorporated treatment it is necessary to apply pendimethalin at a higher rate, but less control of black-berry nightshade and fat hen is achieved (Kloot, 1980; Rawson *et al.*, 1980).

EPTC (Eptam) is a selective pre-emergent herbicide registered for use in furrow irrigated sunflower crops in southern New South Wales and Victoria (Table 1); it must be thoroughly incorporated immediately after application to control many grass and broad-leaf weeds in sunflower (Smith and Potter, personal communication). EPTC is only suitable for low organic matter soils (Swarbrick, 1982 p. 157).

Post-emergent grass weed control in sunflowers can be achieved by directed application of 2,2-DPA (Table 1). This treatment requires a row crop.

Herbicides with potential for pre-emergent weed control in sunflowers

Dinitroanilines

Several dinitroaniline compounds, similar in structure to trifluralin, may have potential for pre-emergent weed control in sunflowers (Table 2).

Oryzalin (as Surflan 50) is registered for pre-emergent use in horticultural crops in New South Wales, Victoria and South Australia, for the control of barnyard grass, fat hen, pigweed and wireweed. Oryzalin is also registered as a proprietary mixture with trifluralin (as Yield) for weed control in cereals. Sarpe *et al.*, (1977) reported that control of weeds in sunflowers by oryzalin was dependent on activation by rainfall. In irrigated crops, this is not likely to present a problem. In trials at Shepparton, oryzalin controlled barnyard grass, although crop damage resulted at the rate required. Oryzalin did not control fat hen or black-berry nightshade (P. Grassick, personal communication, 1981).

Kasasian (1977) reported that benfluralin (as Balan) applied before sowing and incorporated gave good weed control and increased sunflower yields in Saudi Arabia.

Ethalfluralin (as Sonalon) is a soil incorporated herbicide with residual action on numerous broad-leaf and annual grass weeds (Worthing, 1979, p. 240). In south-eastern South Australia trials showed that fat hen and barnyard grass were both effectively controlled by ethalfluralin (K. Smith and T. Potter, personal communication, 1979).

Other dinitroaniline compounds which have a potential for pre-emergent weed control in sunflowers include profluralin (as Tolban) (Hiller and Deerkop, 1979; Berg, 1981), and fluchloralin (as Basalin) (Sarkar *et al.*, 1976; Maley *et al.*, 1977).

Table 2 Dinitroaniline compounds with potential for pre-emergent weed control in sunflowers

Common name	Trade name (Manufacturer)	Application rate (kg a.i. ha^{-1})	Comments
benfluralin	Balan[1] (Eli Lilly)	0.5–1.35 PPI	Annual grass and broad-leaf weed control, including barnyard grass, pigeon grass, *Digitaria* spp., fat hen, pigweed, wire weed and *Amaranthus* spp.
oryzalin	Surflan 50[1] (Eli Lilly)	1.0–2.0 PE	Broad-leaf and grass weed control. May not control fat hen or barnyard grass. Does not control black-berry nightshade.
ethalfluralin	Sonalon (Eli Lilly)	1.0–1.4 PPI	Controls broad-leaf and grass weeds including fat hen, barnyard grass, and pigweed.
profluralin	Tolban (Ciba–Geigy)	1.1 PPI	Controls grass and broad-leaf weeds.
fluchloralin	Basalin (BASF)	1.5 PP	Grass and broad-leaf weed control.

PP = presowing
PPI = preplanting, incorporated
PE = pre-emergent
[1]Registered in some Australian States for other uses

Table 3 Amide compounds with potential for pre-emergent weed control in sunflowers

Common name	Trade name (Manufacturer)	Application rate (kg a.i. ha^{-1})	Comments
alachlor	Lasso[1] (Monsanto)	1.9–2.9 PE	Controls many grass and broad-leaf weeds. Does not control black-berry nightshade.
metolachlor	Dual[1] (Ciba–Geigy)	1.0–2.0 PE	Mainly controls grass weeds. At high rates may control black-berry nightshade and *Amaranthus* spp.
propachlor	Ramrod 65 (Monsanto)	3.5–5.0 PE	Controls many broad-leaf and grass weeds. Does not control wireweed. Controls fat hen and barnyard grass at the high rate only. Less residual effect than alachlor.
propyzamide	Kerb[1] (Rohm and Haas) Poakil (Roche–Maag)	1.0 PPI	Controls most grasses and broad-leaf weeds including black-berry nightshade, *Amaranthus* spp. and barnyard grass. Effect on fat hen unknown.
dimethachlor	Teridox (Ciba–Geigy)	1.25–2.0 PE	Sunflower tolerance uncertain. Controls black-berry nightshade, barnyard grass, other grasses and some broad-leaf weeds.

PPI = preplanting, incorporated
PE = pre-emergent
[1]Registered in some Australian States for other uses

Amides

The amide group of herbicides show a high degree of activity on many annual grasses and some broad-leaf weeds that are troublesome in sunflower crops (Table 3).

Ostojic (1977) reported that alachlor (as Lasso) gave effective pre-emergent grass control. To control a

wider range of weeds, alachlor has been successfully used in mixtures with prometryne (as Gesagard) (Kasasian, 1977; Ostojic, 1977), linuron (as Afalon), chloramben (as Amiben) (Rodriguez and Pacheco, 1976) and chlorthal (as Dacthal) (T. Potter, personal communication, 1982).

Metolachlor (as Dual) has been reported to control barnyard grass, *Setaria viridis* and *Digitaria sanguinalis* and, with appropriate mixtures, broad-leaf weed control could also be achieved without the need to incorporate the compound into the soil (Salto and Guerra, 1978).

Mixtures of metolachlor with monolinuron (as Aresin) (Pintilie *et al.*, 1975) and chloramben (Alley and Humburg, 1980; Humburg *et al.*, 1981) have been used to broaden the weed spectrum controlled.

Other amides which may be useful in sunflowers include propachlor (as Ramrod 65) (Swarbrick, 1982), propyzamide (as Kerb 50 or Poakil) (Gimesi, 1978) and dimethachlor (as Teridox) (Richardson and Parker, 1979; Worthing, 1979 p. 197).

Ureas

The substituted urea group of compounds generally show potential for pre-emergent broad-leaf weed control in sunflowers (Table 4). These include linuron (Ribrioux and Bernier, 1979) which has been successful when mixed with an amide or dinitroaniline compound (Rodrigues and Pacheco, 1976; Berengier and Malbrunot, 1977; Torres *et al.*, 1977).

Ulug (1978) reported that methabenzthiazuron (as Tribunil) controlled pigweed and *Amaranthus* spp. in sunflowers but Richardson and Parker (1978) demonstrated poor weed control at rates where sunflower is tolerant.

Other substituted urea compounds with potential for use alone or in mixtures for pre-emergent weed control in sunflowers include metoxuron (as Dosanex) (Richardson and Parker, 1978), fluometuron (as Cotoran) (Worthing, 1979 p. 275; Berg, 1981), metobromuron (as Patoran) (Alba and Garrozzo, 1977); and monolinuron (Pintilie *et al.*, 1975).

Carbamates

Carbamates including triallate (as Avadex BW), chlorpropham (as Chloro-IPC) (Chiapparina *et al.*, 1976) and vernolate (as Vernam) (Hiller and Deerkop, 1979) show potential for pre-emergence grass weed control in sunflowers (Table 5).

Table 4 Substituted urea compounds with potential for pre-emergent weed control in sunflowers.

Common name	Trade name (Manufacturer)	Application rate (kg a.i. ha^{-1})	Comments
linuron	several[1]	0.25–2.0 PE or PPI	Broad-leaf and some grass weed control. Controls fat hen, black-berry nightshade, *Amaranthus* spp. and pigweed.
methabenz-thiazuron	Tribunil[1] (Bayer)	2.1–3.5 PE	May control pigweed, *Amaranthus* spp. and many grasses. Sunflower tolerance uncertain at high rate.
metoxuron	Dosanex[1] (Sandoz)	4.0 PE	Controls many broad-leaf and grass weeds, including *Amaranthus* spp., fat hen and barnyard grass.
fluometuron	Cotoran[1] (Ciba–Geigy)	1.0–1.5 PE	Sunflower tolerance uncertain. Controls black-berry nightshade, barnyard grass, fat hen and *Amaranthus* spp.
metobromuron	Patoran (Ciba–Geigy)	1.25–1.5 PPI	Controls annual grasses and broad-leaf weeds.
monolinuron	Aresin (Hoechst)	0.8–2.5 PE	Annual grass and broad-leaf weed control.

PPI = preplanting, incorporated
PE = pre-emergent
[1]Registered in some Australian States for other uses

Table 5 Carbamate compounds with potential for pre-emergent weed control in sunflowers

Common name	Trade name (Manufacturer)	Application rate (kg a.i. ha^{-1})	Comments
triallate	Avadex BW[1] (Monsanto)	1.0–1.5 PPI	Wild oat control.
chlorpropham	Chloro-IPC[1] (Roche–Maag)	0.8 PE	Has been used in mixtures in sunflowers. Expensive.
vernolate	Vernam[1] (Stauffer)	2.6 PPI	Controls barnyard grass, fat hen and *Amaranthus* spp.

PPI = preplanting, incorporated
PE = pre-emergent
[1]Registered in some Australian States for other uses

Triazines

The triazine group of compounds has shown potential for pre-emergent broad-leaf weed control in sunflowers.

Metribuzin (Sencor 70 or Lexone 70) has been used in mixtures to control species not controlled by trifluralin alone in sunflower crops (Sarpe *et al.*, 1977) (Table 6).

Prometryne, applied before planting and incorporated (Chikulaer, 1977) or before emergence (Kasasian, 1977; Ostojic, 1977; Karasa and Sonmez, 1978; Tollerney *et al.*, 1980) resulted in good to excellent control of *Amaranthus* spp., fat hen, black-berry nightshade and barnyard grass (Avliyakulov and Dzhumeer, 1977). Terbutryn (as Igran 500), has been used before emergence for weed control in sunflowers. Moderate symptoms of toxicity were observed at rates required to control some weed species (Torres *et al.*, 1977).

Dipropetryn (as Cotofor or Sancap) is selective in sunflowers (Eshel *et al.*, 1979). In South Australian trials, dipropetryn was only moderately effective on fat hen and barnyard grass (K. Smith and T. Potter, personal communication, 1979).

Diphenylethers

A large number of diphenylether compounds have been used overseas for pre-emergent broad-leaf weed control in sunflowers.

Acifluorfen (as Blazer) can give pre-emergent control of broad-leaf weeds and grasses, including satisfactory control of black-berry nightshade and fat hen (P. Grassick, personal communication, 1981) and at high rates *Rumex* spp. and winter grass (*Poa* spp.) (Richardson *et al.*, 1979) (Table 7). Bifenox (as Modown) (K. Smith and T. Potter, personal communication, 1979) and oxyfluorfen (as Goal) (P. Grassick,

Table 6 Triazine compounds with potential for pre-emergent weed control in sunflowers

Common name	Trade name (Manufacturer)	Application rate (kg a.i. ha^{-1})	Comments
metribuzin	several[1]	PE	Controls fat hen and wireweed at 0.2 kg a.i. ha^{-1}. Sunflower tolerance uncertain.
prometryne	Gesagard 50[1] (Ciba–Geigy)	1.0–1.5 PPI	Broad-leaf and grass weed control, including *Amaranthus* spp., fat hen and black-berry nightshade.
terbutryn	Igran 500[1] (Ciba–Geigy)	1.0–1.25 PE	General weed control.
dipropetryn	Cotofor or Sancap (Ciba–Geigy)	1.25–3.5 PE	Controls a wide range of broad-leaf and grass weeds.

PPI = preplanting, incorporated
PE = pre-emergent
[1]Registered in some Australian States for other uses

Table 7 Diphenylether compounds for pre-emergent weed control in sunflowers

Common name	Trade name (Manufacturer)	Application rate (kg a.i. ha^{-1})	Comments
acifluorfen	Blazer[1] (Rohm and Haas)	0.48 PE	Controls black-berry nightshade, pigweed, summer grass and barnyard grass. May not control fat hen or *Amaranthus* spp. May control dock.
bifenox	Modown (Mobil)	0.5 PE	May control fat hen and black-berry nightshade.
oxyfluorfen	Goal (Rohm and Haas)	0.1–1.0? PE	Annual broad-leaf weeds and grasses controlled.

PE = pre-emergent
[1]Registered in some Australian States for other uses

Table 8 Other compounds for pre-emergent weed control in sunflowers

Common name	Trade name (Manufacturer)	Application rate (kg a.i. ha^{-1})	Comments
ethofumesate	Tramat[1] (Schering)	1.0–3.0 PPI or PE	Controls black-berry nightshade. Expensive.
alloxydim	Fervin[1] (Schering)	up to 4 PE	Mainly grass weed control.
chloramben	Amiben (Union Carbide)	2.0–4.0 PPI	Grass and some broad-leaf weed control including fat hen, black-berry nightshade and *Amaranthus* spp.
fluridone	— (Eli Lilly)	0.1–0.2 PPI	Controls broad-leaf and grass weeds including fat hen, barnyard grass, pigweed, black-berry nightshade and *Amaranthus* spp.
oxadiazon	Ronstar (Rhone–Poulenc)	3.0 PE	Controls broad-leaf and grass weeds including fat hen and barnyard grass.

PPI = preplanting, incorporated
PE = pre-emergent
[1]Registered in some Australian States for other uses

personal communication, 1981) show potential for pre-emergence broad-leaf weed control.

Other compounds

Oxadiazon (as Ronstar) gave moderate control of fat hen and barnyard grass, but did not result in yield increases in trials in South Australia (K. Smith and T. Potter, personal communication, 1979). Other compounds including ethofumesate (as Tramat) (Chiapparini *et al.*, 1976; Losada, 1976), alloxydim (as Fervin) (Richardson and Parker, 1978; 1979), chloramben (Hepworth and Fine, 1971; Berg, 1981) and fluridone (Buendia *et al.*, 1978; Richardson and Parker, 1979), also show potential for pre-emergent weed control (Table 8).

There are also experimental herbicides which have shown promising results in a limited number of field trials (Table 9).

A new herbicide BAS 479 OOH has shown pre-emergent control of a number of grasses and broad-leaf weeds (Wurzer and Eichen, 1979).

For control of grasses, including barnyard grass, UBI S734 has shown potential as a presowing herbicide (Peddie *et al.*, 1980).

Post-emergent herbicides

Diphenylethers including acifluorfen have shown potential for selective post-emergent broad-leaf weed control in sunflowers. Acifluorfen selectively controlled black-berry nightshade and pigweed (Richardson *et al.*, 1979). In Australian trials, acifluorfen did not control fat hen or barnyard grass in sunflowers (P. Grassick, personal communication, 1981) (Table 10).

Bifenox can be used after emergence to control broad-leaf weeds, although it causes slight leaf burn and may not control black-berry nightshade or fat hen (K. Smith and T. Potter, personal communication, 1979).

For grass weed control barban (as Neoban) (Hepworth and Fine, 1977), flamprop methyl (as Mataven) and diclofop methyl (as Hoegrass) (Anon., 1979) can be used for post-emergent grass weed control. Alloxydim (Murayama, 1978) and its analogue cietoxidim (Drosihn and Hubl, 1979; Formigoni *et al.*, 1979) as well as fluazifop (Plowman *et al.*, 1980) can be used for post-emergent grass weed control.

Conclusions

The substituted urea based compounds, such as linuron, are very active on broad-leaf weeds and, consequently, may be able to be used alone or in mixtures with dinitroanilines or amides for the control of a wider range of weeds in sunflowers.

The triazine and diphenylether groups of compounds also have potential for pre-emergent broad-leaf weed control in sunflowers. Many of these compounds are available in Australia or will be in the near future.

Experimental herbicides in various stages to commercial release may also be useful for pre-emergent applications in sunflowers.

For post-emergent grass control many herbicides which are currently

Table 9 Experimental pre-emergent herbicides with potential for use in sunflowers

Code name	Manufacturer	Application rate (kg a.i. ha^{-1})	Comments
BAS 479 OOH	BASF	0.25–2 PE or PPI	Wide range of weeds controlled.
UBI S 734	Uniroyal	0.37–2.0 PPI	Mainly grass control.

PE = pre-emergent
PPI = preplanting, incorporated

Table 10 Post-emergent herbicides with potential for selective weed control in sunflowers

Common name	Trade name (Manufacturer)	Application rate (kg a.i. ha^{-1})	Comments
acifluorfen	Blazer[1] (Rohm and Haas)	0.48	Controls black-berry nightshade and pigweed. Does not control barnyard grass. May not control fat hen or *Amaranthus* spp.
bifenox	Modown (Mobil)	0.5	Selective weed control. Some activity on black-berry nightshade and fat hen.
barban	Neoban[1] (Schering)	0.4	2 leaf stage for wild oat control.
diclofop methyl	Hoegrass[1] (Hoechst)	0.7–1.0	2 to 3 leaf stage of grass. Controls barnyard grass.
flamprop methyl	Mataven[1] (Shell)	0.4–0.6	Wild oat control.
alloxydim	Fervin[1] (Schering)	3	Selective control of grasses.
cietoxidim	Fervinal (Schering)	0.2–0.8	Early post-emergence 6 to 8 leaf stage of grass weed.
fluazifop	Fusilade (ICI)	0.2–0.5	2 to 6 leaf stage annual grass weed.

[1]Registered in some Australian States for other uses

available in Australia or will be available shortly show potential. Diclofop methyl, flamprop methyl and alloxydim are all registered for use for grass control in other crops in Australia. Fluazifop and cietoxidim should be available in Australia in the near future.

For weed control to be effective, chemical control should be used in conjunction with other cultural practices to reduce the weed population.

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