DPX 4189 - A NEW SELECTIVE HERBICIDE FOR WINTER CEREALS

J.G. CAMPION and M. TICHON

Du Pont (Australia) Ltd.
168 Walker Street
North Sydney N.S.W. 2060

Summary. DPX 4189[1] is a new herbicide with excellent selectivity to winter cereal crops. It can be safely applied pre-planting, pre-emergence and post-emergence to wheat, oats, triticale and cereal rye, but only post-emergence to barley.

The rate varies from 8 to 32 g ha^{-1}, depending on weed species and time of application. There is negligible response to rates higher than these. Weeds in general and grass weeds in particular, are more sensitive to pre-planting and pre-emergence applications of DPX 4189 than to post-emergence treatments. Shallow soil incorporation improves the activity on grasses under dry conditions. The optimum time for post-emergence application to most broadleaved weeds and annual ryegrass (*Lolium rigidum*) is within 3 weeks of crop emergence. Weeds not completely controlled are stunted or suppressed.

Linseed, rapeseed, field peas, lupins, faba beans and safflower sown 12 months after application of DPX 4189 were not affected by soil residues whereas grain sorghum, maize, sunflower and soybean sown 4 to 5 months after application were severely damaged.

INTRODUCTION

DPX 4189 is a sulphonyl urea herbicide developed by E.I. du Pont de Nemours and Co. Inc. The chemical name for the compound is 2-chloro-N-[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)aminocarbonyl]benzenesulfonamide.

In mode of action studies, inhibition of cell division in corn root tips was detected within 1 to 2 hours after treatment with 2.8×10^{-6}M DPX 4189 (1 ppm) (Ray 1980). DPX 4189 is taken up by the foliage and roots of both sensitive and resistant species and moves throughout the plant. The primary basis of selectivity is metabolism with sensitive species showing little or no metabolism of the herbicide, while wheat, oats and barley rapidly convert the herbicide to inactive products.

DPX 4189 has a favourable toxicological profile. The LD_{50} for fasted male rats is 5545 mg kg^{-1}. It is not a skin irritant or sensitiser and was not mutagenic in the Ames mutagenicity assay. Feeding studies in rats, dogs and mice have been favourable. A provisional maximum residue limit of 0.05 mg kg^{-1} DPX 4189 in cereals has been recommended by the national authority.

Palm *et al.* (1980) reviewed the worldwide development trends with DPX 4189 and suggested probable use patterns. Field development in Australia took its initial direction from the early North American and European studies where comparatively high rates (40 to 80 g ha^{-1}) were applied late post-emergence but subsequent work here in 1980 and 1981 had given considerable emphasis to the investigation of lower rates (7.5 to 16 g ha^{-1}) applied pre-planting, pre-emergence and early post-emergence for the control of mixed grass/

[1] Trade name Glean.

broadleaf weed associations.

This paper summarises field experiments conducted over the past three seasons throughout the Australian winter cereal belt. Approximately 150 trials have been used as a data base for this paper but reference is also made to observations of the extensive programme of grower trials and field experiments in progress this season.

METHODS AND MATERIALS

In experiments during 1978 and 1979 DPX 4189 - 80 WP (800 g kg^{-1} wettable powder formulation) was used while field testing in 1980 included this formulation and two dry flowable formulations DPX 4189-75 DF and DPX 4189 - 20 DF (750 and 200 g kg^{-1} formulations respectively).

Randomised complete block designs have generally been used in weed control efficacy trials with plot sizes varying from 40 to 50 m^2. Trials to assess time of application, method of incorporation, the effects of soil residues on following crops and varietal tolerance studies have been done using split plot designs. In most trials CO_2 pressurised hand sprayers were used with spray volumes varying between 30 and 250 L ha^{-1}.

All trials were assessed for weed control and crop vigour using a numerical rating scale; weed density (plants m^{-2}) was also recorded for many trials. Most trials were mechanically harvested and grain yields recorded.

RESULTS

Table 1 shows the susceptibility of common cereal weeds to DPX 4189 applied pre-planting, pre-emergence or post-emergence. The effective rate range for both sensitive grasses and broadleaf weeds lies between 8 and 32 g ha^{-1}. In general, pre-planting and pre-emergence applications provided better weed control than post-emergence applications, particularly for grass weeds such as annual ryegrass and brome grasses.

Pre-emergence applications. There was little difference between the soil applied methods, pre-plant incorporated (P.P.I.), pre-plant incorporated by sowing (I.B.S.), post-plant surface applied (Po.P.S.A.) and post-plant incorporated (Po.P.I.) in terms of weed control. Annual ryegrass was consistently controlled (80 to 90%) with 16 g ha^{-1}; P.P.I. and I.B.S. treatments in conventionally sown crops at this rate provided excellent control of wireweed, variegated thistle, saffron thistle, wild turnip, fat hen, common fumitory and capeweed. In direct drilled crops DPX 4189 at 20 g ha^{-1} used pre-planting in combination with diquat/paraquat or with glyphosate at recommended rates gave residual control of annual ryegrass, wireweed, corn gromwell, dock, soursob, common sowthistle, storksbill, common fumitory and Indian hedge mustard. In established pasture situations, mixtures of these foliar active herbicides and DPX 4189 were required to give satisfactory desiccation of existing vegetation prior to planting.

Soft brome grass and prairie grass were effectively controlled in all P.P.I. trials at rates of 16 and 20 g ha^{-1} but were only suppressed by 16 g ha^{-1} applied pre-emergence (Po.P.S.A.) in one trial. Doublegee and capeweed were susceptible at this rate.

At all rates and times of application initial control of wild radish was excellent but after 6 to 8 weeks the level of infestation was unacceptable

Table 1. Rates of DPX 4189 which gave acceptable control of weeds of cereal crops (values from 150 trials).

Common name	Botanical name	Rate (g ha^{-1}) Method of application[1]				
		P.P.I.	I.B.S.	Po.P.S.A.	Po.P.I.	E.P.E.
Annual (wimmera) ryegrass	*Lolium rigidum*	12	12	12	12	15
Black bindweed	*Polygonum convolvulus*	-	-	-	-	32
Brome grass - great	*Bromus diandrus*	20	20	-	-	-
Brome grass - soft	*Bromus molliformis*	20	20	-	-	.
Capeweed	*Arctotheca calendula*	15	15	15	15	.
Carrot weed	*Bifora testiculata*	-	-	-	-	20
Corn gromwell	*Buglossoides arvensis*	15	15	15	15	20
Chickweed-mouse ear	*Cerastium* spp.	-	-	-	-	8
Deadnettle	*Lamium amplexicaule*	12	12	12	-	12
Dock (established)	*Rumex* spp.	-	-	-	-	16
Dock (seedling)	*Rumex* spp.	-	-	-	-	8
Doublegee	*Emex australis*	20	-	18	-	.
Fat hen	*Chenopodium album*	16	16	16	16	16
Flatweed	*Hypochoeris* spp.	-	-	-	-	16
Fumitory - common	*Fumaria officinalis*	15	15	15	15	32
Fumitory - denseflower	*Fumaria densiflora*	-	16	-	16	16
Hoary cress	*Cardaria draba*	15	15	15	15	15
Indian hedge mustard	*Sisymbrium orientale*	12	12	12	12	12
Lincoln weed	*Diplotaxis tenuifolia*	-	-	-	-	16
Medics	*Medicago* spp.	-	-	-	-	8
Paterson's curse	*Echium plantagineum*	-	-	-	-	10
Prairie grass	*Bromus unioloides*	20	-	-	-	.
Rough poppy	*Papaver hybridum*	-	-	-	-	20
Rounded chamomile	*Matricaria matricarioides*	-	-	18	-	20
Saffron thistle	*Carthamus lanatus*	20	-	-	-	.
Skeleton weed	*Chondrilla juncea*	.	.	.	.	.
Soursob	*Oxalis pes-caprae*	16	16	16	16	16
Stagger weed	*Stachys arvensis*	-	-	-	-	16
Stemless thistle	*Onopordum acaulon*	-	-	-	-	20
Storksbill	*Erodium* spp.	-	-	-	-	8
Tree hogweed	*Polygonum patulum*	-	-	-	-	16
Turnip weed	*Rapistrum rugosum*	-	-	-	-	12
Variegated thistle	*Silybum marianum*	-	-	16	16	-
Wild oats	*Avena fatua*	.	.	.	.	.
Wild oats - ludo.	*Avena sterilis* spp. *ludoviciana*	.	.	.	.	.
Wild radish	*Raphanus raphanistrum*	.	.	.	.	8
Wild turnip	*Brassica tournefortii*	16	16	16	16	16
Wireweed	*Polygonum aviculare*	16	16	16	16	16
Yellow burrweed	*Amsinckia calycina*	8	8	8	8	8

[1] P.P.I. = Pre-plant incorporated
I.B.S. = Pre-plant applied, incorporated by sowing
Po.P.S.A. = Post-plant, surface applied
Po.P.I. = Post-plant incorporated
E.P.E. = Early post-emergence
- = Not known
. = Not controlled

due to the staggered germination characteristic of this species (Piggen *et al.* 1978) and also due in part to regeneration of some of the original plants. Skeleton weed was not affected by soil applied treatments at rates as high as 64 g ha^{-1}; wild oats were affected (stunting and chlorosis) by these rates, but control was unsatisfactory. The addition of triallate to P.P.I. and Po.P.I. applications of DPX 4189 provided excellent control of wild oats.

Overall grain yields were mediocre due to seasonal conditions but at 20 g ha^{-1}, DPX 4189 gave yields generally better than standard treatments (Table 2). DPX 4189 at all rates pre-planting or pre-emergence was phytotoxic to barley.

Table 2. Effect of DPX 4189 and standard treatments on grain yield (average of all cereals in all trials).

Method of application[1]	Grain yield (t ha^{-1})				
	DPX 4189 rate (g ha^{-1})			Standard treatment[2]	Untreated control
	20 to 29	30 to 39	40 to 49		
P.P.I.	1.76	-3	-	1.59	1.45
I.B.S.	1.47	-	1.58	1.43	1.18
Po.P.S.A.	2.23	2.31	2.20	2.71	1.82
Po.P.I.	2.24	-	2.22	1.90	1.42
E.P.E.	1.62	1.52	1.71	1.57	1.19

[1] Abbreviations as for Table 1.

[2] Standard treatments included the following herbicides used at recommended rates:-
P.P.I., Po.P.I. - trifluralin
I.B.S, Po.P.S.A. - trifluralin/oryzalin
E.P.E. - diclofop-methyl, bromoxynil, bromoxynil/MCPA, dicamba, diuron, terbutryne, linuron, MCPA, and metribuzin/methabenzthiazuron.
Combinations of herbicides were commonly used to control a weed spectrum.

[3] Indicates less than 2 trials conducted.

Post-emergence applications. In general, applications made to weeds in the seedling stage were always more effective than treatments applied later e.g. during crop tillering. At some sites in the southern winter rainfall cereal belt DPX 4189 at 16 g ha^{-1} applied early post-emergence was adequate by itself to control a weed spectrum of annual ryegrass, wireweed, tree hogweed, deadnettle, soursob, denseflower fumitory, corn gromwell, rough poppy, yellow burr weed, docks, Paterson's curse, mouse-ear chickweed, wild radish, Indian hedge mustard and wild turnip. Members of the Brassicaceae family, docks and Paterson's curse were controlled by 8 g ha^{-1}, while capeweed and doublegee were little affected by rates as high as 40 g ha^{-1} unless applied at the 2 to 3 true leaf stage. In the northern wheat belt, black bindweed was suppressed at 20 g ha^{-1} but for acceptable control under moisture stress conditions, 30 g ha^{-1} appeared to be the minimum dosage required.

Promising in-crop control of perennial broadleaves such as hoary cress, cutleaf mignonette (*Reseda lutea*) and creeping knapweed (*Acroptilon repens*) was obtained at 20 to 24 g ha^{-1}. Control of lincoln weed and carrot weed also occurred at these rates.

Best results with DPX 4189 were obtained in warm, moist conditions. Herbicidal responses developed after a few days and weed kill was effected within 2 to 3 weeks. Under dry conditions, susceptible weeds were suppressed for several weeks before death. Larger weeds remained stunted on occasions for the

whole season. Control of established weeds and subsequent germinations with post-emergence application was improved markedly by rainfall.

The addition of a wetting agent at 0.1% v/v improved the performance of DPX 4189 on important weeds such as annual ryegrass, wireweed and common fumitory, without loss of crop selectivity. The improved control was more consistent under dry conditions, while in some instances, half rates with surfactant outperformed full rates used alone. In one trial, addition of oil based flamprop-methyl to DPX 4189 resulted in 8 g ha^{-1} outperforming 16 g ha^{-1} on Indian hedge mustard.

Differential susceptibility between species within one genus was not uncommon with post-emergence treatments of DPX 4189, e.g. docks were far more susceptible than was sorrel; denseflower fumitory was more sensitive than common fumitory (which was moderately tolerant); and tree hogweed appeared more sensitive than wireweed. Little or no useful activity on wild oats was recorded for any rate of DPX 4189 but mixtures with the wild oat herbicides barban, diclofop-methyl and flamprop-methyl were effective without any loss of activity by either compound in the mix.

Chemical fallow. Preliminary studies on the Darling Downs showed that DPX 4189 at 40 g ha^{-1} applied to a summer fallow controlled summer growing broadleaf weeds such as pigweed (*Portulaca oleracea*), thornapple (*Datura* spp.), common sowthistle (*Sonchus oleraceus*), bladder ketmia (*Hibiscus trionum*), redshank (*Amaranthus cruentus*), dwarf amaranth (*A. macrocarpus*). Mintweed (*Salvia reflexa*) was only stunted. DPX 4189 had no significant activity on established barnyard grass (*Echinochloa* spp.) or liverseed grass (*Urochloa panicoides*).

In the winter rainfall areas, annual and perennial broadleaf species have been controlled by carryover levels of DPX 4189, e.g. soursob, common heliotrope (*Heliotropum europaeum*) and prickly paddy melon (*Cucumis myriocarpus*) have been effectively suppressed during the next growth season following application of DPX 4189.

Crop rotations. DPX 4189 has a half-life in the soil of 4 to 6 weeks. The most significant breakdown pathway in both soil and water is by hydrolysis. In the soil the rate of hydrolysis is increased by high soil temperature, low pH and high moisture levels. Photodecomposition and volatilisation in the field play minor roles in the disappearance of applied DPX 4189. Adsorption to clay is low while DPX 4189 has some affinity for organic matter.

Sensitive crops are affected by extremely low concentrations of DPX 4189. Field bioassay studies under Australian conditions indicated that the alternative winter crop lupins, rapeseed, field peas and safflower, and pasture legume crops such as medics and clovers have shown no injury to rates of 20 to 120 g ha^{-1} applied 12 months previously. On the other hand, grain sorghum, maize, sunflower and soybeans were severely damaged when sown 4 and 5 months following treatment with DPX 4189 at rates of 16 to 80 g ha^{-1}. However, grain sorghum showed no evidence of phytotoxicity when planted 13 months after treatment with DPX 4189 at 20 and 40 g ha^{-1}.

Double cropping will not be possible in summer rainfall districts following the use of DPX 4189 in winter cereals but the more normal wheat - grain sorghum rotation (13 to 15 months) appears to be quite safe.

DISCUSSION

DPX 4189 offers many possibilities for use in the Australian winter cereal belt. It has a broadspectrum of activity, excellent crop tolerance, unique flexibility in timing of application, is compatible with most other cereal herbicides and has proven to be relatively reliable under a wide range of soil types and climatic conditions.

DPX 4189 is effective as a pre-plant soil incorporated treatment, but mechanical incorporation tends to shatter soil structure. Each pass with heavy harrow equipment incurs a variable cost of \$1.87 ha^{-1}, while this figure is closer to \$5.00 ha^{-1} where wideline cultivators are used (J. Brennan, personal communication, 1981). DPX 4189 applied pre-planting and incorporated by the conventional seeding operation, would save this cost. A single application of DPX 4189 at this time may replace one or most post-emergence sprays and allow growers to spray and sow into conventional fallow as soon as practicable after the autumn seasonal break and thereby extend the growing season.

The application of DPX 4189 as a post-planting pre-emergence treatment (Po.P.S.A.) without mechanical incorporation would be an attractive option under excessively wet conditions, while a shallow incorporation post-planting (Po.P.I.) appears to be useful under dry conditions. Both approaches add flexibility to a weed management programme.

In the direct drilling technique currently practised in the winter rainfall areas of southern Australia, DPX 4189 could satisfy the outstanding requirement for a broadspectrum residual herbicide, which when applied in conjunction with foliar active herbicides would provide both pre-plant weed desiccation and reliable in-crop weed control. DPX 4189 should also assist in the expansion of chemical fallowing techniques where there is a need for residual herbicides safe to following winter cereal crops and which complement foliar active herbicides. It should also be possible to supplement existing residue levels in the soil with applications during the fallow period. It is also possible that the sensitivity of grain sorghum, maize, sunflower and soybeans to DPX 4189 could be exploited in chemical fallows between these summer crops and winter cereals. A complementary grass herbicide would need to be introduced into fallow systems at appropriate stages.

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